



Which affiliative behaviour can be used as a valid, reliable and feasible indicator of positive welfare in horse husbandry?

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ABSTRACT

To date, the suitability of affiliative behaviours for inclusion in a horse welfare assessment protocol has not been thoroughly studied. This is surprising, given the growing focus on demonstrating the presence of positive welfare rather than just the absence of poor welfare. This shift is driven by the recognition that simply avoiding negative experiences does not necessarily equate to a positive welfare state, and that there is more to good welfare than just the absence of disease, injury or stress. Thus, we critically reviewed the current scientific literature to propose quantitatively assessed animal-based indicators that indicate positive welfare and could therefore be incorporated in a welfare assessment protocol for horses. Amongst the candidate indicators that have previously been associated with positive welfare in horses are socio-positive interactions between horses, such as affiliative activities consisting of social proximity, social play and social grooming. These activities must meet the scientific quality criteria regarding validity, reliability and feasibility to enable an objective assessment of positive animal welfare. However, the current review showed that social play and social grooming amongst adult horses under husbandry conditions are not sufficiently valid indicators. These two affiliative behaviours would meet the requirement for validity only in combination with a differential diagnosis considering the absence of, for example, the stress caused by space restriction. Furthermore, social play and social grooming amongst adult horses may not fulfil the requirement for feasibility, because these behaviours occur rarely and unpredictably throughout the day, hindering their assessment within a limited observation time. As a result of this literature review, we suggest that social proximity may be the only suitable affiliative behaviour indicating positive welfare in adult horses. It best reflects the social bond with preferred partners - a key element for experiencing positive welfare. This affiliative behaviour has been investigated thoroughly in various sport and leisure horse housing systems regarding all three scientific quality criteria. It satisfies the validity criterion because to be counted as a socio-positive interaction, social proximity must be achieved voluntarily whereby the term 'voluntary social proximity' may best fit this requirement. Notably, it also fulfils the reliability and feasibility criteria in terms of good inter-observer agreement given a standardised assessment method including parameters such as distance between horses, duration and context. Thus, social proximity seems to be a promising indicator of positive welfare in horses.

1. Introduction

Animal protection and interest in the welfare of animals, that is, how an animal feels and how it experiences its situation under human care, continue to gain importance in society (Sinclair et al., 2022). The basic

prerequisite for welfare is the absence of pain and suffering along with the realization of species-specific behavioural needs (Jensen and Toates, 1993; Hirt et al., 2023). The 'Five Freedoms' have set the basis for animal welfare assessment by considering freedom from hunger, thirst and malnutrition; freedom from discomfort; freedom from pain, injury and

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disease; freedom from fear and distress; and freedom to express normal behaviour (Farm Animal Welfare Council, 1979). However, the welfare of animals is more than the absence of negative emotional states (Boissy et al., 2007). Scientists agree that it also explicitly includes positive emotional states (Boissy et al., 2007; Keeling and Jensen, 2017; Waran and Randle, 2017; Hall et al., 2018; Rault et al., 2020; Keeling et al., 2021). Therefore, the ‘Five Domains Model’ has been established as a coherent alternative to the Five Freedoms paradigm as it explicitly includes a focus on promoting positive welfare states (Mellor and Beausoleil, 2015; Mellor, 2016; Mellor et al., 2020). A ‘life worth living’, a ‘good quality of life’ or a ‘positive welfare balance’ is ensured when the animals are exposed to positive experiences over extended periods and when negative experiences are reduced to a minimum (Yeates and Main, 2008; Green and Mellor, 2011; Mellor, 2016; Lawrence et al., 2019; Vigers and Lawrence, 2019; Rault et al., 2020). Another analogue to positive welfare refers to ‘happiness’, a long-term, typically stable state of affective experiences where the overall experience is on the positive side of the welfare continuum (Rault et al., 2020). Thus, ‘positive welfare indicators’ should represent a positive affective state that could be incorporated in an overall horse welfare assessment protocol. Yet, it is necessary to include other welfare parameters, such as health status in a protocol, because animals can express positive emotions even if their overall experienced welfare may be poor (Keeling et al., 2021).

Positive welfare indicators are scantily studied in horses (Benedetti et al., 2023). The reason for this might be that the assessment of positive welfare in horses remains a challenge, owing to difficulties in interpreting positive emotions unambiguously. Furthermore, the objective assessment is hampered by the often short-lasting, transient manifestation of positive emotions. Nevertheless, affiliative behaviours that are species-specific have been proposed as suitable indicators of positive welfare (Boissy et al., 2007; Keeling, 2019a) and could therefore be implemented in a welfare assessment protocol.

There is general consensus that the indicators allowing an objective evaluation of animal welfare must meet the scientific quality criteria concerning validity, reliability, and feasibility (EFSA, 2012; Blokhuis et al., 2013; Zapf et al., 2015). Validity in this context is a measure of the indicator’s explanatory power. Validity signifies whether an indicator measures what it is supposed to measure (Dalla Costa et al., 2014; Zapf et al., 2015; Acock, 2016). Reliability is a measure of the indicator’s dependability or its precision. Reliability measures: a) the repeatability of the parameters over time (test–retest reliability), b) the agreement between the multiple measurements made by the same observer (intra-observer reliability) and c) the agreement between the measurements made by different observers at the same time (inter-observer reliability) (Bateson and Martin, 2022). Feasibility targets the cost and time investments and the practicability of an indicator for use under real-life conditions. Considering the various aspects of horse behaviour, it would be essential to observe specific behaviours sufficiently frequently within a limited observation period to obtain good feasibility (Knierim and Winckler, 2009b, 2009a; Zeitler-Feicht and Baumgartner, 2016).

Various welfare assessment protocols have been established internationally during recent years (Botreau et al., 2009; Welfare Quality®, 2009b, 2009a; Zapf et al., 2017). For example, the AWIN Welfare Assessment Protocol for horses and recently also for donkeys (Minero et al., 2015; Dalla Costa et al., 2016; Dalla Costa et al., 2021) or the Horse Welfare Assessment Protocol (Viksten et al., 2017). The so-called ‘BestTUPferd’ protocol was developed in Germany for evaluating the welfare of single- and group-housed sport and leisure horses (Baumgartner and Zeitler-Feicht, 2013b, 2013a, 2017; Baumgartner et al., 2021a).

