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Review
Physical and occupational enrichment in ruminants and equines

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1 Executive Summary

This review summarises the knowledge on physical and occupational enrichment found in the scientific literature for ruminants and equines, identifies what enrichments can be set up in farming systems to improve animal welfare and what should be further investigated. Several enrichments were identified and divided into three main categories: enrichments related to outdoor or indoor environment and cognitive challenges. Outdoor enrichment comprise access to pasture or exercise area, presence of woodlands, shrubs and edges, the provision of shelters and water or solid substrate like sand or mud to wallow and roll in. Indoor enrichment include the subdivision of the pen with visual barriers, elevated places and the provision of objects like ropes, balls or dry teats. Finally, cognitive challenges refer to offering animals the possibility to predict or control some events such as milking or feed distribution. Even if the impact of enrichments has been studied in some species like cattle, horses and to a lesser degree in sheep and goats, there is a lack of scientific knowledge on the farming conditions and enrichment strategies in deer, buffaloes, camelids, donkeys, mules and bison. Among enrichments, providing objects for mature animals and the predictability of the environment are the two main elements that lead to mitigated effects with possible negative impact on welfare. This should therefore be further studied before being applied. Finally, recommendations are made for inspections, with a focal point on pasture or exercise area for all ruminants and equines, which seems to be essential to improving animal welfare. For those already reared under extensive farming systems with outdoor access, particular attention should be paid to shelter availability.

2 Foreword

Domestic ruminants and equines are kept in a wide range of environments with varying complexity, from individual housing in barren pens to rearing in large groups in semi-natural environments. The richness of the environment has an impact on animal welfare. EURCAW *Ruminants & Equines* proposed to review the available knowledge on environmental enrichment for the species covered by the Centre. The first review introduces the issue of environmental enrichment in general: What does a enriched environment mean? What are the various types of enrichment and what are the main consequences of a poor vs. enriched environment? Then separate reviews address the various types of enrichment: occupational and physical enrichment; sensory and feeding enrichment; and relational enrichment (including the impact of the presence of conspecifics and that of other species including humans). The goal is to understand the underlying mechanisms and how they impact on the various animal types. Directive 98/58/EC for the protection of farmed animals mentions ethological (behavioural) needs, but not positive emotions or enrichment. Directive 2008/119/EC for the protection of farmed calves further specifies that calves must have visual and tactile contacts and must be kept in group from the age of 8 weeks. Directive 2010/63/EU for the protection of animals used for scientific purposes mentions enrichment, in reference to the expression of behaviour and the reduction of negative emotions (stress). For the purpose of EURCAW *Ruminants & Equines* the reviews on enrichment will therefore mainly address enrichment relevant to behavioural or sensorial needs and will make no distinction between animals used for farming or scientific purposes.

3 Definitions

Enrichments can be classified into five (non-exclusive) categories (adapted from Bloomsmith et al., 1991; Mandel et al., 2016): relational, feeding, occupational, physical and sensory enrichments. This review is dedicated to two of those categories:

- **physical enrichments** that include complexity of the animal's enclosure as well as the provision of additional elements (e.g. hiding places);
- **occupational enrichments** that promote physical and/or psychological activities by providing opportunities to exercise or to engage in cognitive tasks.

Since these categories are not exclusive, a given enrichment item may refer to several categories. In order to limit repetition between reviews it has been decided to detail such enrichments in only one review. For instance, animals may have different uses of a brush: primarily to brush and scratch themselves, but also for oral manipulations such as chewing. In this example brushing activity is assigned to sensory enrichments through tactile stimulation of the animals, while oral manipulation of the brush is more linked to an occupational activity, in relation to exploration need and, for young animal, suckling need. Thus, enrichments about feeding activity, elements to scratch on and bedding materials are investigated in the review on sensory and feeding enrichments in ruminants and equines (Ginane & Rørvang, 2023).

Furthermore, enrichment is a way to provide stimulation and facilitate animals' behavioural and sensorial needs. As a consequence, housing features and items provided to the animals that only have an impact on their biological functioning and comfort are not considered in this review as physical and occupational enrichments since they must be adjusted or provided to animals when needed. Thus, the following items, sometimes considered as enrichment, are not in the scope of this review: the size of the pen corresponding to spatial allowance and physical comfort, especially for indoor animals (horses: Burla et al., 2017; Lesimple et al., 2019; cattle: Park et al., 2020; goats and sheep: Hansen, 2015; camels: Padalino et al., 2014), sprinklers, fans and shade in hot weather to help animals regulate their body temperature (buffaloes: Bah et al., 2021, 2022; Khongdee et al., 2013; cattle: Butt et al., 2020; D'Emilio et al., 2017; Edwards-Callaway et al., 2021; Kendall et al., 2007; Marcillac-Embertson et al., 2009; Parola et al., 2012; goats: Alvarez et al., 2013; sheep: Gontijo et al., 2021; Sevi et al., 2002; deer: Pérez-Barbería et al., 2021; camelids: Zappaterra et al., 2021) or heat lamps for isolated newborn animals that have poor thermoregulation (calves: Borderas et al., 2009; lambs: Sutherland et al., 2019).

