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Review

Keeping horses in groups: A review

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ABSTRACT

Although husbandry conditions for horses have improved over the last decades, many horses are still kept singly with limited or no physical contact to other horses. This is surprising, given the fact that keeping horses in groups is recognised best to fulfil their physical and behavioural needs, especially their need for social contact with conspecifics, as well as to have a beneficial effect on horse–human interactions during training.

Group housing of farm animals is widely applied in practice. As a consequence, scientists have investigated numerous aspects of group housing to help further improve animal welfare and human–animal interactions under these conditions. However, compared to this literature available in farm animals, and the plentiful studies conducted of feral horse populations, there is much less done when it comes to the management of horses kept in groups in the domestic environment. In particular, limited scientific information is available into the effect of group size and group composition on behaviour and methods of introducing new horses into established groups, even though problems related to social integration are repeatedly taken as arguments against keeping horses in groups.

This review, therefore, aims to provide an overview of the current scientific knowledge regarding keeping horses in groups. Furthermore, it aims to give insight into whether or not some of the concerns related to keeping horses in groups are justified and to review scientifically based solutions that could be useful in practice to improve horse welfare and human safety.

Contents

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1. Introduction

Horses are adapted to live in social groups. Long periods of social isolation are rarely seen in the wild, as most horses prefer to stay with conspecifics (reviewed in Waring, 2003). The social behaviour repertoire of feral and free-ranging horses has been extensively described (Feist and McCullough, 1976; Goldschmidt-Rothschild and Tschanz, 1978; Waring, 2003), and the same social behaviour patterns can also be observed in horses under domestic conditions when given the opportunity.

Because horses are social animals by nature, keeping them in groups, especially as juveniles, has advantages compared to individual housing. For instance, they are less aggressive and they seem to have more refined social skills towards familiar and unfamiliar conspecifics than horses deprived of social contact early in life (Christensen et al., 2002). That a lack of social experience as juveniles can affect adult social behaviour, especially related to increased aggression, has also been shown in several other social species (Bøe and Færevik, 2003; Olsson et al., 1999; Veissier et al., 1994). Thus, it is only through group living that young horses can develop and refine appropriate social skills (Ladewig et al., 2005) and a lack of these social experiences may prevent the adult horse from being kept with peers.

Adequate housing conditions, in terms of opportunities for social interaction, can also affect reactions of young horses to training. Data from Søndergaard and Ladewig (2004) and Rivera et al. (2002) revealed that young horses kept in groups adapted more easily to initial training and showed lower frequencies of unwanted behaviour than singly kept horses. Recent results from Lesimple et al. (2011) showed that keeping adult riding school horses in groups during daytime lowered their reactivity levels, which the authors pointed out would have potentially positive consequences for human safety.

Furthermore, group rearing has been reported to encourage movement (Heleski et al., 2002; Hoffmann et al., 2006; Jørgensen and Bøe, 2007; Søndergaard, 2003), which has been linked to enhance musculoskeletal development (Lepeule et al., 2009; van Weeren et al., 2010). Play, in particular, gives young horses an opportunity to acquire and improve motor skills, as well as enhancing their social behavioural repertoire (Cameron et al., 2008; Crowell-Davis et al., 1987; Kurvers et al., 2006; Waring, 2003). Scientific enquiries have also confirmed that confinement and lack of social contact in horses, among other management factors, are associated with the development of stereotypes such as weaving, box walking or crib-biting (Bachmann et al., 2003; Cooper and Albentosa, 2005; Henderson, 2007; McGreevy et al., 1995; Nicol, 1999; Visser et al., 2008). Stereotypic behaviour and other abnormal behaviours that occur in stabled horses have never been observed in their feral counterparts (Feh, 2005).

Despite the above arguments for keeping horses in groups, the majority of horses are kept singly for large parts of the day (Bachmann and Stauffacher, 2002; Petersen et al., 2006; Søndergaard et al., 2004). Competition horses, especially, are often confined in single boxes and turned out individually on paddocks (Henderson, 2007), whereas young stock is the category of horses most commonly kept in groups over the entire 24-hour period (Petersen et al., 2006; Søndergaard et al., 2004; Waran, 2001).

