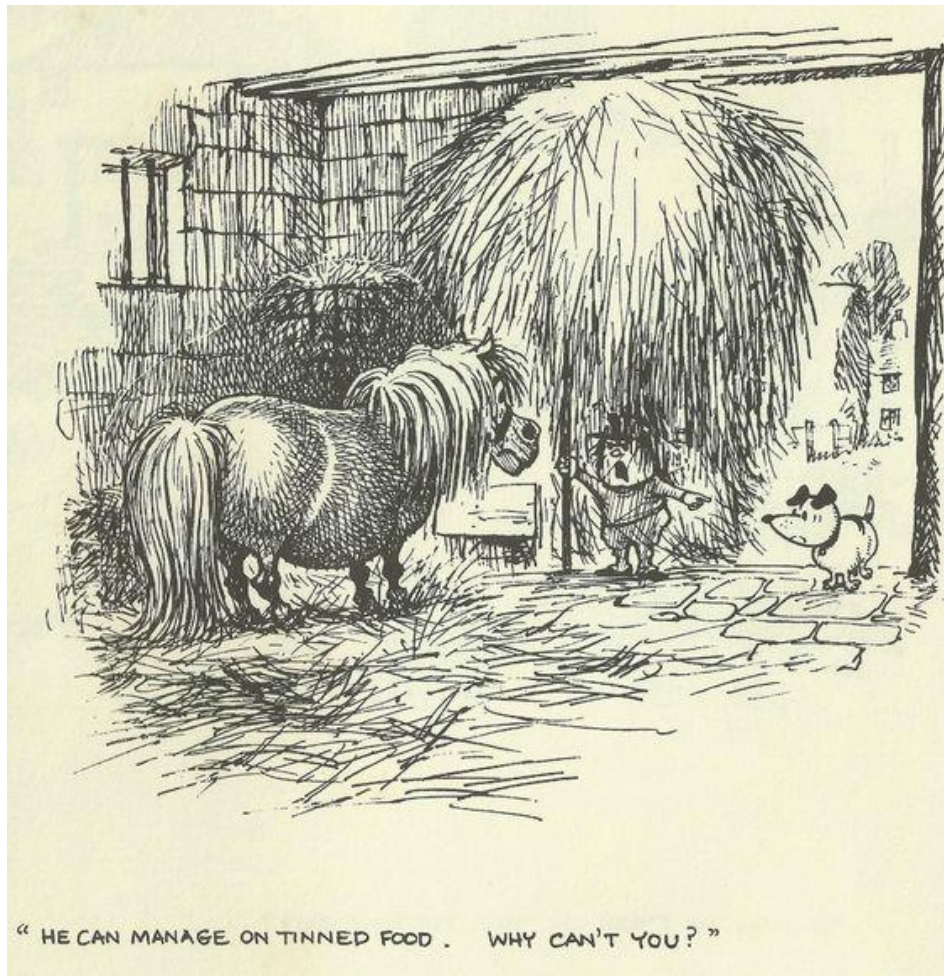


A literature review on welfare improvement possibilities in equine housing systems



Cartoon by Norman Thelwell

Writing assignment for Master's Degree Environmental Biology * Animal Ecology

6 November 2022

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Abstract

The present literature review provides an overview of welfare improvement possibilities for individually and group housed horses. The three most important equine ethological needs are used to identify why and how housing can be adjusted to be more fitting to a horses' nature. These three needs find their origin in the horse's evolutionary history, and they comprise of foraging, locomotion and social contact. Individual stable box housing remains the most used housing system today even though this type of housing is considered unsuitable for horses. Group housing on the other hand has less drawbacks than solitary housing. To remedy equine welfare in individual housing, several adjustments to the husbandry and environment are suggested. Welfare improvement possibilities were identified by performing a structured literature review. Environmental enrichment through the addition of toys in the stable environment only has a limited effect on equine welfare. Providing several types of high quality, low energy roughage forage of a suitable amount has more potential in aiding a horse in fulfilling the need to forage. To help a horse fulfil the need for locomotion, daily free exercise and daily forced exercise are recommended. However, more research is needed how much locomotion is minimally needed to truly fulfil this need. The same goes for social contact. It is not known how much social contact is needed minimally for a horse to reach a state of good welfare. Placing grill bars, mirrors and providing sightlines to other horses are proposed to enable a horse to have more social contact. Opening a window in the stable wall on the other hand is not in the interest of improving equine welfare. Musical enrichment, although not fitting to one of the above-named ethological needs, also shows promising effects on equine welfare. However, more research into this type of enrichment is necessary.

Layman summary

Welzijn van dieren die wij als mens houden is in de laatste jaren steeds een belangrijker punt van discussie in de maatschappij en de wetenschap. Deze literatuurstudie focust op het identificeren van mogelijkheden om welzijn van paarden die gehuisvest zijn in individuele stallen of in groepsverband te verbeteren. Paarden zijn in de loop van de evolutie aangepast aan een leven in een sociale groep, levend van voedsel met een laag energie- en hoog vezelgehalte. Afhankelijk van de kwaliteit van het voedsel leggen wilde paarden grote afstanden af om aan voldoende energie te komen. Gedomesticeerde paarden hebben nog steeds dezelfde behoeftes als wilde paarden. Daarom zijn de belangrijkste natuurlijke behoeftes van het gedomesticeerde paard: sociaal contact, bewegen, en ruwvoer zoeken/eten. Individuele huisvesting van paarden kan beperkend zijn op deze 3 vlakken. Groepshuisvesting heeft meer potentie om te voldoen aan de 3 behoeftes, alhoewel het verschilt per groepshuisvesting of er ook daadwerkelijk aan wordt voldaan. Verrijking in de vorm het plaatsen van speelgoed en objecten in stallen heeft maar een beperkt effect op het welzijn van paarden. Het voeren van een goede kwaliteit en gepaste kwantiteit ruwvoer aan de andere kant, heeft meer potentie om een paard te helpen om in zijn behoefte van ruwvoer te voorzien en zo welzijn te verbeteren. De beste methode om een paard dit aan te bieden is via een slow-feeder. Wanneer een paard geen of niet genoeg ruwvoer mag eten is de tweede beste optie het aanbieden van een speelgoed object met een eetbare factor. Met het type vloerbedekking in stallen kan ook welzijns winst behaald worden. Stro is het geschiktst gebleken om paarden te helpen in hun behoefte te voorzien. Om paarden genoeg te laten bewegen is het aan te raden om een paard dat op stal staat elke dag vrij en gedwongen te laten bewegen. Het is echter nog niet bekend hoeveel beweging nou echt minimaal nodig is om aan de behoefte van bewegen te voldoen. Ook groepshuisvestings systemen die over een beperkt oppervlak beschikken kunnen op zo een manier verbeterd worden dat paarden gestimuleerd worden om veel te bewegen. Dit kan worden bereikt door de ruimte op te delen in gebieden met elke een eigen functie. Om aan de sociale behoefte van een paard die gestald is in een individuele box te voldoen kan men tralies installeren in plaats van solide muren. Het plaatsen van een spiegel in de stal heeft ook de potentie om het welzijn van een paard te verbeteren. Ook heeft het al zin om een ander paard in het gezichtsveld te zetten. Het is nog niet bekend hoe veel sociaal contact een paard minimaal nodig heeft. Muziek kan ook worden gebruikt als een vorm van verrijking, alhoewel muziek niet valt binnen een van de drie basis behoeftes van het paard. Toekomstig onderzoek moet zich vooral focussen op wat er minimaal nodig is aan social contact en beweging om een paard in zich in een goede staat van welzijn te laten bevinden.