Common for these protocols is the incorporation of quantitative and sometimes qualitative behavioural observations for evaluating the animals’ emotional states (Wemelsfelder et al., 2001; Wemelsfelder, 2007; Minero et al., 2018). Furthermore, brief behavioural tests (e.g., social isolation test, novel object test or human approach test) can be applied

on-farm to derive the underlying emotional states of individual animals (Dalla Costa et al., 2014). Similarly, acoustic signals can indicate positive affective states (Boissy et al., 2007; Keeling and Jensen, 2017; Rault, 2019). For example, vocalisations such as snorts and shorter, lower frequency whinnies in horses have recently been linked to positively valenced situations (e.g., Maigrot et al., 2017; Stomp et al., 2018a; Stomp et al., 2018b; Larsen et al., 2021). Vocalisations predominantly occur in specific situations such as social isolation (negative experience) or feed anticipation (assumed positive experience) (Pond et al., 2010; Yeon, 2012; Hall et al., 2018). Thus, they are difficult to quantify in limited observation periods during a welfare assessment (Larsen et al., 2021). Given the sparse frequency of vocalisations in horses, we will focus on visual behavioural signals potentially indicating a positive welfare state.

Hence, with the present literature review, based on an analysis of original research articles, previously published reviews and academic dissertations mainly obtained from the search engine Google Scholar, we aimed to critically analyse quantitatively assessed affiliative behaviours. The specific emphasis, as reflected in the corresponding keywords, was on evaluating the animal-based indicators social play, allogrooming and social proximity through the lens of positive animal welfare assessment. We focused particularly on discussing the aspects of a) validity (reflecting positive emotional states in horses), b) reliability (objective assessment) and c) feasibility (suitability for application in practice) that must be met to fulfil the criteria for scientifically sound indicators.

2. Affiliative behaviours as indicators of positive welfare

According to Torres Borda et al. (2023), the inclusion of social elements in equine welfare assessment focused predominantly on negative interactions. Thus, the authors recommended including affiliative interactions and observations of social tolerance between individuals to further enhance the evaluation of equine welfare, particularly the assessment of positive emotional states. However, which affiliative behaviours are suitable candidates for inclusion in horse welfare assessment protocols?

In horses, social play, social grooming and social proximity have been suggested to represent affiliative behaviours (Tyler, 1972; Feh and Mazières, 1993; Christensen et al., 2002; Wasilewski, 2003; Benhajali et al., 2007; Boissy et al., 2007; Burla, 2008; KTBL, 2014; Zeitler-Feicht et al., 2015, 2024; Zeitler-Feicht and Baumgartner, 2016; Wolter et al., 2018; Costa et al., 2019). What these behaviours have in common is that they facilitate group cohesion and bonding, thereby fulfilling the need for social contact and the willingness to follow others and stay in their vicinity (Lindberg, 2001; VanDierendonck et al., 2009; van Dierendonck and Spruijt, 2012; Keeling and Jensen, 2017). Horses, as social animals, have the need to form socio-positive relationships (van Dierendonck, 2006; Fraser, 2010; Zeitler-Feicht et al., 2024). These ‘friendships’ can have a calming effect in times of stress or provide social support (Rault, 2012). Furthermore, maintaining relationships with preferred partners is important to horses, as demonstrated in the interventions of affiliative interactions that involve their ‘friends’ (VanDierendonck et al., 2009). Thus, affiliative behaviours reflect the inner connection between animals that like each other (positive affect) in an outer connection (association). Social bonding can be assessed by the observation of social interactions and spatial proximity between horses. Wolter et al. (2018), for example, conducted observations on social behaviour and spatial proximity in 145 feral horses. The authors showed that mutual grooming, friendly approaches and spatial proximity (horses standing with body contact versus horses standing within two horse-lengths) were robust parameters to demonstrate the social bonds in feral horses. For an adequate assessment of horses’ social relationships, they suggested recording the frequency of friendly approaches and mutual grooming between pairs of horses, alternatively analysing horses’ nearest neighbours through the assessment of the spatial proximity between horses

(Wolter et al., 2018). Costa et al. (2019) reviewed the affiliative relationships in horses and their assessment under field conditions. The authors recommended that a range of affiliative interactions (i.e., approach, follow, friendly contact, mutual grooming) should be recorded alongside the proximity measures (i.e., nearest neighbour distances, identity of associates) to draw conclusions regarding the individual variation in bonding.

The following sections deal with the potential suitability of the behaviours social play, social grooming and social proximity as animal-based indicators of positive welfare in horses. Based on the relevant literature, we analysed these possible indicators regarding their scientifically proven validity, reliability and feasibility. In the absence of studies specifically focused on horses, research conducted on other socially living farm animals was incorporated.

2.1. Play behaviour

Play, in general, describes a behaviour that provides no immediate benefit, fulfils no obvious function and includes elements of pleasure and surprise for the player (Held and Špinka, 2011). Thus, play behaviour is defined as a pleasure-oriented, internally motivated activity without the typically associated seriousness (Crowell-Davis et al., 1987; McDonnell and Poulin, 2002; Gattermann et al., 2012). Because of these features, play is considered to be associated with positive welfare, including in equines (McDonnell, 2003; Zeitler-Feicht et al., 2024).

As in all mammals, the need to play is much stronger in young horses than in adults and it decreases with advancing age (Tyler, 1972; Feist and McCullough, 1976; Wells and Goldschmidt-Rothschild, 1979; Sigurjónsdóttir et al., 2003; Zharkikh and Andersen, 2009).

Ethologists differentiate play behaviour broadly into solitary and social play, which can be further classified into object play, sexual play, locomotor play and play fighting. The associated behaviour elements in horses were described in detail by McDonnell (2003). The affiliative behaviour 'social play' helps to optimise motor skills to develop an awareness of spatial and individual distance and to condition the behaviour towards conspecifics (Grauvogl, 2000; van Dierendonck and Spruijt, 2012). Solitary play refers to playing alone and may involve the use of one's own body or objects present in the environment. Solitary playful running, for example, occurs most frequently in foals but is rarely observed in adult horses living in free-range conditions. Under domestic conditions, solitary play is seldom observed in group-housed or single-housed adult horses (Dillenburger, 1982; McDonnell and Poulin, 2002; Waring, 2002; Fabritius, 2009; Wille, 2011; Zeitler-Feicht et al., 2015, 2024). Therefore, owing to the low frequency of occurrence in adult horses, solitary play behaviour cannot serve as a feasible indicator of positive welfare. Thus, in the following sections, the focus will be on social play.

2.1.1. Validity of social play as a positive welfare indicator

The motivation to play with conspecifics generally implies positive welfare, because animals play predominantly when their basic needs are met (Fagen, 1981; Lawrence, 1987; Grauvogl, 2000; Boissy et al., 2007). Moreover, play helps to stabilise social relationships, and to ensure group cohesion and bonding (Fagen and George, 1977; Clegg, 1982; Grauvogl, 2000; Boissy et al., 2007; Knierim and Winckler, 2009a; Thompson, 2009; Held and Špinka, 2011; Gattermann et al., 2012; Zeitler-Feicht et al., 2024).