4 Scientific knowledge on animal needs and abilities

General scientific knowledge about environmental enrichment is presented in the review on the introduction to enrichment in ruminants and equines (Botreau et al., 2023).

Enrichments must cover animals' behavioural and sensorial needs. All ruminants and equines present common needs regarding physical and occupational dimensions. For example, animals need to explore their environment and to be appropriately stimulated to avoid boredom (see EURCAW *Ruminants & Equines* Glossary for the definition). The most effective stimulations that come from their environment are those present in natural conditions. On pasture during daylight, cattle, horses, sheep and goats spend approximatively the same amount of time feeding (~60-70%), resting (~20-30%), walking (~5-10%) and involved in other behaviours such as social interactions, drinking or self-grooming (~5%) (*Figure 1*, Duncan, 1980; Ishiwata et al., 2008; Maisonpierre et al., 2019; Neave et al., 2021; Pokorná et al., 2013; Waring, 2003). Note that the distribution of activities may be influenced by the season, the weather, the size of the herd, the available area, etc., so that a general estimation is difficult to establish. When animals are reared in captive and especially indoor environments, they may be not allowed to express natural patterns of behaviours, and may express a rebound effect when moved from a captive into a more natural environment. For example, cattle tethered indoors for 6 days overexpress locomotion behaviours (running, jumping) when moved into a paddock (Nakayama & Ninomiya, 2018). This rebound effect highlights the frustration to inhibit some exploration behaviours, and probably the joy of rediscovering a more pleasant environment. More broadly, beyond the need to exhibit a behaviour (e.g. feeding), the emotional response associated to the way this behaviour is expressed (e.g. grazing in pasture vs. eat hay) is essential to consider in order to take into account how positive or negative the situation is perceived by the animals.

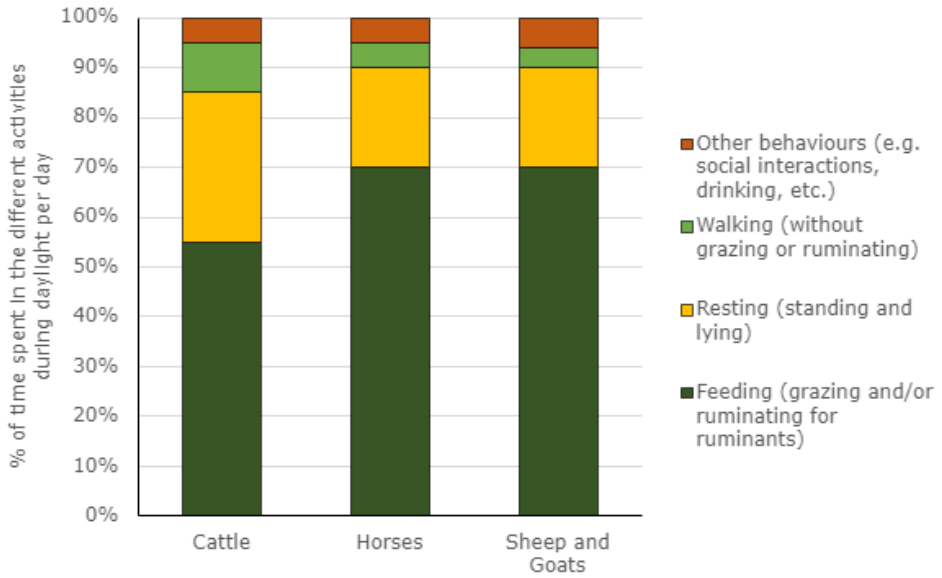

Figure 1: Summary of the estimated time-budget behavioural activity on pasture during daylight for cattle, horses, sheep and goats (Ishiwata et al., 2008; Maisonpierre et al., 2019; Neave et al., 2021; Pokorná et al., 2013; Waring, 2003).

Since emotions are linked to cognition and welfare (Boissy et al., 2007), knowledge about animals' cognitive abilities is required to understand and study their emotions. Even if cognitive abilities of farmed ruminants and equines are still being studied, research has already demonstrated some of their abilities regarding physical (categorisation, numerical ability, object permanence, reasoning/inferences and tool use) and social cognition (discrimination, recognition and communication with conspecifics and humans, social learning, attributing attention, prosocial behaviour and fairness) (Nawroth et al., 2019). Thus, it seems beneficial to animal's welfare to integrate challenges in their environment to stimulate their cognitive abilities as it could be in their natural environments in order to avoid boredom. Also, ruminants' and equines' needs may vary between species. Enrichments consisting of providing platforms and elevated places may be relevant for goats but not for cows or equines, as goats present excellent abilities and motivation to climb. In addition, satisfying exploratory needs is more important if the species is curious, for instance buffaloes have been reported to be more curious than cattle (Napolitano et al., 2005). Indeed, even belonging to the same subfamily (Bovinae), cattle and buffaloes can have different specific behaviours, as buffaloes like to wallow and immerse in water or mud.