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Introduction

In recent years there has been an increasing focus on equine welfare in relation to housing (1, 2). Welfare can be defined as a state of physical and mental wellbeing that is linked to the animal's ability to successfully cope with environmental stressors (3). In this review, equine welfare will be considered from the perspective of the behavioural welfare approach. The behavioural approach to welfare states that an animal should be: i. able to live according to its nature and ii. perform the behaviours fitting to its species without deprivation or aversion (4, 5).

Ethological needs are an important factor when considering animal welfare with respect to living according to an animal's nature (3, 6). Species-specific needs, required for reaching a positive state of welfare, can be categorized as environmental, physiological and behavioural. These needs find their origin in a species evolutionary development (3, 6). The impossibility to satisfy these needs can cause welfare impairments and behavioural problems (3). Foraging, social contact, and locomotion opportunities are considered the three most important equine ethological needs (6). Horses are flight animals that have evolutionarily adapted to live in widely foraging social groups, living off of large quantities of energy-poor roughage for which they developed a hindgut fermentation system during evolution (7). Domestication does not appear to have affected the basic behavioural patterns of horses (1, 7-12). Domestic horses that become feral still show both the same social organisation as that of wild horses (13, 14) as well as similar use of large home ranges, ranging from 0.8 to 303 km² depending on food quality and quantity (7, 13). Stallions are either a dominant male with a group of mares and their offspring, or they form a band of bachelor stallions (15). Only very seldomly do they live in social isolation. Locomotion, social contact, and foraging opportunities are therefore considered the three most important equine ethological needs (6). It is therefore not surprising that design of stables and the opportunity for social interactions, feeding regimes and pasture/paddock regimes have been found to influence domestic equine welfare since these factors directly influence the ability to fulfil natural equine ethological needs (16, 17).

Horses can either be kept solitarily in a stable box with paddock or pasture access, or in a pasture or paddock 24 hours per day. However, 75% of all horses in Western Europe are kept in an individual stable box for at least 18 hours per day (18-20). This housing system primarily focuses on the provision of a clean, safe, and cost-efficient system (21). Several studies however, have found this type of housing inappropriate to meet the three aforementioned basic ethological needs (22-25). For instance an individual stable box can be socially and locomotory restrictive when the stable does not allow for any social contact or free locomotion (23, 24, 26). It is therefore not surprising that individual stable box housing is a known factor in eliciting behaviours linked to lowered welfare, including repetitive and abnormal behaviours such as stereotypies (25, 27, 28).

Horses can also be kept in various types of group housing, such as indoor group housing, with or without access to pasture or paddock, or in a permanent outdoor group system. It is also possible for horses to be kept in a group in pasture or paddock during the day and housed in an individual stable box at night (29). Group housed horses are often kept in homogeneous clusters in terms of sex and age to lower risks of injury from play or aggressive interactions (30). Group housing gives horses more opportunity for social contact compared to individual housing (19). It is therefore stipulated that group housing, with sufficient locomotion opportunities and with *ad libitum* forage opportunity is the optimal housing condition (31). All three ethological needs then have the potential of being fulfilled (19).

Horse caretakers' ignorance of ethological needs may be a factor responsible for non-optimal equine welfare. Misinterpretation or knowledge gaps of equine-welfare-related behaviours are suggested as a reason for poor judgment on actual welfare (32). Owners may make well-intentioned efforts to improve welfare, but the knowledge or tools used may be insufficient (32, 33). Also, views of and attitudes toward equine welfare impact willingness to prioritize welfare (1). For instance, despite

group housing being considered the best housing type to fulfil the basic need of social contact with conspecifics, many horse owners remain hesitant to house their horses in a group (19, 20, 34, 35). Injury prevention and owner convenience are two of the main reasons many horse owners prefer the individual stable box (16, 19). However, owners might overestimate the actual danger posed by group housing. For instance, injuries inflicted by new groupmates after being introduced into group housing have been found to be mostly minor (36). Additionally, 80% of agonistic behaviours after introduction to a group have shown to be non-physical threats (30). Other concerns to horses housed in social groups relate to difficulties with feeding-routines, resting-times, and herd stability after introduction of new group members (19). Additionally, many horse owners believe that their horse does not need free movement and that stable box rest is necessary to rebuild and save energy for work (37). Moreover, the costs of housing horses in pastures can also be an argument for individual stable box housing (35). On the other hand, horse owners were found to be willing to pay 31.9% more to house their horse if so doing would improve their horse's welfare (1). Therefore, it might be difficult, but not impossible to change people's mindsets and stimulate them to improve existing housing conditions.

The aim of this literature review is to identify welfare improvement possibilities in equine housing systems in the context of the three fundamental ethological needs of horses. First, we discuss how equine welfare is measured followed by identification of welfare improvement possibilities. Next, the outcome of the results is discussed. Finally, suggestions for future research are made. It is expected that there are several options for both individual as for group housing that can improve equine welfare while keeping the three basic equine ethological needs in mind.

Methods

A structured literature search was performed in March 2022 using the database of Scopus and Google Scholar, by entering the keywords horse, equine, welfare, housing, housing systems, ethological needs, behavioural needs, stereotypies, improvement, stallions, and enrichment. For full oversight of search terms, see table 1, in the appendix. Also, the forward snowballing technique was applied when read papers provided information that could be of interest. Articles found by this technique were searched with Google Scholar. The combined use of Scopus and Google Scholar, ensured a broad selection of relevant studies. All index subcategories were engaged, and no date restrictions were imposed. In both databases, the search priority tab was set on relevance. Studies were eligible for inclusion if they focused on equine housing in relation to equine welfare, ethological needs of horses or enrichment for horses. Publications' titles and abstracts were first examined for relevance to this literature review. The search was limited to papers written in English, and only peer-reviewed papers were included.

Results

Measuring welfare

Behavioural and physical cues and measurements can be useful when measuring equine welfare (38-40). When welfare is not optimal, a horse can express behaviours that are indicative of lowered welfare (6, 41). For instance, alert standing and vigilance behaviour can be indicators or chronic of acute stress (40). Unresponsiveness to the environment and heightened aggression to humans can also be indicators of compromised welfare (42, 43). Food ingestion and lateral recumbency, on the other hand, are associated with good welfare (8)

When welfare is compromised for a longer amount of time, abnormal, repetitive, and stereotypic behaviours can develop; behaviours that are apparently functionless, detrimental and invariant (24, 28, 44, 45). These behaviours are a signal that a horse is (or was) living in a suboptimal environment and these behaviours have been linked with chronic stress and repeated bouts of frustration, and thus a lowered state of welfare (46). However, while the absence of stereotypical behaviours does not

necessarily imply good welfare, stereotypical behaviours have not been observed in horses in the wild, though they are often observed in housing situations where the three basic equine ethological needs are not met (47-49). Consequently, good welfare can be achieved by fulfilling the three basic ethological needs, and welfare can be predicted by the presence or absence of one or more of these needs in a horse's environment (6). In the next paragraphs, the three basic equine ethological needs, specific welfare indicators and their connection to individual and group housing are discussed.

The three equine basic Ethological needs

Foraging opportunities play a role in both individual as well as group housing (50). The horse has biologically adapted for continuous grazing for up to 18 hours per day on energy low roughage during evolution (51-53). An adult horse, fed *ad libitum*, will consume one to two percent of its body weight in daily forage. Therefore, it is advised to feed a horse *ad libitum* forage or let forage take up at least 50% of the diet (54). Feeding horses only concentrated food and providing limited access to foraging opportunities can therefore be problematic on a physical and a psychological level for the hindgut fermenting horse (8, 55). For instance, low forage diets can cause the development of gastric ulcers (56). On the other hand, the type, quantity, and quality of forage is of importance. For instance, forage only composed of straw can lead to impaction colic (53). Also, feeding *ad libitum* forage can result in horse obesity and this can lead to equine metabolic syndrome and laminitis (57).