However, social play, particularly play fighting, can also be a sign of negative welfare. Studies on adult horses under husbandry conditions have indicated that social play fighting serves to reduce tension and thereby reduces accumulated stress levels. Christensen et al. (2002) observed that previously single-housed stallions play fought significantly more often than stallions that had been group-housed. The authors concluded that this increased level of play fighting may be related to a rebound effect, that is, a build-up of play motivation caused by isolated housing. A rebound-effect in social play after being moved from

restricted housing conditions to a relatively open area has also been described in calves (Napolitano et al., 2009). Hausberger et al. (2012) observed the play behaviour of single-housed horses during a joint 2-hour paddock turnout. The authors showed that those individuals that played more had higher stress levels (as assessed via health status, reactivity to humans, reaction to tactile stimulation, cortisol levels) than those that played less frequently during turnout. For horses kept in 24-hour loose housing systems (barn with permanent access to a paddock), the behavioural observations revealed that most play behaviour occurred on farms with the highest rate of aggression recorded amongst horses (Zeitler-Feicht et al., 2006, 2015). Furthermore, the authors observed that the majority of play bouts, mostly play fights, occurred while the horses were anticipating feeding (Goodwin, 1999; Blois-Heulin et al., 2015). Similar to abnormal behaviours, such as stereotypies, the field studies agree on the general absence of play behaviour in free-ranged adult horses, whereas play behaviour (including social play) is frequent in domestic or captive situations (Blois-Heulin et al., 2015).

In conclusion, for adult horses under husbandry conditions, social play behaviour has not enough validity to indicate a positive emotional state because there are studies suggesting that play behaviour can be linked to stress reduction in both group- and single-housed horses. Therefore, to determine whether observed play behaviour validates as a measure of positive welfare, a concurrent assessment of the housing conditions (e.g., space allowance, feeding management) is necessary to support the welfare assessor's conclusions. According to Boissy et al. (2007), the assessment of play behaviour as an indicator of positive welfare is meaningful only in juvenile animals. Dillenburger (1982) recommended using play behaviour as an indicator of animal-appropriate foal rearing. In feral horses, the play behaviour in foals is linked to increased maternal investment, increased body condition and better survival (Cameron et al., 2008). Further studies should clarify whether social play in foals and young horses represents a suitable indicator of positive welfare. This has already been demonstrated for fattening calves, and social play has been included as an indicator of positive welfare in the Welfare Quality® assessment protocol for calves (Knierim and Winckler, 2009a).

2.1.2. Reliability of social play as a positive welfare indicator

Despite an increasing body of literature that includes observations of play behaviour to establish horses' social networks, there is a limited number of scientific studies that have examined the reliability of social play as a measure of positive welfare in horses. This is surprising, given that any research conducting standardised behavioural observations based on an ethogram should clearly state how well observers reliably and consistently scored the behaviours (Pierard et al., 2015). This is, according to Pierard et al. (2015), fundamental for both inter- and intra-observer reliability.

Bartlett et al. (2022) investigated the social interactions in horses to construct a social network whereby their ethogram included social play behaviour. They particularly mentioned testing the main observer for reliability against another observer prior to the onset of the study. Inter-observer reliability was considered 'very good' based on the Fleiss kappa correlation of 0.83 (Bartlett et al., 2022). Similarly, social locomotor play behaviour was reliably recorded in calves in terms of the agreement between the observers (i.e., Pearson correlation [rs] between 0.96 and 0.99) and within the same observer (rs = 0.94–1.00 according to Krachun et al., 2010; for summary, see Keeling et al., 2021). To conclude, studies testing the reliability of play behaviour for horses are scarce. Hence, more research is necessary to find out whether social play in horses can be assessed reliably.

2.1.3. Feasibility of social play as a positive welfare indicator

A prerequisite for good feasibility is a high enough frequency of the studied behaviour within a limited observation period. In general, the studies that analysed play behaviour in feral and semi-feral managed

horses typically assessed not only the types of play exhibited in foals, mares and stallions but also the frequency of play. The frequency of play behaviour was shown to depend on various factors, such as the animals' age category, sex and the weather conditions (Fagen and George, 1977; Dillenburg, 1982; Carson and Wood-Gush, 1983; Crowell-Davis et al., 1987).

For Welsh pony foals, Crowell-Davis et al. (1987) determined a play frequency (including play behaviours such as running and bucking alone vs. in a group, interactive play, play with an object and play directed at an adult) of approximately 3.6 play bouts per hour in the first four weeks of life, approximately 1.6 play bouts per hour in the fifth to eighth week of life and approximately 1.0 play bout per hour from 9 weeks of life onward. By contrast, the percentage of interactive play bouts increased with increasing age, especially in colts (52% by weeks 5–8) compared with fillies (22% by weeks 5–8; Crowell-Davis et al., 1987). Šandlová et al. (2020) observed that stallions under semi-feral conditions played with their offspring more often than mares, and colts under the same conditions played with their fathers more actively than fillies did. In colts, the majority (60–95%) of their social interactions consist of behaviours that serve the initiation and maintenance of contact with conspecifics, that is, playing and mutual grooming (Kolter and Zimmermann, 2001). Apart from age, sex and the availability of social relatives (e.g. the father), other factors that can influence the occurrence and frequency of play behaviour include the readiness to play as part of an individual's personality (Held and Špinková, 2011) and changes in weather conditions (Tyler, 1972; McDonnell, 2003). In foals, for example, the readiness to engage in play decreases with increasing ambient temperature. Especially during the hot summer season, foals play more during the cooler evening and morning hours (Crowell-Davis et al., 1987).

In summary, young horses are more engaged in social play than adult horses, presumably because it serves their social skills and physical development. Although there are differences in social play among foals and young horses regarding sex and available play partners (group composition), the relatively high frequency of play behaviour in comparison with adult horses makes it a feasible indicator of foal and young horse welfare assessment.

The question remains as to whether social play can serve as a feasible indicator of positive welfare in adult horses. In other species, such as growing pigs (Newberry et al., 1988; Stäbler, 2021) and adult cattle (Jensen and Kyhn, 2000; Fregonesi and Leaver, 2001, reviewed in Napolitano et al., 2009), social play bouts were distributed unevenly and unpredictably throughout the day. Therefore, play was rated as not sufficiently feasible for a welfare assessment and was therefore not included in the Welfare Quality® Protocol (Knierim and Winckler, 2009a; Welfare Quality®, 2009a).