Variability in animals' behavioural and sensorial needs may also differ according to the age of the animal. Young ruminants and equines, especially dairy lambs, kids, calves and foals express the need to suckle soon after birth. If suckling needs are not satisfied on farms, particularly if neonates are separated from their mothers, they may redirect suckling and licking to other conspecifics, objects or pen features (Margerison et al., 2003), thus generating abnormal or stereotypic behaviours. In contrast, adult ruminants and equines are not motivated to suckle. Play behaviours, which can be elicited with physical enrichments, are much more expressed by young but may be present in adults. They are observed in animals when they are not subjected to stressful events and are associated with positive emotions (Mattiello et al., 2019). Thus some enrichments may be more relevant to young rather than adult ruminants and equines.

Thus, potential enrichments presented in this review are discussed according to the behavioural and sensorial needs of the different animal types concerned.

5 Minimising welfare problems and supporting best practices

5.1 Outdoor environment

Access to the outdoors is an excellent way to fulfil behavioural and sensorial needs such as grazing behaviour. Exploration can, for instance, be stimulated by the access to an outdoor area (pasture or exercise area), even more if this area is complex.

5.1.1 Pasture

All ruminants and equines are grazers (and browsers, depending on the species). When ruminants and equines are reared indoors, a part of their natural behavioural repertoire cannot be expressed (such as grazing behaviour) or is limited (such as exploration behaviour). Animals reared in free-range systems or with access to pasture spend more time walking, feeding, exploring the environment and express reduced agonistic behaviours than animals kept indoors (dairy cows: Arnott et al., 2017; fattening bulls: Braghieri et al., 2011; buffaloes: De la Cruz-Cruz et al., 2014;

sheep: Bettencourt et al., 2022; horses: King et al., 2013; deer: Pollard & Littlejohn, 1998). Access to pasture may also improve the repertoire of self grooming behaviours such as wallowing in buffaloes (De la Cruz-Cruz et al., 2014). In addition to behavioural consequences, access to pasture also presents positive consequences on health status such as lower level of lameness, hoof and hock pathologies or skin damage (horses: Popescu et al., 2019; dairy cows: Arnott et al., 2017; goats: Anzuino, 2016; deer: Mattiello, 2009; Pollard & Littlejohn, 1998). For working horses, better training performance (reduced training duration and inappropriate behaviours) is observed in horses raised in groups on pasture than in those raised in individual boxes (Rivera et al., 2002, note there were confounding effects of pasture and social group). In addition to a clear preference for access to pasture vs. indoors (dairy cows: Arnott et al., 2017), access to pasture after indoor housing may induce a positive bias (horses: Löckener et al., 2016).

However, keeping animals on pasture does not necessarily mean that their welfare is guaranteed. Poor management of the outdoor grazing area can result in insufficient feed provision, and in turn to a negative energy balance (dairy cows: review by Arnott et al., 2017); insufficient water provision in quantity and quality, or inability to take shelter against extreme weather conditions are also associated to poor welfare (dairy cows: Arnott et al., 2017). In addition there is a risk of impaired welfare in the case of extensive conditions where many animals are spread over a large geographical area, making the surveillance more difficult (Stafford & Gregory, 2008).

When animals have the opportunity to access a vegetated outdoor area, this area becomes a source of feed for the animals. If the plant cover is diversified (such as permanent natural grasslands with a high diversity of mono- and dicotyledons), this allows the animals to select what they eat (see Ginane & Rørvang, 2023 for the review on sensory and feeding enrichment in ruminants and equines).

5.1.2 Exercise area (indoor and outdoor)

When access to pasture is possible, it is often limited to a part of the year (late spring, summer and early autumn). The rest of the year animals may be maintained indoors, sometimes tethered (e.g. for some dairy cows). Their locomotion can thus be reduced, as shown by their motivation to access an exercise area even if indoors (tethered cows: Veissier et al., 2008). Access to such an outdoor exercise area (without necessarily any edible material) appears to be beneficial for almost all ruminant and equine species (horses: Lee et al., 2011; Werhahn et al., 2011; donkeys: EU Platform on Animal Welfare, 2019; buffaloes: De la Cruz-Cruz et al., 2014; Tripaldi et al., 2004; cattle: Langford et al., 2021; Park et al., 2020; calves: Moser et al., 2020; goats: Stachowicz et al., 2018; Zobel & Nawroth, 2020; sheep: Hansen, 2015; Piirsalu et al., 2020; Stubsjøen et al., 2022; camels: Padalino et al., 2014). For instance, stabled horses with access to an exercise area have a lower rebound effect when released to a large sand area in comparison with when they are confined in a stable (Freire et al., 2009). They express motivation to be released in a paddock, even more if it is with conspecifics (Lee et al., 2011) and present a more relaxed behaviour in a stable when access to an exercise area is allowed in addition to training (Werhahn et al., 2011).