Free locomotion is also an important ethological need (58). Horses housed in open barns with adjacent paddock access walk an average of 1.2 km per day in contrast to only 0.17 km per day for horses housed continuously in individual stables. These results signify that an individual stable box can limit the opportunity for locomotion significantly (23, 24, 26). However, it is important to distinguish between free locomotion (pasture or paddock) and forced exercise (riding, walker, pulling). Even though forced exercise reduces motivation for activity and movement, this does not necessarily mean that the horse does not have a need for additional free exercise (59). It is not known how much time a day a horse should minimally have access to free locomotion. It can be determined, however, if a certain free locomotion regime leads to more exercise and to less stereotypical behaviour (24). For instance, it is known that 39 to 63 minutes of paddock release per day is sufficient to elevate oxytocin levels and decrease stereotypical behaviours during a paddock session. However, when the paddock session stops, the welfare indicators rapidly return to base level (58).

Social contact is also one of the most important equine ethological needs (9, 10, 60). In individual stables, however, the opportunity for social contact depends on the stable design (61). Group housing on the other hand provides horses with *ad libitum* social contact. Horses housed in a social group show a higher state of welfare by showing more active locomotion behaviour, spend more time eating, and spend less time standing passively than horses housed in an individual stable (19). Additional proof that Group-housed horses have a state of better welfare than individually housed horses can be found in the fact that group housed horses have lower eye temperatures than horses housed with limited or no social contact opportunities. Low eye temperature indicates lower stress levels, and consequently higher welfare levels (62). Additionally, social grooming can occur in group housing and this behaviour lowers the heart rate, and a lower heart rate is also associated with better welfare (11). Moreover, horses housed in pastures or paddocks in groups display more behaviours correlated with positive welfare than horses housed in individual paddocks or pastures (59). The benefit of housing a horse in a paddock or a pasture can be enhanced by grouping multiple horses together in the paddock or pasture, which simultaneously combines the benefits of free locomotion and social contact. Although, it is not known exactly how much social contact is sufficient for a horse, it can be determined which environmental changes can lead to more opportunity for a horse to fulfil the social ethological need (6).

As a concluding remark, group housing has the advantage of providing more social contact and more locomotion opportunity. In both housing types, a suitable quality and quantity of roughage can be fed to fulfil the need for foraging (8). In the next paragraphs, possibilities are discussed that can be implemented to improve equine welfare. Per ethological need, the welfare improvement possibilities are discussed for both individual as well as group housing.

Welfare improvement possibilities

When looking to improve welfare, environmental enrichment is often the first option proposed to enhance animal welfare. Environmental enrichment is typically associated with changes to the content and structure of the animal's environment, and it can reduce or eliminate stereotypical behaviours (48). It is a known promotor of cognitive functionality and emotional well-being. Research revealed that fearfulness, sensory sensitivity, reactivity to humans, learning ability, and general levels of curiosity are positively influenced when housed with environmental enrichment (63). However, to have a positive effect, the enrichment must play into the animal's species-specific ethological needs (64).

Fulfilling foraging

Toys as environmental enrichment

Numerous toys designed for environmental enrichment, that can be hung or placed in a stable box, are available on the commercial market (50). This type of environmental enrichment can especially provide a level of satisfaction for foraging (50). A feeding ball filled with pellets, for instance, keeps a horse occupied for long periods, and might aid in fulfilling the foraging ethological need. Such a ball allows small pieces of food to fall out when a horse pushes it, and this movement mimics the horse's natural foraging movements (50).

To discriminate between the effect of objects with and without food and regular straw forage, preference for items containing food versus not containing food versus straw(roughage) was tested. It was concluded that horses housed in individual stable boxes and those housed in groups both perform the most item-directed behaviours to the items containing an edible aspect. However, it was uncovered that straw is preferred above an enrichment object with and without food. Moreover, in the same study it was found that straw reduces the amount of agonistic behaviours in group-housed horses (65).

Furthermore, expression of stereotypical behaviour can be reduced by using a feeding ball. Placing a for equids designed ball, the Equiball™, in the stable of an individually stabled horse can reduce stereotypic behaviour during the periods that the ball is present in the stable. This ball can be filled with food pellets that are dispensed as the horse pushes it around. However, this Equiball™ does not elicit a significant effect but only a trend in stereotypical behaviour reduction (66). Also, when 4 other commercially available environmental enrichment toys were tested, only one of the investigated environmental enrichment toys significantly reduced stereotypical behaviour: a sphere with sugar and gelatine inside, known on the commercial market as the Likit Tongue twister®. A feeding ball, (Snak-a-Ball®), regular Likit®, and a sweet object hanging from the ceiling (Boredom Breaker®) did not exhibit any effects on stereotypical behaviour (67).

Not only commercial toys can be implemented in housing. The effect of homemade enrichment objects without food on the behaviour of individually stabled horses was also studied. For instance, a plastic PET bottle filled with sand and a rope were placed in a stable box for one week. Stallions and younger horses were found to interact significantly more with the objects than mares, geldings, and older horses. Most interactions occurred when there was no roughage in the stable box, and the frequency of interactions with both rope and bottle did not reduce after a week. However, the used objects

aroused only limited interest. When no hay was available in the individual stable box, more biting behaviour was observed. This finding might be explained by the need for oral activity (68). When testing long-term interest in Jolly Balls® and ropes, item-related behaviour was more present when straw bedding was unclean. The Jolly Ball® maintained the horse's interest for a longer period than the rope. The rope was no longer interesting to the horses after two weeks, while the Jolly Ball® continued to elicit interest (68).

The impact of roughage forage

There are alternatives to environmental enrichment toys to satisfy the foraging need when pasture access is not available (61). Feeding *ad libitum* hay (roughage forage) with a high fibre content, for instance, can help accommodate a horse in the foraging need ((10, 35). Also, in group housing that does not provide horses with sufficient grazing opportunity, the foraging needs of horses can be more fulfilled with providing roughage. This was tested by allowing horses in a bare group paddock for six hours a day with *ad libitum* and without *ad libitum* hay. The horses with the *ad libitum* hay spent more time feeding and less time moving, alert standing, and stand resting. Moreover, the horses showed more social bonding behaviour, more social interactive behaviour, and less aggression than horses who were in a bare paddock without foraging opportunity. To conclude, giving group housed horses the opportunity to forage on *ad libitum* hay benefits their welfare (8).

The type of foraging material, for instance hay or straw, is of importance on foraging behaviour. This was studied by providing stabled horses with a single forage (hay) diet or with a multiple forage diet (six types of commercially available roughages, three with long and three with short-chopped fibres). The multiple forage fed horses performed significantly more and exhibited more frequent foraging behaviours than horses fed only hay. Additionally, no stereotypes were performed when provided with multiple forage types, whereas the single forage fed horses did show stereotypical behaviours (53). These findings suggest that providing horses with multiple forage types instead of only hay can satisfy the need to forage more. Moreover, offering low-energy forage in higher amounts limits the risk of abnormal behaviour (69). Additional support that providing enough roughage is beneficial for equine welfare can be observed by the fact that the expression of abnormal behaviours increases when the amount of rough feed is dropped below 6.8 kilograms per day and decreases when it is given *ad libitum* (28).