Studies on the frequency of social play in adult horses under husbandry conditions have shown that social play is relatively rarely observed within a feasible time frame because of its generally rare occurrence with increasing age (McDonnell and Poulin, 2002; Hausberger et al., 2012; Frank et al., 2014). Moreover, Hausberger et al. (2012) confirmed sex differences in the motivation for social play in adult horses, that is, geldings seem to engage more readily in social play than mares. Play bouts were recorded in only two of the six observed mares compared with 20 of the 23 geldings during a joint 2-hour paddock turnout (four stable groups of mixed sex with seven to eight horses per group in sand paddocks with restricted access to roughage). Hausberger et al. (2012) determined on average 3.0 social play bouts per horse during turnout. The authors included play fighting (biting and kicking another's head, neck or chest) and pursuit (chasing another animal, occasionally with attempts to nip or to push the pursued play partner) in social play behaviour, characterised by mobile ears in forward or axial position whereas 'real' fighting, with ears pinned backwards (McDonnell and Poulin, 2002), did not occur during the observations. Social play behaviour occurred even less frequently in the study by Frank et al. (2014). The authors determined a median of <0.01

social play bouts (head and locomotion play) per horse during a 20-minute observation of adult horses housed in groups (8–31 horses on 15 different farms, observations spread during 6 hours of daytime, 72 hours of observation). Hence, the low frequency of adult play in horses questions the feasibility of this behaviour as a positive welfare indicator. This is supported by the fact that weather and season seem to influence the occurrence of play. Similar to foals and young horses, free-living adult horses show little play behaviour in winter (McDonnell, 2003; Held and Špinková, 2011) whereas during or after strong wind gusts, play activity (play running, play fighting) can increase (Tyler, 1972).

In conclusion, play behaviour in adult horses occurs too seldom and depends on environmental conditions, season, and sex. In addition, different housing conditions, group compositions (e.g. single versus mixed sex groups of same or different age), and time of the day can influence the play frequency. For these reasons, social play is not feasible for an objective welfare assessment.

2.1.4. Social play - conclusion

Considering the suitability of social play as a valid, reliable and feasible indicator of positive welfare, the reviewed literature allows the following conclusion: For adult horses under husbandry conditions, social play behaviour does not exclusively indicate positive welfare, as studies have suggested a link between play behaviour and stress reduction. Play can be measured reliably, but, considering the feasibility, social play in adult horses occurs too infrequently within a limited observation period. It is also highly dependent on diurnal and seasonal fluctuations and group composition. Therefore, it may not be suitable for integration in a welfare assessment protocol for adult horses.

2.2. Social grooming

The affiliative behaviour social grooming (also referred to as mutual grooming or allogrooming) in horses is generally seen as a socio-positive interaction in the context of welfare (Feist, 1971; Tyler, 1972; Goldschmidt-Rothschild and Tschanz, 1978; Keiper and Sambras, 1986; Feh and Mazières, 1993; Christensen et al., 2002; Wasilewski, 2003; Benhajali et al., 2007; Zeitler-Feicht, 2013). Van Dierendonck and Spruijt (2012) argued that mutual grooming could be considered an 'ethological need', because the behaviour is self-rewarding. Moreover, according to Christensen et al. (2002), mutual grooming has a rebound effect, as it was observed more often in stallions that were socially deprived prior to being kept in groups, which also suggests that the absence of social partners can elicit stress (Christensen et al., 2002; Søndergaard et al., 2011). During social grooming, horses stand in antiparallel position and mutually rub or nip along the coat or skin of each other with their incisors, usually on corresponding body parts and often around the withers. Licking movements with the tongue were also observed (Feist, 1971; Tyler, 1972; Goldschmidt-Rothschild and Tschanz, 1978).

2.2.1. Validity of social grooming as a positive welfare indicator

On the one hand, social grooming serves as body care (e.g. controlling parasites) (Boyd et al., 1988; McDonnell and Haviland, 1995; Shimada and Suzuki, 2020); on the other hand, it helps to form or strengthen social bonds and thereby group coherence (Wolter et al., 2018; Sigurjónsdóttir and Haraldsson, 2019; Shimada and Suzuki, 2020). Empirical evidence further suggests that social grooming can signal appeasement (Kolter, 1984; McDonnell, 2003; Feh, 2005; Shimada and Suzuki, 2020; Zeitler-Feicht et al., 2024) and can have a calming effect (Feh and Mazières, 1993). According to Feh and Mazières (1993), social grooming on preferred body areas can induce a reduction in heart rate in the receiving horse. Thus, social grooming also serves as stress reduction, as suggested by several authors (Wells and Goldschmidt-Rothschild, 1979; Hogan et al., 1988; McDonnell, 2003; Sigurjónsdóttir and Haraldsson, 2019; Zeitler-Feicht et al., 2024), based on observations that the grooming frequency increased after new horses

joined an existing group or when the available pasture area was reduced. A recent study confirmed the higher frequency of allogrooming under restricted housing conditions (high stress) compared to a low stress setting on pasture (Kieson et al., 2023). Further studies showed that not only aggressive behaviour (Flauger and Krueger, 2013; Suagee-Bedore et al., 2020), but also the frequency of affiliative behaviours such as social grooming and social play increases with decreasing space allowance (Hogan et al., 1988; Majecka and Klawe, 2018). Studies with cattle have found evidence that social licking under husbandry conditions is performed to reduce social tension and may be connected to the experience of self-stimulation or self-calming, facilitating stress relief (Knierim and Winckler, 2009b; Tresoldi et al., 2015). Because of its insufficient validity, social licking in cattle was not included in the Welfare Quality® assessment protocols for cattle (Knierim and Winckler, 2009a; Welfare Quality®, 2009a). The findings from recent investigations by Freslon et al. (2020), who demonstrated the occurrence of social grooming among newly integrated cows, support these previous findings from cattle and horses. As reviewed by Keeling et al. (2021), for cattle, social grooming may therefore be a behaviour that makes a receiving animal feel better, but it may occur because the situation is less than optimal.