5.1.3 Woodlands, shrubs and hedges

In contrast to buffaloes, which are more grazers than browsers (Napolitano et al., 2013), other ruminant species such as goats (Anzuino, 2016) and deer (Canals, 2019) browse on trees and bushes/shrubs, which represent an important source of feeding diversity. Zobel and Nawroth (2020) reported that wooded grazing areas mobilize goats' cognitive skills to remember and relocate preferred wood patches, while encouraging browsing above head level, which is a natural goat behaviour. Thus, positive consequences of providing wooded areas are not only nutritionally beneficial but also behaviourally important. Access to an outdoor area with woodlands and shrubs in addition to grasslands may also provide elements to scratch on (satisfying grooming need) (Ginane & Rørvang, 2023) or to climb on (for adapted species like goats, Delibes et al., 2017), thus increasing the behavioural repertoire of these animals. Trees and bushes, in addition to offering a natural protection against adverse weather conditions (i.e. hot, rainy or windy), offer protection against predators thus contributing to security feeling, while fulfilling the need for social isolation at particular periods such as parturition (e.g. ewes giving birth in boxwood bushes, Hazard et al., 2021) (see *5.1.4 Shelter (natural and artificial)*).

5.1.4 Shelter (natural and artificial)

Shelter can be artificial (constructed) or natural (trees) in outdoor environments. Even if the primary aim of shelters is to protect against extreme weather conditions (not in the scope of enrichment as described in *3 Definitions*), this is not the only role played by them: in an open environment, animals can use shelters, for social isolation and as refuge areas.

Artificial shelters can be constructed of walls of different materials, a roof hanging between trees or the combination of a roof and walls providing protection against wind, sun, rain and snow. However, most of the studies investigating the use of shelters only considered the shade provided by a steel roof on feedlot beef cattle (Edwards-Callaway et al., 2021), which is not considered as an enrichment.

Animals on pasture use shelters, artificial or natural (e.g. trees, see *5.1.3 Woodlands, shrubs and hedges*), in any weather conditions and significantly increase their use during warm, cold, rainy, snowy and/or windy events (horses: Heleski & Murtazashvili, 2010; Snoeks et al., 2015; donkeys: Haddy et al., 2020; Proops et al., 2019; cattle: Rovira & Velazco, 2010; Titto et al., 2011; sheep: Marcone et al., 2021; Pritchard et al., 2021). Goats avoid sunlight, wind and rain and could benefit from shelter (Stachowicz et al., 2019). In cattle and sheep, providing shelters decreases the respiratory rate (cattle: Rovira & Velazco, 2010; Van Laer et al., 2015; sheep: Marcone et al., 2021), the panting score (cattle: Van Laer et al., 2015; sheep: Marcone et al., 2021) and increases ruminating and grazing behaviours (cattle: Titto et al., 2011; sheep: Marcone et al., 2021). In some species, pregnant females need to isolate themselves from the herd in the hours/days around parturition. Providing shelters can fulfill this need as demonstrated in ewes giving birth outdoors in bushes (Hazard et al., 2021), cattle seeking more isolated calving pens on farm (Proudfoot et al., 2014) or deer that are hider species and need to have a sufficient number of areas to give birth and hide their newborn(s) in paddocks (Mattiello, 2009). Shelters can also be useful for newborns; fawns prefer natural hiding places like 1 m height herbaceous plants rather

than trees, shrubs and artificial shelters after birth (Janiszewski & Cilulko-Dolega, 2019), but will use artificial shelters in outdoor paddocks when no natural shelters are available (Hodgetts et al., 2002). When animals are raised in paddocks, with limited space, shelters can be provide visual barriers allowing individuals to hide, which can decrease aggressive behaviours (deer: Whittington & Chamove, 1995), in the same way as barriers in indoor housing (see *5.2.1 Subdivision of the pen*).