Bedding

Horses bedded on straw in their individual stable box, in contrast to horses housed on nonedible bedding (paper shavings or wood pellets), show less stereotypic behaviour. Moreover, a preference test clearly illustrated that individually stabled horses preferred straw bedding over wood shavings and wood shavings over paper bedding (70). Additionally, housing on straw bedding, compared to peat shavings and crushed wood pellets as bedding, reduce negative behaviours like biting neighbouring horses and the bars of the stable box, and behaviours indicating a positive state of wellbeing, such as lying down and occupation with the bedding, are observed more frequently in horses housed on straw bedding (71, 72). Providing individually stabled horses with straw bedding might therefore be beneficial for equine welfare.

Methods to provide roughage

Hay can be placed in a haynet, slowfeeder, or it can be scattered around the floor. The haynet keeps the horse occupied for a longer time than when the hay is placed on the floor (68). However, small-mesh haynets (25-30 mm mesh) keep horses occupied the longest (73). When the effects of haybags, hay placed on the floor and hay-slow-feeders' effects on foraging behaviour, feeding time, undesirable, stereotypical, or frustration behaviours and friendliness toward humans were investigated, results showed that haybags and slow-feeders both increase foraging time compared to hay on the ground. However, haybags increase expression of frustration behaviours while the slow-feeder increases friendliness towards humans and decreases the number of stereotypies displayed by the horses (74).

Impact of feeding moments

It has been suggested that spacing feeding moments over the day mimics the natural feeding pattern of a horse (75). However, it was found that increasing feeding frequencies leads to more stereotypic behaviour but fewer oral stereotypies overall (75). Remarkably, for individually stabled horses that do not have pasture access the likelihood of performing stereotypies is the highest at four feeding times per day while horses fed more or fewer times per day show significantly less stereotypic activity (76).

Fulfilling locomotion

Locomotion in individual stable box housing

To compensate for loss of locomotor opportunity that individually stabled horses experience, regular exercise has been proposed to enhance welfare (77). Providing individually stabled horses with forced exercise for one hour per day is suggested to effectively fulfil a part of the locomotor needs. Namely, one hour of treadmill, walker, turnout in paddock or riding, already decrease unwanted behaviours of individually stabled horses, and all four exercise types decrease locomotor rebound effect during turnout in a large arena. This rebound effect is expressed by a period of more physical activity after a time period where active behaviour was restricted. Additionally, exercising six times a week significantly reduces pre-feeding stereotypies and aggression in individual stabled horses (78).

Moreover, access to a paddock for at least one hour per day next to being ridden for one hour per day also reduces stereotypical behaviour and improves oxytocin levels in the blood (a hormone associated with better welfare) of horses housed in individual stable boxes (60). However, when horses are turned back into their individual stable after their hour in the paddock, stereotypical behaviour expression and oxytocin levels return rapidly to levels from before paddock turnout. When there is limited to no access to pasture or paddock, hand walking and hand grazing are proposed as an alternative (35).

Locomotion in group housing.

In group housing with relatively small surface area where the ability to fulfil the ethological need of locomotion is compromised, the housing structure can be organised to boost locomotor activity by dividing the area into smaller functional spaces. Each area with a different function, such as roughage, resting, concentrated pellet feeding, drinking areas, resting, and larger open areas (19, 79). These types of systems with several functional areas can increase daily walking distance to 4.7 km (79). Electronic feeding stations activated by a chip present on every individual horse can also be a useful tool for providing each horse with a peaceful and safe feeding time and prevent obesity (29). These modifications can help horses housed in groups have a more locomotory active lifestyle.

Fulfilling social contact

Adjusting the stable

The amount of social contact that a stable allows affects frequency and type of stereotypical behaviour expressed (80). Visual/nose-to-nose/olfactory contact with other neighbours diminishes the risk of vigilance and stereotypical behaviours and increases behaviours reflecting positive emotions (76, 81). Optimizing the opportunity for social contact is thus important to optimize equine welfare in individually housed horses. In individual housing there are multiple options to provide horses with more social contact opportunity (61). Adjusting the amount of openness (visual horizon) of the stable is an option to accommodate social contact (81, 82). The placement of grill bars between stables instead of solid walls is therefore suggested. For instance, horses housed in individual stables with grill bars but with no opening to put a head through, spent more time foraging and resting (81). Additionally, weaving (a common stereotype that is considered to reflect social frustration in stabled horses (81)) is decreased when horses have the opportunity to interact with a neighbour through grill

bars on the front and the side of the stable box, and weaving ceases entirely when all four sides are grill bars (81). However, allowing only visual contact with another horse in the housing situation already reduces the risk of developing stereotypical behaviours (28, 81).

Instead of grill bars, placing a window where a horse can put its head through in individual stable boxes has been suggested by several authors (61, 83). Increasing the visual horizon by providing individually housed horses with a window opening toward the external environment can lead to the expression of less aggressive behaviour (61). On the other hand, providing a view to the outdoors by placing a window can also lead to increased vigilance (81) and to the increased expression of stereotypies (24).

Individual housing and the impact of mirrors

Moreover, several environmental enrichment options besides architectural changes are suggested to remedy impaired social contact opportunities for horses housed in individual stable boxes (84). Using mirrors is one enrichment method proposed to artificially increase the opportunity for social contact (81, 85, 86). When these mirrors are placed in view of horses, they can reduce stereotypies (86). For instance, when six horses that were known weavers, were exposed three times a day for five consecutive days to three different stable designs: a conventional stable box, a conventional stable box with a one-square meter mirror, and a conventional stable box with a grilled one square meter looking out on a non-weaving horse, stereotypic behaviours and especially weaving was observed significantly less in the stables with windows or grill bars. There was no significant difference in stereotype expression between the window and mirror stable (85).

When determining whether reduced weaving via introduction of a mirror occurs because of the reflected image of a horse or because of another influence associated with the mirror it was found that horses react to the image of another horse and not because of the novel object (i.e., the mirror) that is placed in the stable. This was investigated by recording the responses of six known weavers to three types of posters. The posters depicted a full-size image of a horse's front with the difference between the posters being as follows: the true image, the same image cut into 54 randomised pixelated squares, and a blank poster of the same size as the rest of the posters. Weaving was more significantly reduced in the horses given the horse front poster than in the horses given the white and pixelated image. However, the image of the horse's front was associated with heightened alertness and with longer time spent looking at the posters (86).

On another note, the sound of music

Auditory enrichment may be a low-cost and effective form of enrichment and could serve to stimulate equine welfare (87). Even though this type of enrichment does not truly fit into a category of one of the three basic ethological needs of horses, the positive effect it can bring makes it worthwhile to consider. Several studies focused especially on the effect of music (87-91). When exposing individually stabled horses to classical music for five hours per day, alert standing and frequency of food ingestion were positively affected. When music playing time increased, the frequency of food ingestion also increased and the amount of time spent alert standing was significantly lower after a daily period of music. Moreover, stereotype expression was reduced during the playing of classical music (90).

However, it is important to note that different types of music affect horses differently. When individually stabled horses are exposed to four types of music -rock, country, classical and jazz music-, none caused significant differences in behavioural responses. However, jazz music tended to decrease and country music to increase eating behaviour (88). Additionally, there is a significant association between negative state behaviours, such as less time spent resting, eating, and ears being held alert, and jazz and rock music. Classical and country music with a slow tempo and a major key resulted in

more positively associated behaviours like resting, eating, and ears being held in a relaxed position (89).

Moreover, music positively effects the emotional state and race performances of individually stabled race horses, with horses that were exposed to a music treatment performing better in races and having a lower heartrate and HRV (also a heart parameter) (87). This lowered heartbeat and HVR are suggested to correlate with a more positive emotional state. However, the effect of music becomes less pronounced after three months of treatment. Also, the music in this study was specifically composed for horses. The New Age genre soundtracks had a low sound frequency (200 Hz – 12 KHz) with the intention to soothe the horses.