In summary, even though individual animals may perceive social grooming as a positive experience, elevated levels of social grooming may also indicate social conflict and other adverse conditions. This might imply that a higher frequency of social grooming does not mean more positive experiences, but rather just a reduction of the negative environmental impacts for the animals involved; hence, it serves for stress reduction (Wells and Goldschmidt-Rothschild, 1979; Hogan et al., 1988; McDonnell, 2003; Granquist, 2008; Wolter et al., 2018; Zeitler-Feicht et al., 2024). Furthermore, the fact that social grooming is performed by some but not all horses in a group (see Section 2.2.3) independently of housing conditions leads to the question of whether this variability is due to the individual ability to experience positive affective states (with some individuals being much more positive than others) or if social grooming is not linked to the expression of positive welfare at all. Therefore, social grooming has poor validity as an indicator of positive welfare.

2.2.2. Reliability of social grooming as a positive welfare indicator

Studies incorporating testing the reliability of social grooming in horses were not found in the present literature search. The reason for this might be that this behaviour is so conspicuous and easily recognised that you cannot regard it as anything else (Keeling, 2019b; Keeling et al., 2021). To transfer from other social species (e.g. cattle) to horses, social grooming has been reliably detected by multiple observers (Schulze Westerath et al., 2009; Freslon et al., 2020; cited in Keeling et al., 2021).

2.2.3. Feasibility of social grooming as a positive welfare indicator

An allogrooming bout can last a few seconds or several minutes. Sometimes the horses briefly pause or change sides (McDonnell, 2003; Wasilewski, 2003). The frequency of engagement in social grooming varies between individuals. In some studied horse groups, mutual grooming occurred relatively often (Sigurjónsdóttir et al., 2003; van Dierendonck et al., 2004), whereas, in others, the frequency was low and some horses never engaged in it (Wells and Goldschmidt-Rothschild, 1979; Crowell-Davis et al., 1986; Heitor et al., 2006). Hoffmann (1985), who observed a group of feral horses during a period of two years, calculated that only 20–30% of all adult animals demonstrated allogrooming across the entire observation period. These findings were confirmed by Mendonça et al. (2021), who recorded allogrooming events in only 24% of 16 feral horses over 193 hours of focal group observations. Furthermore, the average allogrooming frequency per dyad was low (0.06 ± 0.12 events per dyad per hour). The findings from Frank et al. (2014), who observed daytime group-housed adult leisure horses on 15 farms (in total 72 hours of observation), also indicated a very low frequency of social grooming (median of <0.01 occurrences

per horse per 20-minute observation interval).

The affiliative behaviour social grooming is usually expressed with preferred partners and often occurs between familiar horses (Kimura, 1998; Kieson et al., 2020). The number of preferred grooming partners generally varies between one and three partners (Clutton-Brock et al., 1976; Goldschmidt-Rothschild and Tschanz, 1978; Houpt, 2001; Sigurjónsdóttir et al., 2003; van Dierendonck et al., 2004; Feh, 2005; Heitor et al., 2006; Costa et al., 2019). Keiper (1988) observed mutual grooming significantly more often among low-ranking than among high-ranking Przewalski horses. Often, the lower ranking horse initiates this affiliative behaviour (Tyler, 1972; Kimura, 1998). Horses of similar rank are inclined to groom each other more frequently than horses of differing rank. There is also evidence that horses prefer grooming partners of similar age (Clutton-Brock et al., 1976; Wells and Goldschmidt-Rothschild, 1979; Houpt, 2001). Hence, group composition regarding age and dominance relationships influences whether or not social grooming is observable.

Foals and mares can be observed participating in social grooming more frequently than stallions. Social grooming is especially pronounced between dam and foal and among foals and young horses (Crowell-Davis et al., 1986; Keiper, 1988; Rho et al., 2007; Granquist et al., 2012). It occurs significantly more often in sub-adult than in adult horses (Hoffmann, 1985; Granquist, 2008). Among stallions, mutual grooming was observed exclusively in sub-adult bachelors, whereas sexually mature bachelors aged four years and older showed no social grooming at all (Hoffmann, 1985). Also, the number of preferred grooming partners was larger in young than in adult horses. In general, female horses participate more than male horses in mutual grooming (Houpt, 2001). Moreover, an effect of group size on mutual grooming seems to exist. The larger the group of feral horses, the more the horses were observed allogrooming (Wolter et al., 2018). In contrast, the smaller the group size, the more approaches and standing in proximity were shown per animal within the group (Wolter et al., 2018). The frequency of social grooming can also vary depending on season and time of the day. Horses were more frequently observed to engage in social grooming during times of coat shedding in the spring, on pasture during the summer months and in times of high insect pressure (Tyler, 1972; Wells and Goldschmidt-Rothschild, 1979; Ihle, 1984; Kimura, 1998; Steidle, 2011).

To conclude, the frequency of allogrooming may be too low for a feasible observation during a welfare assessment. Moreover, a year-round feasible assessment of this affiliative behaviour during limited observation periods is impossible, because social grooming occurs unpredictably throughout the day and varies according to season (Hoffmann, 1985; Heitor et al., 2006; Frank et al., 2014; Costa et al., 2019). In addition, social grooming cannot be compared between individuals (because not every horse shows it) and within individuals over time, especially taking different seasons into account. Last, the frequency of social grooming is influenced by numerous group-specific (e.g. group size and composition, stability) as well as animal-individual factors (e.g. sex, age and health status, especially ectoparasite infestation).

2.2.4. Social grooming - conclusion

In conclusion, social grooming can be a sign of both positive and negative welfare, and its assessment during restricted observation periods is unpredictable in adult horses. As a result, social grooming is neither a valid nor a feasible indicator of the positive welfare state of adult horses, even though it is highly likely that it can be recorded reliably.

2.3. Social proximity

According to Wolter et al. (2018), spatial proximity is a robust parameter to demonstrate social bonds. Via social proximity, the internal affinity between horses is reflected in an external association (Christensen et al., 2002; Wasilewski, 2003; Boissy et al., 2007;

Zeitler-Feicht and Baumgartner, 2016; Zeitler-Feicht et al., 2024). Social proximity is usually assessed via recordings of the nearest neighbours of the focal animal and has been studied widely in free-ranged and group-housed horses, particularly during resting or joint grazing (Goldschmidt-Rothschild and Tschanz, 1978; Costa et al., 2019; Zeitler-Feicht et al., 2024). In addition, social proximity occurs when horses stand together in an alert body posture (alert standing) or when horses jointly change locations (McDonnell, 2003). In general, the studies measuring the distance between a focal animal and its 'nearest neighbour' and the studies assessing the preferred social partner found not only close proximity (horses standing with body contact or within two horse-lengths) but also distances of up to 15 m between the preferred partners (Tyler, 1972; Kolter, 1984; Kimura, 1998; Wasilewski, 2003; van Dierendonck et al., 2004; Heitor et al., 2006; Burla, 2008; Cameron et al., 2009; Baumgartner et al., 2018; Wolter et al., 2018; Inoue et al., 2019; Hildebrandt et al., 2021; Mendonça et al., 2021).