The question, therefore, remains of why keeping horses in groups is not more widely applied in practice? One possible answer is that this is due to the horse owners concerns. The risk of injury during social interactions may be taken as one argument, among others, against keeping horses in groups (Mejdell et al., 2010). However, this argument contradicts with findings from recent research where it has been indicated that injuries from agonistic interactions or play in stable groups of horses are not a problem (Grogan and McDonnell, 2005; Jørgensen et al., 2009; Lehmann et al., 2006). Even competition horses can be permanently kept in groups with no negative consequences on performance (Arnemann, 2005; Gerken et al., 1996). Nevertheless, a recent survey on owners' attitudes to keeping horses in groups in the Nordic countries had revealed that injury risk remains a concern (Keeling et al., unpublished results). Other concerns may be related to the perceived difficulties of feeding (Fleege, 1990; Kreimeier et al., 2005), decreased resting times (Fader and Sambraus, 2004; Zeitler-Feicht et al., 1998) and when introducing new horses into established groups (Hartmann et al., 2011b). These concerns will be discussed in more detail later.

Clearly, experimental work addressing these concerns is warranted to counterbalance some of the negative effects that may emerge from suboptimal management of group kept horses. Therefore, the aim of this review is to give an overview of the current scientific knowledge on keeping horses in groups and to give suggestions for future research for areas where scientific enquiry is sparse.

2. Group composition

Horse owners tend to keep horses in homogeneous groups with regard to age and sex in an attempt to ease management and avoid potential injury from aggressive or playful interactions (Jørgensen et al., 2009). Yet, the consequences of keeping horses in more artificial group structures than would be expected under free-ranging conditions have not been thoroughly studied.

Under free-ranging conditions, the typical reproductive social unit consists of a relatively stable association of mares, their pre-dispersal offspring and one or more

stallions (reviewed in Feist and McCullough, 1976; Linklater, 2000). Occasionally, harem bands are seen without the company of a stallion (Waring, 2003). Other group types are the bachelor band and the mixed sex peer band of non-breeding juvenile horses and subadults (Salter and Hudson, 1982; Waring, 2003).

Under domestic conditions, it is common practice that horse breeding establishments keep mares together with their foals until the foals are weaned, usually between 4 and 6 months of age (Parker et al., 2008; Waran et al., 2008). Afterwards, weanlings are commonly housed with peers of the same sex and age until they enter training (Gibbs and Cohen, 2001; Rose-Meierhöfer et al., 2010b). The majority of mature stallions are usually kept physically separate from other horses, either in total isolation or with very restricted physical contact to box and paddock neighbours (Irrgang and Gerken, 2010; Pollmann, 2003). Even breeding is often done in-hand rather than allowing the stallion to run freely with the mare (McDonnell, 2000). Non-breeding mares and geldings tend to be kept in separate groups, but mixed sex groups also occur in practice (Pollmann, 2006; Rose-Meierhöfer et al., 2010a).

The tradition of keeping stallions isolated and under very restrictive conditions is likely to compromise welfare (Kiley-Worthington, 1997). It may contribute to the development of stereotypic behaviour, but it may also lead to increased aggression towards other horses and humans (Goolsby et al., 2004; Irrgang and Gerken, 2010), to self-mutilation (McDonnell, 2008) or reduced reproductive efficiency (McDonnell, 2000). The most plausible reason for keeping stallions separated from mares is to prevent uncontrolled reproduction. That they also tend to be separated from other males may be to suppress their natural tendencies to show intermale aggression, as dominance relationships are more frequently challenged among male horses than females (Heitor and Vicente, 2010). Also, breeding stallions can have a high economical value, which possibly leads owners to try to protect them from injuries by keeping them singly. However, several studies have shown that sexually mature and immature stallions (resembling bachelor bands seen in the wild) can be successfully kept together with few injuries occurring as a result of aggressive encounters (Christensen et al., 2002; Heitor and Vicente, 2010; McDonnell and Haviland, 1995; Tilson et al., 1988). Furthermore, allowing the stallion to breed by giving it free contact to mares has been documented to significantly reduce unwanted behaviour according to Irrgang and Gerken (2010).