On another note, playing classical music for horses housed in individual stable boxes has effect on nocturnal behavioural time budgets, with more nightly roughage intake when exposed to music at night (92). A significant increase in lateral recumbency, a behaviour considered a positive indicator for equine wellbeing, can also be noticed when playing classical music at night (92). And lastly, music decreases salivary cortisol levels in racehorses. A lowered salivary cortisol level has shown to correspond with a lower stress level (93).

Discussion

Equine welfare in individual and group housing has become increasingly important over the recent years (1). The aim of the present review was to identify welfare improvement possibilities in equine housing systems by first considering how equine welfare is measured and then by viewing the basic ethological needs of horses with respect to individual and group housing. For all three ethological needs, several options have been found to improve equine welfare. The results demonstrate that environmental enrichment, roughage management and adaptations to the housing design are suitable to improve equine welfare. Below, the results are discussed more extensively.

Foraging

Ad libitum forage is recommended in both individual as well as group housing (8, 54, 75). However, if *ad libitum* forage is unsuitable due to metabolic reasons, then there are several options to stimulate the horse's foraging need in other ways. Enrichment toys were suggested as an alternative. However, straw was found to be preferred above an enrichment object with and without food (65). This finding suggests that providing straw is more suitable for fulfilling the foraging need, than an enrichment toy with and without food, but if providing straw is not an option, than providing an object with an edible aspect is the next best choice. Therefore, if pasture foraging is not available to individually or group housed horses, then roughage forage supplementation is the preferred enrichment to fulfil the foraging need.

When one does need to choose an enrichment toy, the preference goes to a toy with an edible aspect. For instance, the Equiball™'. However, because this ball did not elicit a significant effect but only a trend in stereotypical behaviour reduction, it is suggested using the Equiball™' in conjunction with other environmental enrichment methods to enhance and combine positive effects (66). Moreover, because other commercially enrichment objects and homemade enrichment objects also only aroused limited interest and did not exhibit any effects on stereotypical behaviour, they likely provide only limited enriching effect for the foraging need (67). The welfare enhancing capacity of this type of enrichment can therefore be questioned. For future research it would be interesting to study the effects of combinations of enrichment objects.

An interesting factor that affects interest in toys is the level of cleanliness of the bedding (94). Clean roughage availability in the stable box decreases object interest and decreases biting behaviour, suggesting that the need to forage and the need for oral activity are both stimulated by roughage. Additionally, duration of interest was found to be dependent on the item. In the study where interest

in a Jolly Ball® and a rope was compared, the Jolly Ball® was still interesting after two weeks, and the rope was not. The researchers suggest that the limited interest in the two objects might be because there always was an abundance of forage present, or because of the method of presentation of the enrichment (hanging from the ceiling). To explore long-term interest in enrichment objects, effect of enrichment presentation, and differences of the effect of enrichment toys on horses in stables and horses housed in groups more extensive research is necessary. However, providing a horse with sufficient clean bedding material that can be foraged is more efficient than providing a horse with an enrichment object.

A fact to be noted is that stereotypical behaviour expression in individual stabled horses increases when bedding is any material other than straw (28). However, *ad libitum* straw can lead to colon impaction and can therefore be unsuitable for some horses (53). The effect of a combination of non-edible bedding with an addition of limited amount of straw would therefore be interesting to study in the future.

When it comes to the method of roughage provision, a slow feeder has the most welfare benefits compared to haybags and hay placed on the ground (74). This knowledge can be implemented in both individual as in group housing that has no pasture foraging opportunity. For feeding moments it is still not known what the best amount of feeding moments per day is. However, for individual housing it was found that feeding four times per day heightens the risk for stereotypical behaviour expression and is therefore the least beneficial amount of feeding moments per day (76). Feeding 4 times per day should therefore be avoided. More research needs to be conducted to identify how many feeding times per day are optimal.

Locomotion

Individual stable box housing deprives horses of free movement (58). To improve equine welfare, it is therefore presumed that a horse should have access to free movement (24). It is still not known however, how much free movement per week or day is enough (58). On the other hand, forced movement was found to have a positive effect on reducing stereotypical behaviour expression, aggression and locomotor rebound effect (78). This, next to the fact that stereotypical behaviour expression and oxytocin levels return rapidly to base levels after a daily one hour session of free movement, leads to the question if free locomotion is truly the only option to enable a horse in fulfilling this ethological need (60). The positive effect of exercise could also be due to the study treatment being a 100% improvement of locomotion, since control groups have no locomotion treatment. Perhaps a combination of daily forced exercise with a daily session of free movement is therefore an option to enhance equine welfare of horses individually stabled. More research that investigates this combination is needed. Moreover, hand walking individual stabled horses was proposed (35). However, the effects of hand walking have not yet been studied. In conclusion, for the time being it can be recommended to give individually stabled horses at least a minimum of one-hour free movement and one hour of forced exercise per day to provide them with locomotor opportunity. It is, however, not yet known if this truly is enough locomotion to satisfy the ethological need for locomotion.

Group housing is considered more accommodating to the ethological need of locomotion (24). Within group housing, however, there are differences of spatial opportunities for locomotion, depending on the group housing type (29). It was found here that locomotion can be boosted by dividing the group housing into functional areas (19, 79). However, the study that this result is based upon only used two active stable designs in comparison to 3 regular group housing systems. Only between two stables a significant effect was found on overall locomotion behaviour. This, and the fact that it is still not clear what difference between stable designs the increased locomotion can be attributed to, makes more research into active stables crucial. In the future, only one parameter should be changed at a time in an experimental setup with a larger sample size and using the same horses in every setup (79).

Social contact

Especially for individual housing it is important to provide horses with opportunities to fulfil the ethological need for social contact, even though it is not known how much social contact is minimally needed for good welfare (24, 26). Replacing solid walls with grill bars has a positive effect on stereotype expression. This effect can be due to more social contact. However, the effect on stereotypical behaviour can also be due to more environmental interaction and not only due to social interaction that therefore creates competition with stereotypic behaviour. It is also possible that bars may allow environmental monitoring as well as social interaction. Further research can focus on discrimination between these two. Additionally, the effect can also be due to the novelty of the environment, even though no effect of time was witnessed in the study (81).

Opening a window in the individual stable wall on the other hand was found to have fewer positive effects on equine welfare even though it decreases aggressive behaviours (61). Namely, it was also found that a window leads to increased vigilance and expression of stereotypies (81, 82). In stables with grill bars instead of a window, horses spent more time resting and foraging (82). It is suggested that the outdoor view induces frustration and agitation for the horse that sees the surroundings but cannot interact with them (82). Another reason that could explain the increased weaving in stables with a window is that the weaving movement with the head above the door is easier for the horse in a stable with a window. Opening a window to the environment can therefore not be recommended.

Providing a horse with a visual sightline, on the other hand, was found to reduce stereotypical behaviour (28, 81). Providing a horse with a visual sightline to another horse might therefore already be an improvement over a situation where a horse can have no physical contact with other horses (for instance during quarantine). This method can be interesting for housing horses that are to be prevented of making physical contact, as for instance is the case in isolation for medical reasons.

Another method that can be interesting for the same reason, is placing mirrors in individual stable boxes since this can reduce the expression of stereotypies (85). It is suggested that horses feel less isolated by seeing another horse. However, the effect of the mirror can also be due to the distraction it provides from the otherwise non-social environment or because of the increased horizon. Also, when a comparison of effects is made between a blank poster and a picture of a horse, the picture of the horse front was associated with heightened alertness and vigilance (86). These behaviours can be indicators of acute stress, and therefore the positive effect of a poster can be questioned (95). In conclusion, placing a mirror in the view of an individually stabled horse can benefit its welfare. More research should be conducted to compare the effect of mirrors, posters and windows. Especially a comparison between the effect of a mirror and a poster would be interesting.