2.3.1. Validity of social proximity as a positive welfare indicator

During standing rest, horses often settle in a parallel or antiparallel position. Goldschmidt-Rothschild and Tschanz (1978) reported the distance between resting horses to range from body contact to a distance of 0.2 m. The distance between horses feeding together was shown to increase to approximately 0.5 m (Goldschmidt-Rothschild and Tschanz, 1978), although other authors also observed body contact between feeding horses (Wasilewski, 2003; Zeitler-Feicht and Baumgartner, 2016). According to Clutton-Brock et al. (1976) and Ralston (1977), the distance during joint feeding can also be larger, ranging from 4 to 15 m. When assessing 'resting together' and 'grazing together', one should consider that horses typically maintain a smaller individual distance during 'standing rest' and 'standing alert' (when threatened) than during feed intake. Social proximity, pairing up or standing together is defined in a similar range of distance of less than 0.5–1.0 m (Kolter and Zimmermann, 1988; Heitor and Vicente, 2010).

General attention should be paid to the finding that horses show individual differences in the preferred distance to the social partner. Young horses maintain smaller individual distances than adult horses. Furthermore, warmbloods and thoroughbreds usually need a larger distance from their neighbours than ponies and Arabians (Goldschmidt-Rothschild and Tschanz, 1978; Kolter, 1984; Waring, 2002; Wasilewski, 2003; Zeitler-Feicht et al., 2024). Independent of the age and breed, the horse's body size might also affect the preferred distance between conspecifics (e.g. Shetland pony compared to Shire horse), but this has not been studied so far.

The behaviour 'following', which also falls into the category of the measures of social proximity, is defined as moving immediately behind another horse and staying within three body-lengths (i.e. $2.4 \text{ m} \times 3 = 7.2 \text{ m}$) without the prevalence of agonistic interactions (reviewed by Torres Borda et al., 2023). Recently, social networks and the proximity between horses were also measured, not only using direct or video observations, but also using GPS data (e.g. Hildebrandt et al., 2021) or photos taken by a drone (e.g. Inoue et al., 2019; Mendonça et al., 2021). The authors using these technical devices defined the distances for social proximity in the same range of distance (0–3 m and 0–7 m) as described for 'following' by Torres Borda et al. (2023). Clearly, it is important to define social proximity, irrespective of recording methods, in terms of the distance between individuals and the context in which it is observed, such as during moving, feeding or resting. Only then is it possible to draw valid conclusions about whether or not being socially close reflects a socio-positive interaction and, thereby, positive welfare. In the reviewed literature, we did not find any evidence for stress-associated behaviour related to social proximity, unlike in social play and social grooming. For example, prior studies found no correlation between horses engaging in social grooming and those displaying social proximity towards one another (Kimura, 1998; Inoue et al., 2019).

In general, 'social proximity' is described in a socio-positive or

'amicable' context. An amicable relationship, i.e. a 'friendship' can be defined by Gattermann et al. (2012) as a voluntary, reciprocal, non-sexually motivated, socio-positive bond between non-related individuals. It is primarily dyadic and has a subjective value for both involved partners. Furthermore, friendship finds expression in a lasting inter-individual preference and is characterised by positive affect ('sympathy') in both partners (Christensen et al., 2002; Wasilewski, 2003; Gattermann et al., 2012). The presence of a close bond in a social species might reflect psychological welfare (Gattermann et al., 2012; Rault, 2012, 2019). Thus, the existence of a close bond with the social partner must be demonstrated as described below to allow interpreting social proximity as being indicative of positive interactions based on friendship and, ultimately, positive welfare (Goldschmidt-Rothschild and Tschanz, 1978; van Dierendonck et al., 2004; Baumgartner et al., 2018).

For a valid assessment of social bonds, Baumgartner et al. (2018), in agreement with Forkman and Keeling (2009) and Knierim and Winckler (2009b), recommended a precise definition of the affiliative behaviour 'social proximity' to allow its integration as an indicator of positive welfare in a welfare assessment protocol. Baumgartner et al. (2018) defined the characteristics and modalities of this behaviour as part of the validation of an assessment protocol for horses during the research project 'BestTUPferd'. As a premise, the distance between the focal animal and its spatially close partner at the beginning of the observation had to reflect the close social bond between the horses. According to their study, a close bond with the social partner is demonstrated when the horses stay in close proximity (distance $\leq 1.5 \text{ m}$) for at least 60 seconds with relaxed displays of facial expression, body posture and the absence of agonistic behaviour (such as a bite or kick threat). A distance of, at most, 1.5 m corresponds to an individual distance that represents a very close proximity between two horses, that is, a highly probable undercutting of the individual distance. Only when the close relationship to the social partner could be proven by the mentioned definition, did the authors record the affiliative behaviour. Based on this, voluntary social proximity occurs predominantly at a distance of 0.2–5 m depending on space and food supply (Baumgartner et al., 2018). In addition, an important prerequisite for the chosen observation is that external stressors must be absent and the horses should be in their familiar surroundings and not in novel or test situations. The reason is that voluntary social proximity should not be mistaken for a general social buffering effect of conspecifics. Very stressful events are easier to handle (attenuation of fear) in the presence of experienced group members (Rørvang and Christensen, 2018) or another feral horse in confined conditions (Fletcher et al., 2023). Hence, a general social buffering effect differs from the mentioned voluntary social proximity.

Other authors have used other time spans to define the bonds that reflect positive associations. For example, several authors defined the 'affiliate approach' as moving to within 1 m up to 5 m (one to two body-lengths) of another horse that does not immediately move away and staying there for at least 5–10 seconds without agonistic interactions. This 10-second rule can also be applied to the behaviour 'following' (reviewed by Torres Borda et al., 2023). However, for social proximity, Baumgartner et al. (2018) and Hildebrandt et al. (2021) identified 60 seconds as the most useful time span. The former found that the required initial duration of at least 60 seconds proved to be applicable under different housing conditions (varying space allowance and feed provision). Hildebrandt et al. (2021) assessed social proximity in horses in one housing condition via GPS devices. They stated the importance of increasing the temporal proximity definition in order to exclude short-lasting interactions, such as aggressive behaviour, which cannot be differentiated from affiliative behaviour in a social network analysis via GPS locations. Baumgartner et al. (2018) conducted their assessment of voluntary social proximity by direct observation. They considered a close bond with a social partner when two or more horses were within a maximum distance of 1.5 m for a minimum duration of 60 seconds. This approach ensured that the evaluation accounted for genuine positive

interactions and avoided the inclusion of the random nearest neighbours as social partners.