5.1.5 Water to wallow

Providing water to farmed animals in hot conditions by sprinklers or showers with or without fans is not considered as an enrichment (see *3 Definitions*). Nevertheless, some species need to immerse in water to satisfy a natural behaviour. Red deer like to wallow in water but, at the same time, ponds could spread diseases on farms (Kilgour & Dalton, 1984). In hot conditions, buffaloes can wallow in the cold water and remain completely submerged for several hours. Providing pools to farmed buffaloes allows them to express natural behaviours (Upadhyay & Chaiyabutr, 2017). Adding space and water pools seems to be an efficient way to improve positive social interactions and to reduce heat stress, since the number of buffaloes wallowing in pools increases as the temperature rises (De Rosa et al., 2009). It is also efficient to improve the reproductive performance of buffaloes, which can be an issue in farming systems because of the seasonal influence of the reproduction process (Zicarelli, 2017). Studies on play behaviours in water for ruminants and equines species were not found in the scientific literature.

5.1.6 Solid substrate to wallow and roll

Animals may express the natural behaviour of wallowing (or rolling) in dirt or mud, depending of the species. While it is not typical of domestic cattle (Rioja-Lang et al., 2019), it is an important natural behaviour for other species like horses, bison, buffaloes and deer (Bracke, 2011). Wallowing allows a better thermoregulation in hot weather conditions (drying the sweat for horses, Matsui et al., 2009; increased heat dissipation for buffaloes, Koga et al., 1999) but also constitutes an important grooming and comfort behaviour (bison: Coppedge & Shaw, 2000; Bracke, 2011). It allows protection against biting insects and ectoparasites (Matsui et al., 2009; Napolitano et al., 2013) and increases self-grooming and integumentary care (buffaloes: De Rosa et al., 2009). However, the preferred characteristics of the wallows or pools vary according to the considered species. While horses and bison naturally wallow in mud (horses: Matsui et al., 2009; bison: Rioja-Lang et al., 2019), buffaloes prefer to wallow in mud and water ponds (Napolitano et al., 2013). Enriching the environment of those animals thus requires to offer microsites adapted to the species: for horses and bison, bare ground areas with exposed coarse soil (Rioja-Lang et al., 2019) are preferred to sand and straw (Matsui et al., 2009); while buffaloes prefer to wallow in watered areas, water ponds, potholes or pools (Napolitano et al., 2013).

5.2 Indoor environment

When animals are kept inside, different types of enrichments can be used to reduce boredom and agonistic behaviours, increase affiliative behaviours and allow the expression of natural behaviours.

5.2.1 Subdivision of the pen

Providing partitions to divide the enclosure of farmed animals into different functional areas improves opportunities for hiding (refuge areas), camouflage, exploration, patrolling and social mate choice (Newberry, 1995). Also, it has been demonstrated that adding partitions to divide an area or restrict it to some individuals (e.g. distributing feed temporally and spatially by allowing a small number of animals to enter the feeding area) is beneficial for cognitive abilities (e.g. spatial orientation) and welfare in goats, by increasing feeding performances and decreasing social stress (Zobel & Nawroth, 2020). Indeed, goats kept in enriched enclosures with partitions and platforms had longer feeding bouts, less interruptions in feeding and resting bouts, especially in low- and medium-ranking individuals (Aschwanden et al., 2009). Moreover, the presence of niches or other hiding places is particularly important for neonatal kids in the first day of life, to allow the development of the "hider" type of mother-infant relationship, typical of goats (Lickliter, 1987; Poindron et al, 2007). In the same way, enriched lambs with a platform and a large screen in the middle of the pen used the part underneath the platform a lot, performed less stereotypies and aggression, increased social positive behaviours, but had a higher cortisol level and eye temperature during a reactivity test (Aguayo-Ulloa et al., 2015). In addition, calves provided with brushes, partitions at the feeding barrier, a wooden wall in the pen and a log showed decreased agonistic behaviours and increased affiliative behaviours compared to calves in barren pens (Ninomiya & Sato, 2009). In these studies, partitions in the enclosure were always associated with other enrichments such as a platform (which is often the same device that provide partitions). It is therefore difficult to establish a strong link between only a division in a pen and increased social behaviours or reduced stress. However, overall and in comparison with other vertebrate species, it is clear that providing visual barriers is beneficial in captive environments (Newberry, 1995). Another type of partitioning, briefly mentioned above, is the use of a visual barrier at the feeding point between animals. With wooden partitions at the feeding point, agonistic behaviours decreased in goats, more individuals were found feeding next to each other and disturbance during feeding was decreased (Nordmann et al., 2015). Moreover, in a study investigating the presence of headlocks and/or partitions at the feeding barrier, agonistic behaviours were decreased with headlocks and partitions provided at the same time in horned and hornless goats. To ensure that a maximum number of animals can eat immediately and with few agonistic interactions, it is therefore beneficial to add headlocks with visual barriers at the feeding points (Hillmann et al., 2014). To improve welfare by increasing affiliative or reducing agonistic behaviours and reducing stress of low-ranking animals, it is effective to add visual barriers into indoor enclosures where animals are kept in groups.