Even though music does not necessarily improve social contact in individually housed horses, it can still improve equine welfare (87-91). However, it is not known for how long and with what intervals music should be played to have an optimal effect on welfare, even though music can improve welfare within a short period of time (96). The effects of music should be analysed with more studies of a larger sample size and in varying housing systems. Lastly, there was no literature found about horse-made sounds being used as enrichment. Playing horse-made sounds might stimulate a horse's social contact need. Therefore, future research investigating if, and how horse-made sounds can enrich the environment of individually stabled horses is required.

Overall, several of the studies discussed, measure welfare only or mostly in terms of stereotypy expression. However, taking a single behavioural parameter into account is not advisable when measuring welfare (97). Also, it remains debatable if a display of stereotypical behaviours signifies that a horse is still in a situation where it is suffering. Stereotypical behaviours tend to stay in an animal's behavioural repertoire once they appear, even when the environment improves and is no longer challenging to welfare (28). Additionally, several studies were based on surveys filled in by horse owners. It is likely that the welfare indicators used in those studies are under- or overestimated by respondents since horse owners have a positive bias when it comes to judging their horse's welfare

(32, 61). Moreover, it is unlikely that all relevant studies focussing on the improvement of equine welfare were found. Therefore, this literature review should not be seen as a complete guide to improving equine welfare, but as an overview of several relevant welfare improvement directions.

Conclusion

The aim of this literature review was to identify welfare improvement possibilities for equine housing systems. The present review showed that solitary housing is typically not accommodating to the three basic ethological needs of horses. The drawbacks of individual housing can be remedied by several adjustments in the husbandry and environment that seem to assist in fulfilling the needs. Group housing has the potential to fulfil in the needs. However, when group housing is not optimal to fulfil in the ethological needs, several of the proposed remedies for individual housing, can also be implemented in group housing. Therefore, more suitable housing conditions for both individual as group housed horses can be reached based on the welfare improvement options discussed in this literature review.

The most important finding is that environmental enrichment in the form of toys only has a limited effect on equine welfare. Instead, for both individual and group housing it is advisable to provide several types of high quality, low energy roughage forage of a suitable amount. The most welfare benefitting method of presenting this forage is through a slow-feeder. However, when roughage forage is not possible, the preference goes to an enrichment toy with an edible aspect. Additionally, for individual housing bedding of straw is advised. To fulfil in the ethological need of locomotion, free movement is recommended for individually housed horses, though it is not known how much free movement is necessary for optimal welfare. Next to free movement, forced exercise can be helpful to fulfil a part of the locomotion need. For group housed horses in a system that does not have a large surface area, adjusting the space to functional areas can boost locomotor activity. To give individually stabled horses more opportunity for social contact, installing grill bar walls instead of solid walls is advised. However, opening a window in the stable wall is not advisable. Placing a mirror or creating a sightline to another horse on the other hand are both options that can be beneficial for horse welfare. Lastly, musical enrichment can be implemented in individual stable box housing. However, more research is needed to identify the optimal treatment regime and music type. Future research should also focus on identifying the minimal amount of free movement per day, and the minimal amount of social contact that is needed for optimal equine welfare.

References

1. Beer L, Beulke C, Theuvsen L, Heise H. Animal-friendly horse husbandry: Analysis of factors influencing riders' additional willingness-to-pay. *Journal of the Austrian Society of Agricultural Economics*. 2019;28:121-5.
2. Drittler L, Heise H, Theuvsen L. Animal welfare in equine keeping: Evaluation and implementability of animal welfare measures. *Zuchtungskunde*. 2017;89(3):219-30.
3. Carenzi C, Verga M. Animal welfare: review of the scientific concept and definition. *Italian Journal of Animal Science*. 2009;8(sup1):21-30.
4. Rollin BE. On telos and genetic engineering. *Animal biotechnology and ethics*. 1998;162.

5. Dawkins MS. Behavioural deprivation: a central problem in animal welfare. *Appl Anim Behav Sci.* 1988;20(3-4):209-25.
6. Krueger K, Esch L, Farmer K, Marr I. Basic needs in horses?—a literature review. *Animals.* 2021;11(6).
7. VanDierendonck MC, Spruijt BM. Coping in groups of domestic horses—Review from a social and neurobiological perspective. *Appl Anim Behav Sci.* 2012;138(3-4):194-202.
8. Benhajali H, Richard-Yris M, Ezzaouia M, Charfi F, Hausberger M. Foraging opportunity: a crucial criterion for horse welfare? *animal.* 2009;3(9):1308-12.
9. Christensen JW, Ladewig J, Søndergaard E, Malmkvist J. Effects of individual versus group stabling on social behaviour in domestic stallions. *Appl Anim Behav Sci.* 2002;75(3):233-48.
10. Cooper JJ, Albentosa MJ. Behavioural adaptation in the domestic horse: potential role of apparently abnormal responses including stereotypic behaviour. *Livest Prod Sci.* 2005;92(2):177-82.
11. Feh C. Alliances and reproductive success in Camargue stallions. *Anim Behav.* 1999;57(3):705-13.
12. Lesimple C, Reverchon-Billot L, Galloux P, Stomp M, Boichot L, Coste C, et al. Free movement: A key for welfare improvement in sport horses? *Appl Anim Behav Sci.* 2020;225:104972.
13. McCort WD. Behavior of feral horses and ponies. *J Anim Sci.* 1984;58(2):493-9.
14. McDonnell SM. Reproductive behavior of stallions and mares: comparison of free-running and domestic in-hand breeding. *Anim Reprod Sci.* 2000;60:211-9.
15. Sarrafchi A, Blokhuis HJ. Equine stereotypic behaviors: Causation, occurrence, and prevention. *J Vet Behav : Clin Appl Res.* 2013;8(5):386-94.
16. Benhajali H, Richard-Yris M, Leroux M, Ezzaouia M, Charfi F, Hausberger M. A note on the time budget and social behaviour of densely housed horses: A case study in Arab breeding mares. *Appl Anim Behav Sci.* 2008;112(1):196-200.
17. Rivera E, Benjamin S, Nielsen B, Shelle J, Zanella AJ. Behavioral and physiological responses of horses to initial training: the comparison between pastured versus stalled horses. *Appl Anim Behav Sci.* 2002;78(2-4):235-52.
18. Christensen JW, Ladewig J, Søndergaard E, Malmkvist J. Effects of individual versus group stabling on social behaviour in domestic stallions. *Appl Anim Behav Sci.* 2002;75(3):233-48.
19. Hartmann E, Søndergaard E, Keeling LJ. Keeping horses in groups: A review. *Appl Anim Behav Sci.* 2012;136(2-4):77-87.