Thus, for a correct interpretation of the nearest neighbour data, assessors must consider whether or not the measured social proximity is achieved voluntarily. When using GPS measurements, it is necessary to obtain a high frequency of the nearest neighbours over a certain time and within a certain distance in order to identify the preferred partners. Even then, it cannot be assured that the nearest neighbours are voluntarily close to each other. The reason is the group dynamics, meaning that the nearest neighbours are not always the preferred partners. In a group, the behaviour and relationships of all the horses influence the distance between every horse (Salau et al., 2020; Hildebrandt et al., 2021). Hence, although it is possible to reveal the individual distance between horses (nearest neighbours) and social networks by GPS measurements, behavioural observations are necessary to assess the social proximity in the context of a socio-positive interaction. Only voluntary social proximity can be a valid indication of friendly relationships between horses.

Furthermore, under husbandry conditions, Baumgartner et al. (2018) suggested observing the horses during specific situations in reference to Zeitler-Feicht et al. (2006): a 'non-relaxed situation' (period during feed anticipation: 20 minutes before feeding) and a 'relaxed situation' (period without feed anticipation: 20 minutes). The latter allows the observer to assess social proximity with a high probability during a short observation period, because there is no management-related restriction or anticipation-related arousal of the animals. Especially restrictions, for example, limited feeding places, can lead to competitive and, therefore, more aggressive than affiliative behaviour.

Besides the varying frequency of social proximity in different situations, further factors significantly influence the individual distances between horses. Baumgartner et al. (2018) investigated to what extent the distance between two companions in the defined proximity range (max. 1.5 m for at least 60 seconds, without agonistic behaviour) is influenced by space allowance and feed provision. They observed 50 adult horses in single housing with daily turnout in groups for approximately eight hours. Data were collected on pasture (approximately 700 m² per horse) and on a surfaced paddock (approximately 100 m² per horse). The mean measured distance of social proximity was 1.43 ± 0.58 m (mean ± SD) on the paddock and increased to 4.25 ± 2.40 m on pasture (Baumgartner et al., 2021b). The majority of the distances ranged between 0.2 and 5.0 m. Hence, the larger the space allowance, the further the distance between the horses showing 'social proximity' will become. However, the maximum starting distance of 1.5 m for at least 60 seconds determined by Baumgartner et al. (2018) could be applied regardless of the space and context of the behaviour (resting, feeding). Nevertheless, the dynamic character of the behaviour 'social proximity' is limited with the limited space available. According to Zeitler-Feicht and Baumgartner (2016), the assessment of 'social proximity' is not valid enough on paddocks with too little space allowed. Under such housing conditions, horses standing closely together can simply be in forced 'social proximity'. Zeitler-Feicht and Baumgartner (2016) thus postulated that the space available to horses in an observation area must be large enough that the affiliative behaviour is voluntary. That means the space allowance must allow a free choice to stay within a close distance to conspecifics (<1.5 m) and thus can be seen in a socio-positive context. Hence, social proximity was not counted as such when the space was restricted. The question therefore arises as to how large a turnout area needs to be in order to allow voluntary social proximity. In Germany, for example, the binding values for a sufficiently large space allowance are stipulated in the 'Guidelines for Assessing Equine Housing from an Animal Welfare Perspective' of the German Federal Ministry for Food and Agriculture (GFFA, 2009). Accordingly, the minimum size requirement is 150 m² for one or two horses plus 40 m² for each additional horse. Practical experience has shown that at least an 80–150 m² turnout area or more per horse is advisable (Zeitler-Feicht et al., 2024). According to Baumgartner et al. (2018), these

space allowances are appropriate in order to observe voluntary social proximity. It is not yet clear which space allowance is the optimum to observe voluntary social proximity, but at least studies show that aggressive behaviour caused by forced proximity decreases considerably with increasing space allowance (Hogan et al., 1988; Flauger and Krueger, 2013; Suagee-Bedore et al., 2020).

In summary, the validity of social proximity is relatively high but is only given when certain prerequisites are met. Most importantly, the voluntariness of the behaviour is a basic requirement. Thus, only when the external factors such as limited space can be excluded as a cause of forced proximity, are we able to observe 'voluntary social proximity', a sign of positive interactions between conspecifics ('friendship') and, ultimately, a positive welfare indicator (Boissy et al., 2007; Zeitler-Feicht et al., 2024).

2.3.2. Reliability of social proximity as a positive welfare indicator

To allow including the behaviour 'voluntary social proximity' as an indicator of positive welfare in any assessment protocol, a thorough investigation regarding its reliability was conducted. The inter-observer reliability was assessed by three observers as part of validating the BestTUPferd welfare assessment protocol (Baumgartner et al., 2016). The observers recorded the voluntary social proximity simultaneously in 48 assessments (12 horse farms with 685 horses in total, four repetitions per farm, each per season) but independently of one another. Owing to the precise definition of the affiliative behaviour (see Section 2.3.1), a very good inter-observer agreement (Kendall's W = 0.77) was found. Therefore, 'voluntary social proximity' can be included in a welfare protocol as a reliable indicator of positive welfare (Baumgartner et al., 2016; Zeitler-Feicht and Baumgartner, 2016). The results for test–retest reliability and intra-observer reliability have yet to be published.

2.3.3. Feasibility of social proximity as a positive welfare indicator

Horses have, independent of herd size, only one to two (seldom three) preferred social partners (Tyler, 1972; Ralston, 1977; Kolter, 1984; Wasilewski, 2003; Feh, 2005). Frank et al. (2014), observing leisure horses on the paddock, also found mostly pairs of preferred partners (95.2%), rarely a horse with two (4.1%) and even more seldom one horse with three preferred social partners (0.7%). Close contact occurred almost exclusively during standing; in only 3.7% of the cases, one of the participating horses was resting in a lying position. Horses that are 'friends' stay most of the time in the vicinity of their companion. Stallions in a family group can have a preferred friendly relationship with one or two mares. They approach these mares, even when they are not receptive, to rest in their vicinity or to engage in mutual grooming (Feh, 1988, 2005). Geldings maintain steady and often very close friendships among one another (Wasilewski, 2003). In general, 'preferred partners' are often of the same sex (Araba and Crowell-Davis, 1994; Sigurjónsdóttir et al., 2003). This means that, from a feasibility point of view, horses can almost always be observed in relationships of two and are usually standing while showing voluntary social proximity.