5.2.2 Elevated places

Considering the literature in farmed animals, the use of platforms seems to be relevant only for goats and sheep. Providing elevated places to goats is essential to express their natural behaviour of climbing. Platforms are very often used by animals, especially when housed and in contrast preventing goats from climbing may lead to frustration and increased stress. Goats particularly like to rest on elevated places, which also provide a vertical space allowance, where indoor farming systems have limited floor space (Zobel et al., 2019). For instance, goats provided with a two-level platform extensively uses it to rest; the presence of a platform also decreases aggressive

behaviours, displacements, and improves social behaviour compared to goats with one-level platform (Andersen & Bøe, 2007). Also, goats provided with one or several enrichment situations (including one treatment with only logs of wood on the floor for climbing with front legs) decreased their respiratory rate, their coat- and rectal temperature compared to the control group. However, no differences were observed for lying, drinking, ruminating and social behaviours between treatments (Araújo do Nascimento et al., 2022). When different enrichments were provided at the same time, kids provided with a roughage feeder, semi-automatic concentrate feeder, platform, bridge and wood block used all of the enrichments. There were more interactions and bipedal postures in the enriched group, but more abnormal oral activity before weaning. The authors concluded that providing platforms and more feed opportunities allowed kids to express more natural behaviours (Tölü et al., 2015). Finally, as already stated in *5.2.1 Subdivision of the pen,* enriched goats with partitions and platforms had improved feeding and resting behaviours (Aschwanden et al., 2009).

Studies on sheep provided with elevated places are fewer, and sheep do not seem to be as interested as goats in platforms to rest (Hansen, 2015). However, feedlots lambs kept in enriched enclosures with a platform and cereal straw had less stereotypies, more positive social behaviours, spent more time resting and had a better immunity. The enriched lambs were also faster to leave the start box and to resolve a maze on the first exposure (Aguayo-Ulloa et al., 2014). As already mentioned, enriched lambs with a platform and visual barrier used the part underneath the platform, which corresponded to improved social behaviours (Aguayo-Ulloa et al., 2015).

It is concluded that providing elevated places are essential for goats and kids, which express natural behaviour of climbing particularly to rest, increase positive social behaviours and reduce stress. It could also be beneficial for lambs since they use platforms to hide under or to climb on. However due to confounding factors in the studies, the precise effect of platforms on lamb behaviour cannot be determined since other enrichments were always provided at the same time.

5.2.3 Interactions with objects

In pens, individual or group housed animals may experience boredom, which is often manifest by abnormal behaviours. Objects can therefore be added to the environment to increase curiosity, exploration, play and suckling needs of young animals (when the motivation to suckle is not facilitated by the feeding process). Some studies tested the effects of providing several enrichments at the same time on the behaviours and welfare of young animals. The combination of enrichments such as brushes, plastic chains, rubber teats, ropes or balls may improve the locomotory and object related play behaviours and could decrease non-nutritive sucking behaviours (on pen features), facilitating sucking needs (calves: Pempek et al., 2017; Strappini et al., 2021; Zhang et al., 2021, 2022; Zobel et al., 2017; lambs: Chapagain et al., 2014). Although these studies showed the interest to enrich the living environments of young animals with several objects, the combination of these objects did not allow for determining the influence of each item on sucking needs or play behaviours.

Other studies on mature animals used ropes or balls, which can be either suspended from the ceiling or left on the ground in order to decrease stereotypies or increase play behaviours. Horses and heifers, showed little interest when provided with ropes (between 30 cm and 2 m long) or balls, with few and short interactions per day, decreasing with the amount of hay available (horses: Bulens et al., 2013, 2015; heifers: Bruno et al., 2020). When basic needs are not satisfied such as feeding (insufficient amount of forage), these objects may be used in a stereotypic way or may favour stereotypies. If so, objects cannot be considered as enrichments and must be avoided until the basic needs are met.

Overall, habituation to enrichment objects introduced permanently into the living environment seems to take place after approximately one or two weeks. Such enrichments (ropes, balls, chains) should therefore be regularly changed to maintain a sufficient level of stimulation.