20. Søndergaard E, Ladewig J. Group housing exerts a positive effect on the behaviour of young horses during training. *Appl Anim Behav Sci.* 2004;87(1-2):105-18.
21. Atoji K, de Almeida Oliveira, Ana Alix Mendes, Weary DM. Assessing the impact of housing on the welfare of horses: A Scoping Review Protocol. . 2021.
22. Benhajali H, Richard-Yris M, Ezzaouia M, Charfi F, Hausberger M. Reproductive status and stereotypies in breeding mares: a brief report. *Appl Anim Behav Sci.* 2010;128(1-4):64-8.
23. Heleski CR, Shelle AC, Nielsen BD, Zanella AJ. Influence of housing on weanling horse behavior and subsequent welfare. *Appl Anim Behav Sci.* 2002;78(2-4):291-302.
24. Lesimple C, Poissonnet A, Hausberger M. How to keep your horse safe? An epidemiological study about management practices. *Appl Anim Behav Sci.* 2016;181:105-14.
25. Visser EK, Ellis AD, Van Reenen CG. The effect of two different housing conditions on the welfare of young horses stabled for the first time. *Appl Anim Behav Sci.* 2008;114(3-4):521-33.
26. Cooper JJ, MASON GJ. The identification of abnormal behaviour and behavioural problems in stabled horses and their relationship to horse welfare: a comparative review. *Equine Vet J.* 1998;30(S27):5-9.
27. Cooper J, McGreevy P. Stereotypic behaviour in the stabled horse: causes, effects and prevention without compromising horse welfare. In: *The welfare of horses.* Springer; 2007. p. 99-124.
28. McGreevy PD, Cripps PJ, French NP, Green LE, Nicol CJ. Management factors associated with stereotypic and redirected behaviour in the Thoroughbred horse. *Equine Vet J.* 1995;27(2):86-91.
29. Yarnell K. A life less solitary. *Equine Veterinary Education.* 2016;28(12):659-60.
30. Jørgensen GHM, Borsheim L, Mejdell CM, Søndergaard E, Bøe KE. Grouping horses according to gender—Effects on aggression, spacing and injuries. *Appl Anim Behav Sci.* 2009;120(1):94-9.
31. Winskill L, Waran NK, Channing C, Young R. Stereotypies in the stabled horse: Causes, treatments and prevention. *Curr Sci.* 1995;69(4):310-6.
32. Lesimple C, Hausberger M. How accurate are we at assessing others' well-being? The example of welfare assessment in horses. *Frontiers in psychology.* 2014;5:21.
33. Hemsworth LM, Jongman E, Coleman GJ. Recreational horse welfare: The relationships between recreational horse owner attributes and recreational horse welfare. *Appl Anim Behav Sci.* 2015;165:1-16.
34. Hartmann E, Bøe KE, Christensen JW, Hyypä S, Jansson H, Jørgensen G, et al. A Nordic survey of management practices and owners' attitudes towards keeping horses in groups. *J Anim Sci.* 2015;93(9):4564-74.

35. Henderson AJ. Don't fence me in: managing psychological well being for elite performance horses. *Journal of Applied Animal Welfare Science*. 2007;10(4):309-29.
36. Keeling LJ, Bøe KE, Christensen JW, Hyypä S, Jansson H, Jørgensen GH, et al. Injury incidence, reactivity and ease of handling of horses kept in groups: A matched case control study in four Nordic countries. *Appl Anim Behav Sci*. 2016;185:59-65.
37. Popescu S, Diugan EA, Spinu M. The interrelations of good welfare indicators assessed in working horses and their relationships with the type of work. *Res Vet Sci*. 2014;96(2):406-14.
38. Lesimple C. Indicators of horse welfare: State-of-the-art. *Animals*. 2020;10(2):294.
39. Botreau R, Veissier I, Butterworth A, Bracke MB, Keeling LJ. Definition of criteria for overall assessment of animal welfare. *ANIMAL WELFARE-POTTERS BAR THEN WHEATHAMPSTEAD-*. 2007;16(2):225.
40. Young T, Creighton E, Smith T, Hosie C. A novel scale of behavioural indicators of stress for use with domestic horses. *Appl Anim Behav Sci*. 2012;140(1-2):33-43.
41. Zeeb K, Schnitzer U. Housing and training of horses according to their species-specific behaviour. *Livest Prod Sci*. 1997;49(2):181-9.
42. Fureix C, Jegou P, Henry S, Lansade L, Hausberger M. Towards an ethological animal model of depression? A study on horses. *PloS one*. 2012;7(6):e39280.
43. Rochais C, Henry S, Fureix C, Hausberger M. Investigating attentional processes in depressive-like domestic horses (*Equus caballus*). *Behav Processes*. 2016;124:93-6.
44. Lesimple C, Fureix C, LeScolan N, Richard-Yris M, Hausberger M. Housing conditions and breed are associated with emotionality and cognitive abilities in riding school horses. *Appl Anim Behav Sci*. 2011;129(2-4):92-9.
45. Mills DS, Clarke A. Housing, management and welfare. In: *The welfare of horses*. Springer; 2007. p. 77-97.
46. Benhajali H, Ezzaouia M, Lunel C, Charfi F, Hausberger M. Stereotypic behaviours and mating success in domestic mares. *Appl Anim Behav Sci*. 2014;153:36-42.
47. Feh C. Relationships and communication in socially. *The domestic horse: The origins, development and management of its behaviour*. 2005:83.
48. Mason G, Clubb R, Latham N, Vickery S. Why and how should we use environmental enrichment to tackle stereotypic behaviour? *Appl Anim Behav Sci*. 2007;102(3-4):163-88.
49. Mason GJ. Stereotypies: a critical review. *Anim Behav*. 1991;41(6):1015-37.
50. Winskill LC, Waran NK, Young RJ. The effect of a foraging device (a modified 'Edinburgh Football') on the behaviour of the stabled horse. *Appl Anim Behav Sci*. 1996;48(1-2):25-35.

51. Goodwin D. The importance of ethology in understanding the behaviour of the horse. *Equine Vet J.* 1999;31(S28):15-9.
52. Goodwin D. Horse behaviour: evolution, domestication and feralisation. In: *The welfare of horses.* Springer; 2007. p. 1-18.
53. Thorne JB, Goodwin D, Kennedy MJ, Davidson H, Harris P. Foraging enrichment for individually housed horses: Practicality and effects on behaviour. *Appl Anim Behav Sci.* 2005;94(1-2):149-64.
54. Evans P, McKendrick S. *Equine Nutrition: Forages.* . 2010.
55. Houpt KA, McDonnell SM. Equine stereotypies. *Comp Cont Educ Pract Vet.* 1993;15(9):1265-71.
56. Andrews FM, NADEAU JA. Clinical syndromes of gastric ulceration in foals and mature horses. *Equine Vet J.* 1999;31(S29):30-3.
57. Chapman SJ. Obesity and the health and welfare of the leisure horse. *The Veterinary Nurse.* 2014;5(2):94-9.
58. Lesimple C, Reverchon-Billot L, Galloux P, Stomp M, Boichot L, Coste C, et al. Free movement: A key for welfare improvement in sport horses? *Appl Anim Behav Sci.* 2020;225.
59. Jorgensen G, Boe KE. Individual paddocks versus social enclosure for horses. PUBLICATION-EUROPEAN ASSOCIATION FOR ANIMAL PRODUCTION. 2007;122:79.
60. Lesimple C. Indicators of horse welfare: State-of-the-art. *Animals.* 2020;10(2).
61. Ruet A, Lemarchand J, Parias C, Mach N, Moisan M-, Foury A, et al. Housing horses in individual boxes is a challenge with regard to welfare. *Animals.* 2019;9(9).
62. Yarnell K, Hall C, Royle C, Walker SL. Domesticated horses differ in their behavioural and physiological responses to isolated and group housing. *Physiol Behav.* 2015;143:51-7.
63. Lansade L, Valenchon M, Foury A, Neveux C, Lévy F, Moisan M. Enriching a horse's environment not only enables to improve its welfare, but also enables to reduce its emotions and to increase its learning ability, while at the same time promoting the safety of handlers. Équi-meeting Infrastructures, Horas national du Lion d'Angers, France, 6-7 October 2014. *Proceedings; Institut Francais du Cheval et de l'équitation;* 2014.
64. Mason GJ. Age and context affect the stereotypies of caged mink. *Behaviour.* 1993;127(3-4):191-229.
65. Jørgensen GHM, Liestøl SH, Bøe KE. Effects of enrichment items on activity and social interactions in domestic horses (*Equus caballus*). *Appl Anim Behav Sci.* 2011;129(2-4):100-10.