Furthermore, 'preferred partners' are mostly of similar social rank (Ellard and Crowell-Davis, 1989; Kimura, 1998). Pairs of horses with equal rank develop stronger affiliative relationships (Clutton-Brock et al., 1976; Wells and Goldschmidt-Rothschild, 1979; Kimura, 1998; Sigurjónsdóttir et al., 2003) and spend more time with each other in proximity than pairs of horses with differing rank (Vries et al., 1994; Kimura, 1998; Heitor et al., 2006). There seems to be no correlation between the number of preferred partners and social rank (Arnold and Grassia, 1982; Ellard and Crowell-Davis, 1989). Because the studies on social rank are contradictory, future studies should focus on whether personality instead of dominance relationships influences the choice for a preferred partner in horses.

Another influencing factor for a feasible assessment of the social proximity between horses is group composition regarding the age of the horses. The same or a similar age can facilitate friendship between horses. Explanations for this finding include the age-dependency of

locomotion activity and of social needs (Clutton-Brock et al., 1976; Wells and Goldschmidt-Rothschild, 1979; Sigurjónsdóttir et al., 2003; Zeitler-Feicht et al., 2024). Nevertheless, the age-dependency of ‘social proximity’ was not observed in adult Sorraia mares (Heitor et al., 2006), Konik horses (Bouskila et al., 2015) and Icelandic horses (Sigurjónsdóttir et al., 2003). These findings suggest that older horses have the same need for affiliative interactions as younger horses and that older horses can affiliate with younger ones. The opportunity to choose a preferred partner increases with the number of available horses in a group. However, so far, there are no studies on the effect of group size on the frequency of voluntary social proximity.

Weather conditions and other external factors can influence the frequency of ‘social proximity’. Horses increasingly seek contact when the weather becomes cold, especially in combination with wind and rain, and when insect pressure is high (Duncan and Vigne, 1979; Fraser and Broom, 1990; Cymbaluk, 1994; Waran, 2001; Jordan et al., 2002; Wasilewski, 2003; Mejdell and Bøe, 2005; Zeitler-Feicht et al., 2024). Hence, the feasibility of social proximity, as was the case for the validity of the behaviour, is negatively affected by external factors if the observer does not take them into account. That means that, in cases of high insect pressure or wind, voluntary social proximity cannot be assessed feasibly and validly. This limitation also applies for space allowance, as mentioned in Section 2.3.1.

Wolter et al. (2018) analysed social proximity and other behaviours related to social bonds in horses (such as mutual grooming and affiliative approaches). According to their results, 15 hours of observation per group would be required to collect reliable data for the analysis of social bonds, in general. However, for assessment protocols to be applicable in practice, observation periods need to be much shorter. In addition, for a welfare assessment, there is no need to assess social bonds in general if only voluntary social proximity is a valid sign of positive welfare. Frank et al. (2014) investigated whether the frequency of the behaviour ‘voluntary social proximity’ (defined by a maximum distance between horses of 1.5 m for at least 60 seconds without agonistic interactions) was a suitable indicator of positive welfare in leisure horse husbandry. In their study, they observed this affiliative behaviour in a ‘relaxed situation’ sufficiently often within a feasible observation period of 20 minutes (median of 0.5 scans of voluntary social proximity per horse in 20 minutes).

To summarise, the behaviour ‘voluntary social proximity’ occurs in horses regardless of sex, breed, social rank or age group. The definition of ‘voluntary social proximity’ as proposed in this article includes a standardised distance between horses, duration and behaviour (i.e. initial distance between horses ≤ 1.5 m for at least 60 seconds without agonistic behaviour). Furthermore, along with the recordings of the spatial distance and weather conditions, the context should be stated (i.e. whether observations are made during a relaxed or tense situation and whether enough space per individual is available to allow voluntary social proximity).

2.3.4. Social proximity – conclusion

Considering the suitability of ‘social proximity’ as a valid, reliable and feasible indicator of a positive welfare state in horses under husbandry conditions, the reviewed literature allows the following conclusion: Solely proximity between the animals must not be used as an indicator of positive welfare, because proximity can be facilitated by external factors. Therefore, the BestTUPferd assessment protocol uses the indicator ‘voluntary social proximity’, which needs to be assessed in familiar surroundings and considers the mentioned external factors, that is, excludes extreme-weather-driven or space-driven forced social proximity.

Under the outlined conditions, the affiliative behaviour ‘voluntary social proximity’ is a reliable and feasible indicator of positive welfare for use in an assessment protocol of adult horses. Considering the aspect of validity in contrast to social grooming and social play, social proximity – according to previous findings in the literature – does not serve

for stress reduction but might reflect best the bond between preferred horses and, therefore, indicate positive welfare.

3. Conclusion

Scientific frameworks that allow evaluating and grading animal welfare on farms are increasingly demanded, especially those that include indicators of positive welfare (van der Stede et al., 2022). Studies evaluating the effects of farm animal husbandry have revealed that more than a few of the short-lasting behaviours, such as social licking in cattle, are ambiguous. On the other hand, some are valid but cannot be assessed reliably enough within a limited observation period, because their frequency of occurrence is too low. In horses, the affiliative behaviours social play, social grooming and social proximity are thought to be associated with welfare, because they can contribute to a positive experience in animals. All of these behaviours support building social relationships and social bonds with preferred partners, which is a key element in experiencing positive welfare. Nevertheless, social play and social grooming in adult horses under husbandry conditions are not unambiguously associated with positive welfare. Only with the aid of an expert differential diagnosis (e.g. exclusion of stress, diseases, environmental influences) can these two affiliative behaviours meet the requirements for a valid indicator in the context of positive welfare. Moreover, social play and social grooming in adult horses are not sufficiently feasible for assessment, because their occurrence in adult horses is rare overall, unpredictably distributed throughout the day and influenced by numerous factors. In foals and young horses, play behaviour might be a suitable indicator of positive welfare, but it has yet to be tested regarding its validity, reliability and feasibility.

Taken together, the results from the present literature review show that, for adult horses, only the affiliative behaviour ‘voluntary social proximity’ could be a suitable indicator of positive welfare, regarding its validity and considering the aspects of reliability and feasibility. The prerequisites for its application are a precise definition of the behaviour and a standardised assessment protocol.

CRedit authorship contribution statement

Michael H. Erhard: Writing – review & editing. **Elke Hartmann:** Conceptualization, Investigation, Visualization, Writing – review & editing. **Margit H. Zeitler-Feicht:** Conceptualization, Methodology, Project administration, Writing – original draft. **Miriam Baumgartner:** Conceptualization, Investigation, Methodology, Project administration, Resources, Supervision, Visualization, Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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