5.3 Cognitive challenges

Farmed animals have less opportunities to express their entire cognitive abilities (e.g. perception abilities, adaptation, capacity to control the environment, knowledge acquisition such as memorization and learning abilities etc) compared to wild animals. Besides the mobilisation of cognitive abilities by some enrichments presented above, allowing farmed animals to control and/or predict their environment was shown to have a positive effect on their welfare (Mandel et al., 2016), but attention should be paid to avoid too much environmental predictability, which will lead to boredom (Veissier et al., 2009). However, varying some routines such as the feeding schedule may compromise welfare, feeding behaviour can decrease when feed is given earlier, or lead to frustration when given later (horses: Zupan et al., 2020; calves: Johannesson & Ladewig, 2000). Overall, maintaining a routine is important to reduce stress, but providing some unpredictable emotional positive events (e.g. social interactions) increases the welfare of animals. Regarding control of the environment, some daily events can be controlled by animals such as milking when an automatic milking system is used, and this control may improve animal welfare on the condition that there is no competition between animals for access to the device (Jacobs & Siegford, 2012). Furthermore, farmed animals can be subjected to cognitive challenges using instrumental learning. Instrumental learning is a learning procedure in which behaviours are reinforced or inhibited by their consequences, typically using a lever or a button to push to gain access to a positive or a negative reward. Combined with a discrimination task (learning test where animals learn to discriminate two or more stimuli), this type of learning is particularly used in research to study cognitive abilities of animals because it supposes that 'they know what they are doing' (Shettleworth, 2009). In farming systems, such methods can be applied to enrich the environment by occupying the animals with reflexive tasks to access a food reward. Furthermore, increasing the possibilities to have cognitive challenges has been demonstrated to significantly improve the welfare of captive animals (Mandel et al., 2016). In ruminant and equine species, little information is available about instrumental learning in farming systems as a cognitive enrichment. Globally, heifers trained to use a device with an associative learning task seem to be more excited and motivated to perform the test than control animals with the same reward but not having to work to obtain it (Hagen & Broom, 2004; Meagher et al., 2020). Also, when learning to access a water point using a visual discriminative task, goats seek the intrinsic value of learning

beyond the motivation to obtain the reward in choosing the learning device even when there is free access to water (Langbein et al., 2009). It seems that farmed animals could have an interest in learning opportunities (also called contrafreeloading), but attention must be paid to preferences and specificities of species, as well as individual traits. Animals housed in groups should have sufficient access to learning devices, in order to avoid decreasing motivation or agonistic behaviours (Manteuffel et al., 2009). Also, the complexity of the task may be individually adapted to prevent frustration and disinterest. Finally, the animals' cognitive stimulation and social learning may be activated by human-animal interactions, as shown in Naworth et al (2016) (see de Oliveira & Boivin, 2023 for the review on relational enrichment in ruminants and equines).

Table 1: Summary of physical and occupational enrichments found in the scientific literature and their relevance for ruminants and equines species. ✔ = tested and relevant, -- = tested and mitigated effects, ✗ = tested and not relevant, ? = not tested but probably relevant (expertise), ___= not tested and uncertain

	Enrichment	Roles/needs covered	Comment	Cattle	Buffaloes	Bisons	Goats	Sheep	Horses	Donkeys	Camelids	Deer
Outdoor enrichment	Access to pasture	Expression of natural behaviour (grazing/ browsing), exploration, freedom to choose feed		✔	✔	?[1]	✔	✔	✔	✔	?	✔
	Exercise area			✔	✔	?[1]	✔	✔	✔	✔	✔	?
	Shelter	Shade, refuge area, thermoregulation		✔	?	?	✔	✔	✔	✔	?	✔
	Water pond	Expression of natural behaviour (wallowing, bathing), thermoregulation			✔							✔
	Dirt, Sand, Mud	Reduce external parasites; facilitate scratching, thermoregulation		✗	✔	✔			✔	?		✔
Indoor enrichment	Objects	Play (young), exploration, sucking need (young)	Adult	--	?				--			
			Young	✔	?		?	✔	?	?		
	Partitions	Refuge area, social behaviour	Adult	?	?		✔	?	?	?		
			Young	✔	?		✔	✔	?	?		
	Platforms	Expression of natural behaviour (climbing), dominate surroundings	Adult				✔	?				
			Young				✔	✔				
Cognitive challenge	Predictability	Stress reduction		--				--	--			
	Controllability	Stimulation, free will, learning	⚠ Unsuitable if too simple or too complex	✔	?		✔	?	?	?		

[1] Despite the lack of literature, bisons are generally kept outdoors.

6 Key factors to focus on during welfare inspections

To date, European legislation does not establish rules about the provision of enrichments for ruminants and equines in farming systems, except that calves must have visual and tactile contacts with neighbours when they are in individual housing (under 8 weeks of age). In this section some primary points to focus on are provided, according to the scientific literature regarding physical and occupational enrichment.