66. Henderson JV, Waran NK. Reducing equine stereotypies using an Equiball™. *Anim. Welfare*. 2001;10(1):73-80.
67. Whisher L, Raum M, Pina L, Pérez L, Erb H, Houpt C, et al. Effects of environmental factors on cribbing activity by horses. *Appl Anim Behav Sci*. 2011;135(1-2):63-9.
68. Bulens A, Van Beirendonck S, Van Thielen J, Driessen B. The enriching effect of non-commercial items in stabled horses. *Appl Anim Behav Sci*. 2013;143(1):46-51.
69. Parker M, Goodwin D, Redhead ES. Survey of breeders' management of horses in Europe, North America and Australia: comparison of factors associated with the development of abnormal behaviour. *Appl Anim Behav Sci*. 2008;114(1-2):206-15.
70. Mills DS, Eckley S, Cooper JJ. Thoroughbred bedding preferences, associated behaviour differences and their implications for equine welfare. *Animal Science*. 2000;70(1):95-106.
71. Kwiatkowska-Stenzel A, Sowińska J, Witkowska D. The effect of different bedding materials used in stable on horses behavior. *Journal of Equine Veterinary Science*. 2016;42:57-66.
72. Werhahn H, Hessel EF, Bachhausen I, Van den Weghe, Herman FA. Effects of different bedding materials on the behavior of horses housed in single stalls. *Journal of equine veterinary science*. 2010;30(8):425-31.
73. Ellis AD, Fell M, Luck K, Gill L, Owen H, Briars H, et al. Effect of forage presentation on feed intake behaviour in stabled horses. *Appl Anim Behav Sci*. 2015;165:88-94.
74. Rochais C, Henry S, Hausberger M. "Hay-bags" and "Slow feeders": Testing their impact on horse behaviour and welfare. *Appl Anim Behav Sci*. 2018;198:52-9.
75. Cooper JJ, Mcall N, Johnson S, Davidson H. The short-term effects of increasing meal frequency on stereotypic behaviour of stabled horses. *Appl Anim Behav Sci*. 2005;90(3-4):351-64.
76. Bachmann I, Audigé L, Stauffacher M. Risk factors associated with behavioural disorders of crib-biting, weaving and box-walking in Swiss horses. *Equine Vet J*. 2003;35(2):158-63.
77. Freire R, Buckley P, Cooper JJ. Effects of different forms of exercise on post inhibitory rebound and unwanted behaviour in stabled horses. *Equine Vet J*. 2009;41(5):487-92.
78. Hockenhull J, Creighton E. Pre-feeding behaviour in UK leisure horses and associated feeding routine risk factors. *Anim Welfare*. 2014;23(3):297-308.
79. Rose-Meierhöfer S, Klaer S, Ammon C, Brunsch R, Hoffmann G. Activity behavior of horses housed in different open barn systems. *Journal of equine veterinary science*. 2010;30(11):624-34.
80. Lesimple C, Gautier E, Benhajali H, Rochais C, Lunel C, Bensaid S, et al. Stall architecture influences horses' behaviour and the prevalence and type of stereotypies. *Appl Anim Behav Sci*. 2019;219.

81. Cooper JJ, McDonald L, Mills DS. The effect of increasing visual horizons on stereotypic weaving: implications for the social housing of stabled horses. *Appl Anim Behav Sci.* 2000;69(1):67-83.
82. Lesimple C, Gautier E, Benhajali H, Rochais C, Lunel C, Bensaïd S, et al. Stall architecture influences horses' behaviour and the prevalence and type of stereotypies. *Appl Anim Behav Sci.* 2019;219:104833.
83. Cooper JJ, McDonald L, Mills DS. The effect of increasing visual horizons on stereotypic weaving: implications for the social housing of stabled horses. *Appl Anim Behav Sci.* 2000;69(1):67-83.
84. McAfee LM, Mills DS, Cooper JJ. The use of mirrors for the control of stereotypic weaving behaviour in the stabled horse. *Appl Anim Behav Sci.* 2002;78(2-4):159-73.
85. Mills DS, Davenport K. The effect of a neighbouring conspecific versus the use of a mirror for the control of stereotypic weaving behaviour in the stabled horse. *Animal Science.* 2002;74(1):95-101.
86. Mills DS, Riezebos M. The role of the image of a conspecific in the regulation of stereotypic head movements in the horse. *Appl Anim Behav Sci.* 2005;91(1-2):155-65.
87. Stachurska A, Janczarek I, Wilk I, Kędzierski W. Does music influence emotional state in race horses? *Journal of Equine Veterinary Science.* 2015;35(8):650-6.
88. Houpt K, Marrow M, Seeliger M. A preliminary study of the effect of music on equine behavior. *Journal of Equine Veterinary Science.* 2000;20(11):691-737.
89. Carter C, Greening L. Auditory stimulation of the stabled equine; the effect of different music genres on behaviour. *Proceedings of the 8th International Equitation Science Conference, Royal (Dick) Veterinary School, Edinburgh, 18th ; 2012.*
90. Huo X, Wongkwanklom M, Phonraksa T, Na-Lampang P. Effects of playing classical music on behavior of stabled horses. *Vet Integr Sci.* 2021;19(2):259-67.
91. Kędzierski W, Janczarek I, Stachurska A, Wilk I. Massage or music meant to be relaxing, result in lowering salivary cor. . 2017.
92. Hartman N, Greening LM. A Preliminary Study Investigating the Influence of Auditory Stimulation on the Occurrence of Nocturnal Equine Sleep-Related Behavior in Stabled Horses. *J Equine Vet Sci.* 2019;82.
93. Kędzierski W, Janczarek I, Stachurska A, Wilk I. Massage or music meant to be relaxing, result in lowering salivary cortisol concentration in race horses. *Pferdeheilkunde.* 2017;33(2):146-51.
94. Bulens A, Dams A, Van Beirendonck S, Van Thielen J, Driessen B. A preliminary study on the long-term interest of horses in ropes and Jolly Balls. *Journal of Veterinary Behavior.* 2015;10(1):83-6.

95. Morgan KN, Tromborg CT. Sources of stress in captivity. *Appl Anim Behav Sci.* 2007;102(3-4):262-302.
96. Huo X, Yaemklang S, Pimmai P, Kupittayanant P, Na-Lampang P. A preliminary study of the effects of enrichment on stereotypic and non-stereotypic stabled horses. *Vet Integr Sci.* 2021;19(3):407-16.
97. Ruet A, Arnould C, Lemarchand J, Parias C, Mach N, Moisan MP, et al. Horse welfare: A joint assessment of four categories of behavioural indicators using the AWIN protocol, scan sampling and surveys. *Anim Welfare.* 2022;31(4):455-66.

Appendix

Table 1. Scopus

Search Terms.	Hits	Full articles read	Articles included
horse* OR equine* AND welfare AND housing OR "housing systems"	3633	47	28
horse* OR equine* AND "etiological needs" OR "behavioural needs" AND housing OR "housing systems" AND welfare	91	5	5
horse* OR equine* AND enrichment AND welfare AND improvement*	273	6	5
horse* OR equine* AND welfare AND stereotypies	760	15	9
horse* OR equine* AND welfare AND stallions	758	5	3