The splitting of geldings and mares into separate groups tends to be done to suppress sexually related behaviour by geldings towards mares. Over-bonding has been described as the cause for a gelding to aggressively guard a female in a case study by Houpt (1993), and mounting by geldings of mares can also occur (Rios and Houpt, 1995). Higher levels of aggression and mounting are certainly a result of the sexual experience geldings may have gained prior to castration (van Dierendonck et al., 1995). Despite the fact that some individuals, like highly sexual geldings, can potentially cause problems, keeping horses in mixed sex groups did not seem to impact behaviour when studied under diverse practical conditions by Jørgensen et al. (2009). The authors did not find any significant differences in the frequencies of aggressive interactions in mixed sex groups compared to groups comprising mares or geldings only. Neither were geldings reported to affect mare behaviour negatively, or to interfere in the mare-foal bonding and subsequent maternal care in a free ranging herd of Icelandic horses (van Dierendonck et al., 2004). Furthermore, Wood-Gush and Galbraith (1987) did not observe that the high proportion of geldings (11) kept with two mares on small pasture altered the social behaviour of this group.

However, Jørgensen et al. (2009) recorded less play behaviour in mare groups than in groups comprising geldings only and when horses were kept in mixed sex groups. This relationship between sex and play was also evident in Icelandic horses studied by Sigurjonsdottir et al. (2003) and Welsh pony foals by Crowell-Davis et al. (1987). Colts seemed to engage in more interactive play bouts than fillies and, with increasing age, horses spent less time playing (Kurvers et al., 2006). Most injuries in race-bred weanlings were attributed to horses playing (Gibbs and Cohen, 2001). The potential risk of injuries from play tends to reinforce the horse owners' beliefs that play should be prevented by keeping horses solitary (Goodwin and Hughes, 2005). What seems to be neglected is the importance social play serves for the development of social as well as physical motor skills, including the role it serves for social bonding and group cohesion (Fraser, 1992; Goodwin and Hughes, 2005; Ladewig et al., 2005). Although most horses prefer a play partner of the same sex and similar age and to bond with conspecifics within their sex and age class (Goldschmidt-Rothschild and Tschanz, 1978; Kimura, 1998; Sigurjonsdottir et al., 2003), keeping horses in more complex groups has additional benefits.

Experienced adult horses can be regarded as essential in regulating the behaviour of young horses and for providing role models for the appropriate use of signalling in a social context later in life (Bourjade et al., 2008, 2009a; Khalil and Kaseda, 1998). After the introduction of foreign adults into homogenous groups of 1- and 2-year-old horses, the number of preferred partners and positive social interactions increased, whereas the number of agonistic interactions decreased (Bourjade et al., 2008). Age is a determining factor in rank (Houpt et al., 1978; Keiper and Sambraus, 1986; van Dierendonck et al., 1995), thus different age classes may contribute to clearer dominance relationships as was hypothesised by Christensen et al. (2002) and Sigurjonsdottir et al. (2003) so potentially minimising overt aggressive interactions. An exception may be the rank position in male horses, as this seems to depend on previous sexual experience (van Dierendonck et al., 1995).

In summary, keeping horses in mixed age groups has clear advantages, especially for young horses. The benefits of introducing horses of the opposite sex into a group are less clear. Although mixed sex groups can function well, keeping weanlings with the opposite sex is not common practice because of problems expected when reaching sexual maturity. However in practice, foals are usually weaned early compared to the later dispersal of juvenile horses under free-range conditions and so probably lack the mixed sex and mixed age interactions they would otherwise have experienced. What remains unclear is the time frame under

which young horses should be exposed to different age (and possibly sex) classes to sufficiently prepare them for being kept in groups as adults. Adult mares and geldings can be kept together, but individual characteristics, particularly of geldings should be taken into consideration when forming mixed sex groups. More scientific focus could be devoted to practical solutions of keeping breeding stallions with conspecifics.

3. Group size

Under feral conditions, group size in horses is self regulated, based on individual decisions to leave or stay with the group, environmental conditions, birth rate or mortality and is consequently unlikely to be stable (Boyd and Keiper, 2005). Family band size can vary from 2 to 35 horses (Boyd and Keiper, 2005; Linklater, 2000), although fewer than 10 horses is most common (Feist and McCullough, 1976; Waring, 2003). Bachelor bands usually do not exceed 17 horses (Boyd and Keiper, 2005; Linklater, 2000), and similar group sizes were reported for mixed sex peer bands by Goldschmidt-Rothschild and Tschanz (1978). Very large numbers of horses can also cohabit, in which case they consist normally of discrete bands including solitary roaming individuals (Goldschmidt-Rothschild and Tschanz, 1978; Waring, 2003; Wernicke and van Dierendonck, 2003).

In the domestic environment, group size is determined by human management and space constraints. Pollmann (2006) gives an average group size of 8.5 horses, ranging from 2 to 60 horses kept in the same group in loose housing systems. Data from a Nordic survey from Keeling et al. (unpublished results) revealed a group size of fewer than five horses to be most common.