The farming systems depends on the animal type (beef vs. dairy cattle, young vs. adult) and geographic area. As a consequence, the main points to focus on in terms of needs insufficiently covered by farming conditions are different. For dairy cows and calves, fattening cattle, equines reared indoors (with or without work outside), sheep and goats in intensive and semi-intensive systems, access to outdoor (pasture or at least paddocks or loafing area) is a main focus. The lack of grazing and outdoor access prevents the expression of key aspects of their normal behavioural repertoire: grazing and browsing behaviour, wallowing and rolling, etc. For animals with access to pasture, a main focus is the possibility to have natural or artificial shelters to protect them against rain, wind or cold conditions and providing shade in case of hot conditions, while providing refuge areas to animals. For young animals separated from their dams, the provision of teats is recommended to facilitate suckling behaviour. According to the Italian farms risk classification program Classyfarm (2021), the presence of spaces and enrichment suitable for stimulating play, curiosity and interaction, and the provision of places where young can feel protected (such as niches) is considered optimal for young animals - especially for kids. Also, enrichments such as vertical dividing walls, tables and steps which favour movement and the natural tendency to climb, as well as stones, rocks or tree trunks should be provided to goats reared indoor and outdoor. According to scientific literature, buffaloes can be assimilated to cattle in terms of needs and behaviours, except for a few important differences such as wallowing and bathing. Thus, access to ponds or wallowing areas appears essential in addition to key elements reported above for cattle. For deer, the principal recommendations from scientists and livestock cooperatives are to keep animals outside in order to reduce stress, injuries and aggressiveness. Deer are sensitive to human presence and need to hide when being kept in an open area, especially the young. Shelters should be provided at least during the parturition period, with one hiding place per newborn deer, with a preference for natural shelters (e.g. long grass). Regarding bison, although there is a lack of scientific literature, the Canadian Bison Association (2017) recommend pasture-based systems (which is required for example in French legislation (French official journal, 2001)). Also, extreme heat is not well tolerated by bison, especially in the early summer, and attention should be paid to feed availability and shelters. Unfortunately, there is not enough data for camelids to set recommendations. However, as for all other species, outdoor access should be provided for camelids raised indoors, with access to shelters.

Finally, if setting up enrichments on farms, checking the efficiency of physical and occupational enrichments (see Botreau et al., 2023) is important during inspections.

7 Gaps in knowledge and further studies needed

As clearly illustrated in *Table 1*, scientific knowledge is still lacking concerning physical and occupational enrichment for ruminants and equines, especially for deer, camelids, buffaloes and bison. To date, cognitive challenges are not used on farms because it is too complex to implement and can easily lead to frustration. Further studies are required to support the application of cognitive enrichments on-farm. Also, studies should be conducted on the number of enrichments in relation to the number of animals to reduce competition between individuals, and allow all individuals to access the proposed enrichments. In addition, the combination of different enrichments seems to be beneficial (and thus to be recommended) in order to fulfil different animals' needs and to match individual preferences at a given time. However, studies focusing on single types of enrichment are necessary to identify their potential positive and negative impact, in the short and in the long term. This review has highlighted studies leading to both positive and negative impacts and those leading to the opposite conclusion of the potential interest of a given type of enrichment. Until these scientific gaps are filled, it is difficult to propose robust guidelines for inspections.

8 Conclusions

More than 160 million ruminants and equines are permanently raised in Europe. Most of them are managed in farming systems, ranging from restrictive housing conditions without any outdoor access and limited social interactions to extensive systems with free access to pasture all year long. Irrespective of the production system, the welfare of animals has to be supported by facilitating their behavioural and physiological needs and to promote positive emotions. Although provision of environmental enrichments for farmed animals is not in current European legislation, it is without any doubt an effective way to improve animal welfare. Physical and occupational enrichments can be provided in indoor housing such as objects, platforms or subdivision of the pen, to satisfy needs which could be impaired by captive environment. Regarding outdoor environments, allowing farmed animals to express normal patterns of behaviour (e.g. access to pasture with shelter) significantly improves their welfare whether by behavioural and physiological responses or by animals' preferences, and should be a priority.

It is clear that the farming system is a key determinant of animal welfare, with psychological and physical health decreasing when the level of captivity increases, partly because of boredom. It is thus necessary to compensate through the provision of physical and occupational enrichment. Furthermore, it is essential to adapt enrichments to the special needs of each species, including differences in the developmental stages of individuals, with particular behaviours of play and suckling in young animals. Finally, to limit boredom, cognitive challenges could be implemented on farms to allow animals to predict or control their environment, but particular attention should be paid to the availability and the complexity of the tasks in order to prevent frustration and stress. However, to truly promote positive emotions and thus enable positive animal welfare, the addition of a single enrichment object in the environment is not sufficient. To fulfil different animals' needs while covering individual preferences, a combination of different physical and

occupational enrichments is to be promoted. This non-exhaustive review of the scientific literature illustrates the gaps in knowledge, especially for some species, that needs to be further investigated. Overall, physical and occupational enrichment is an effective way to improve animal welfare in livestock systems, provided that these systems already meet all the minimum welfare requirements defined by scientific knowledge.

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- Directive 98/58/EC concerning the protection of animals kept on farms;
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- Scientific and technical studies
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