Studies have been conducted with farm animals, but there seems little evidence for an optimal group size in any social species, probably because what is 'optimal' depends on so many factors. On the one hand, it was hypothesised that more agonistic interactions would occur in large groups because dominance relationships cannot be established nor maintained with all group members (Estevez et al., 2007). On the other hand, it has been proposed that the number of agonistic interactions would decrease as the number of potential competitors increases because individuals would move from investing in dominance relationships to alternative, non-aggressive strategies (Estevez et al., 2007). Although, there is agreement that avoiding fights is adaptive (Færevik et al., 2007; Rodenburg and Koene, 2007), inquiries about how many individuals can be recognised are scarce (Croney and Newberry, 2007) and may not necessarily relate to optimal group size in any case.

Keeping an even number of horses in a group had been suggested to facilitate pair-bonding (McGreevy, 2004) which promotes group stability (Waring, 2003). Yet, there are no experimental studies in horses supporting this and it may only be relevant for very small groups with restricted choices for preferred partners. There is also no evidence for sub-grouping behaviour in response to large groups of horses in captivity. Again, this may not have any functional significance in practice since groups of horses are usually small compared to the large group sizes routinely used in farm animals. Although, as stated previously, some individual pairs of horses may be found closer together than expected in a group.

What becomes apparent from research is that large group sizes combined with high densities (the number of animals per unit of space) are likely to increase physical and behavioural indicators of poor welfare in many species. Benhajali et al. (2008) observed a high density herd (200 mares/ha) of 44 Arab breeding mares kept in a barren paddock. The mares restricted their social interactions to agonistic behaviours with a total absence of positive social interactions (e.g. allogrooming) and maintenance behaviour (e.g. lying down, rolling). Rose-Meierhöfer et al. (2010b) studied the effect of different group sizes (8, 11 and 23 horses) on activity, body condition and social behaviour of yearlings and 2-year-old horses kept in homogeneous groups. The authors recorded higher frequencies of aggressive behaviour and increased locomotion in the largest group whereas group size did not affect body condition scores. However, Rose-Meierhöfer et al. (2010b) had not considered space allowance in their analyses and acknowledged that insufficient space in the largest group may have influenced results. An experiment by Kusunose et al. (1986), who pastured yearling horses singly and in groups of up to 12 individuals in fields of 2.4 ha each, indicated constant mean distances to the nearest neighbour, irrespective of group size; however, group members were generally more spread out when group size increased. In addition to spacing patterns, locomotion and grazing behaviour was recorded, but no reference was made to social interactions in these groups of horses.

Besides space allowance, another aspect confounding group size may be related to group composition. Rutberg and Greenberg (1990), for example, noted an increase in aggression between feral pony mares with increasing group size, which they explained by possible competition between mares due to the presence of a stallion.

Since experimental approaches to study the impact of group size on horse behaviour are rare, and comparisons between studies confound effects of space restrictions and group composition, controlled studies are warranted.

4. Change of group membership

Change of group membership is a natural process in the wild. Even if harem bands seem to be relatively stable compared to other group formations (Waring, 2003), group members do not remain together for life and it is mainly juvenile horses leaving the natal band (Boyd and Keiper, 2005; Kaseda et al., 1997; Waring, 2003).

Under domestic conditions, horses are faced with social challenges throughout their lives, given that they are regrouped, moved to another yard or sold. Unstable social groups contribute to the higher aggression levels observed in domestic horse groups compared to their feral counterparts (Waran, 2001; Waring, 2003).

In general, meeting unfamiliar conspecifics typically leads to aggression (Addison and Baker, 1982; Erhard and Mendl, 1997; Mench et al., 1990; Tennessen et al., 1985) as the group's social structure becomes disrupted and individuals are seeking a new or defending their old position. Since position in the dominance hierarchy has been correlated

with time of residency in horses (van Dierendonck et al., 1995), newcomers are normally at a social disadvantage in that resident animals almost always behave aggressively towards intruders (Alexander and Irvine, 1998; Hartmann et al., 2009).

Little information is available on the time frame for individuals to familiarise and the time point when a group can be regarded as socially stable. Kondo and Hurnik (1990) defined it as the time when non-physical agonistic interactions predominate and when the ratio of physical to non-physical interactions remains relatively stable. Literature reveals changes in interaction patterns returning to basic levels between 1 and 2 weeks after grouping cattle (Hasegawa et al., 1997; Kondo and Hurnik, 1990; Tennessen et al., 1985). Søndergaard and Turner (2008) suggested a time frame for horses to become familiar with new group members of around 1 week, which was indicated by reduced greeting behaviour and decreased distances between horses. Related to this is the question of how long horses have the ability to recognise conspecifics after prolonged separation, as this could influence the level of aggression when reunited. This is of practical relevance when horses may be away for training or a breeding season. McDonald and Warren-Smith (2010) tested this ability between related and unrelated mares and foals when meeting after more than 1 year of separation. Although agonistic interactions occurred in all meetings, members of related dyads showed more greeting approaches and had greater distances prior to agonistic encounters, suggesting not only that they were able to recognise each other, but also that injury risk is potentially lower if related horses are grouped. But whether the same would apply to familiar, but unrelated horses is not known.

4.1. Method of grouping

Clearly, introducing a new group member into an established group is a stressful event for all individuals involved, but predominantly for the one being introduced. Overt aggression after grouping can increase the risk of physical injuries, which remains a major welfare concern. As a stable social hierarchy is likely to help prevent injuries, several authors suggest avoiding frequent regrouping (Fürst et al., 2006; Knubben et al., 2008). However, often mixing cannot be avoided. The question arises of how integration of newcomers into a group can be done with the lowest possible risk of dominance related aggression.

One possible approach to introduce unfamiliar horses to each other is by first placing them in neighbouring boxes that allow limited contact through the box partition. During this pre-exposure, it is assumed that horses will have the possibility to gain information about each other through visual, olfactory, auditory and the restricted physical assessment, and that is likely to modify social interactions when the individuals meet freely later on. The idea of information gathering originated from game theory models. These models examined how different assessment strategies might be used by each contestant to adjust the costs and benefits of engaging in a fight to reduce energy expenditure and risk of injury or even death (Arnott and Elwood, 2009; Maynard Smith, 1974).

Findings from experimental resident-intruder tests in different species, for example in rainbow trout (*Oncorhynchus mykiss*; Johnsson and Åkerman, 1998), pigs (Jensen and Yngvesson, 1998), elephants (*Loxodonta africana*; Burks et al., 2004), hamsters (*Mesocricetus brandti*; delBarco-Trillo et al., 2009) and in horses (Hartmann et al., 2009) all revealed that animals engaged in fewer aggressive interactions when they met after being pre-exposed in neighbouring pens compared to individuals that lacked this experience. Pre-exposing young horses to each other in neighbouring boxes for 5 min before they met in a paddock reduced biting and tended to reduce contact aggression (bite, kick, strike, push), i.e. the category of behaviour that carries a higher risk of physical injury (Hartmann et al., 2009). But when this study was replicated with older horses, pre-exposure failed to have an effect on subsequent aggression (Hartmann et al., 2011b). Possible reasons for this difference may be that the benefit of pre-exposure is less pronounced in older horses who were socially more experienced in meeting unfamiliar conspecifics. This may be supported by Rutberg and Greenberg's (1990) observations of feral ponies, where younger mares tended to be more aggressive when establishing rank while aggression declined when mares grew older. Alternatively, the duration of the pre-exposure used in Hartmann et al. (2011b) may have been too short for these older horses. Nevertheless, interacting in boxes is unlikely to be a substitute for gaining full physical contact when establishing a relationship (Christensen et al., 2002; Hartmann et al., 2011b).

Another question that arises is whether it is preferable to introduce a new horse to each resident group member separately or to introduce it into the entire group at once. There is disagreement between horse owners as to which method is best in terms of lower aggression, and there are few, if any, science based recommendations available. Results from a German survey revealed that the new horse was immediately put together with the entire resident group in 65% of the yards (64 respondents, 1165 horses; Pollmann, 2006) whereas survey data from Keeling et al. (unpublished results) showed that only 40% of horse owners (3230 respondents, 15 133 horses) preferred this approach. Unfortunately, neither study gives information on why horse owners preferred one mixing method over the other.

Brent et al. (1997) recorded higher aggression levels during paired encounters of chimpanzees (*Pan troglodytes*) than when a newcomer was introduced to the larger resident group directly. They hypothesised that the more defensive behaviour of the resident animal during paired meetings was due to the lack of social support, which would otherwise be present in group introductions. Social support could lower stress responses by the mere presence of, or interactions with familiar conspecifics (Wiepkema and Schouten, 1990). The effect of a paired encounter versus triadic encounters, where the unfamiliar horse met a pair of familiar horses was investigated by Hartmann et al. (2011b). The authors came to the conclusion that one triadic meeting was better than two separate dyadic meetings, based on their observation that the level of aggression received by the new horse was not significantly different in either of the mixing methods. If two or more animals

need to be introduced simultaneously into a resident group, then differences in the frequencies of social interactions after grouping can be expected (Bøe and Færevik, 2003). The newcomers will usually form subgroups, regardless of familiarity prior to introduction, and this tends to reduce the involvement of subgroup members in social interactions with resident animals, as was shown in cattle and pigs (Durrell et al., 2003; Knierim, 1998).

Since there can be strong social ties between familiar horses, especially between mares (Carson and Wood-Gush, 1983), the introduction of unfamiliar conspecifics may lead to horses interfering in dyadic interactions in an attempt to safeguard already existing relationships (Schilder, 1990; van Dierendonck et al., 2009). Interventions have mainly been studied systematically in primates, whereas quantitative studies in equines are sparse. Hence, it would be of interest to gain more insight into the circumstances in which interventions occur and the functions it serves when grouping horses (Hartmann et al., 2011b).

In conclusion, giving unfamiliar animals the opportunity to familiarise in an environment that allows first assessment yet restricts full physical contact, has been proven successful in reducing aggression in several social species, including young horses. However, more scientific insight is needed, for example, on the duration and form of the pre-exposure. Although there has been much work done on horse temperament, a horse's aggressive tendencies towards conspecifics has hardly been studied experimentally. In pigs, for example, different studies have documented consistent individual differences in aggressiveness towards meeting unfamiliar conspecifics (D'Eath, 2002; Hessing et al., 1993). In horses, Christensen et al. (2011) and Hartmann et al. (2009) showed that some individuals acted more aggressively than others towards meeting conspecifics. Being able to identify these characteristics could benefit individuals by adjusting mixing methods, especially for those horses that are less flexible in their responses to changes of social partners.

4.2. Repeated grouping

The importance of early social experience was discussed in previous paragraphs. In this section, research on the effects of exposing animals to repeated grouping is presented. It is discussed whether horses may adapt to repeated grouping and whether this has the potential to improve social skills in horses that were not reared in groups. Interestingly, given the practical relevance of this question, this has hardly been looked at from an experimental perspective.

Studies on cattle give contradictory results on the benefits of frequent regrouping on social behaviour (Gupta et al., 2008; Raussi et al., 2006; Veissier et al., 2001). Data from Kondo et al. (1984) and Veissier et al. (2001) indicate that repeated mixing reduced agonistic interactions and that animals seemed to habituate to the mixing processes. On the contrary, this was not supported by Raussi et al. (2006) who observed that repeated grouping of heifers consistently induced agonistic interactions. In a study by Christensen et al. (2011), group membership was shifted every week. The horses did not seem to become accustomed to this repeated grouping as no significant reduction of aggressive encounters was observed with increasing number of grouping events. This lack of habituation was also found by Hartmann et al. (2009). Although horses were flexible in their behaviour towards meeting unfamiliar opponents, results did not reveal an effect of time on aggression during the six paired encounters (Hartmann et al., 2009). It may be that, given the social organisation of horses, it is not adaptive to become accustomed to meeting new horses. Alternatively, it may be that a reduction in aggressive interactions only occurs when the animals are inexperienced with social interactions at the start of the study. If the individuals are already socially competent, as they were in both horse studies, then there may be no further benefit of repeated grouping.

5. Human–horse interactions

The development and maintenance of a positive human–horse relationship is essential in order to decrease horse related accidents and reduce negative states of horse welfare (Hausberger et al., 2008). Several elements influence the relationship, such as early experience and training (Fureix et al., 2009; Henry et al., 2006; Sankey et al., 2010), breed and temperament (Hausberger and Muller, 2002; Lesimple et al., 2011), and even chronic discomfort (Fureix et al., 2010). Other important elements are environmental factors such as housing conditions, including the possibility for social contact with other horses (Lesimple et al., 2011; Søndergaard and Ladewig, 2004).

5.1. Handling horses in groups

Most studies on human–horse interactions have focussed on measuring the reactions of a single horse towards a human whereas very little work has established tools to assess the reactions to humans in a social context, i.e. when horses are kept in a group (Hausberger et al., 2008). Søndergaard and Halekoh (2003) found that singly kept horses showed more interest in approaching a human and were more easily approached by the experimenter in their home environment than group housed horses. This has also been found, for instance in cattle (Raussi, 2003). However, as Søndergaard and Halekoh (2003) have pointed out, the type of contact singly kept horses were motivated for (e.g. biting) is certainly undesirable from the human's perspective. In the paragraphs below, we reflect upon some possible determents of reactions of horses to humans and on ways of safely approaching and handling horses in groups.

Verrill and McDonnell (2008) have studied compliance with catching in 104 domestic and semi-feral horses and ponies approached at pasture. They focused on the effect of human-to-horse eye contact on catching outcome, so no reference was made to other conditions that could have influenced the catching process. Almost all subjects were either consistently approachable or unapproachable regardless of maintaining or avoiding eye contact (Verrill and McDonnell, 2008). Jørgensen et al. (2011) and Hartmann et al. (unpublished results) studied the reactions of other horses in the group and the ease of catching and

removing a horse from its group. This situation is commonly argued to constitute an increased safety risk for the human as other horses of the group could interfere in the catching process. Even though Jørgensen et al. (2011) suggested that risk of injury to humans is overestimated, they found that in 25% of 100 occasions when one horse was being removed from its social group, other horses interacted with the human and the horse being led. By dividing the catching process into distinct phases, Hartmann et al. (unpublished results) found that the risk for the human was potentially higher, as estimated by the number of horses within one horse length, when the human was standing still in the paddock. Presumably, this was because it allowed other horses of the group to approach and is in keeping with the fact that risk was estimated to be least when walking the horse to the gate. In this situation, other horses spread out as they followed the horse being led and its handler at different speeds (Hartmann et al., unpublished results).

Since it is a natural tendency in horses to show synchronised activity and coordinated patterns of movements to promote group cohesion, the questions remains of how group dynamics impact on human–horse interactions, as horses may follow the horse being led and, as a result of this, will interfere with the handling of other horses in the group. The rules underlying group decision-making processes around collective movements are much debated in the scientific community. It has been proposed that a combination of different factors determine whether an individual will follow an initiator of movement or not. These include social status and affiliative relationships (King, 2010; Petit and Bon, 2010), the number of individuals already moving (Bourjade et al., 2009b; Bourjade and Sueur, 2010; Pillot and Deneubourg, 2010) and distances between individuals (Ramseyer et al., 2009). Although there seemed to be an effect of the proportion of the group that was being removed on whether or not horses followed, there was no effect of social rank of the target horse that was being followed by the remaining group members in the horse study by Hartmann et al. (unpublished results). This corresponds with findings from Pillot and Deneubourg (2010) who could not show that dominance was a prerequisite for the initiator of movement to being followed in sheep. The consequences of removing either high or lower ranked horses from their group may possibly be overestimated by horse owners, but needs further investigation in larger groups.

Considering the practical relevance of improving ways of safely approaching and handling horses kept in groups, it would be important to elaborate on the various effects of handling routines on the motivation of horses to approach or avoid humans.

5.2. Handling horses away from conspecifics

Living in groups has clear survival value for horses and other social species because of mutual vigilance and protection against predators. Therefore, any situation that prevents expression of the horses' natural tendency to rejoin the group (i.e. being isolated) can be experienced as negative if the horse has not been specifically trained for this. Behavioural reactions to separation will influence the horse's manageability and impair safe handling.

Typical behaviours associated with separation and isolation in horses are neighing (whinnying), snorting, defecation, increased locomotion, pawing and taking a vigilant posture (Harewood and McGowan, 2005; Lansade et al., 2008; Visser et al., 2008). However, the magnitude of the reaction can vary considerably between individuals due to genetics, temperament, age, experiences during early development and it is continuously modulated (Moberg, 2000). Jørgensen et al. (2011), for instance, recorded a higher arousal and increased locomotion in young compared to older horses when placed out of sight from remaining group members. A horse's reaction towards separation and temporary isolation from conspecifics can be diminished through appropriate habituation training, and this was probably the case in the older horses studied by Jørgensen et al. (2011).

In an attempt to increase training efficiency and aid the habituation process, Hartmann et al. (2011a) trained naive young horses to tolerate separation from their group by training them initially in the presence of a familiar companion. There is clear scientific evidence that behaviour of individuals can be influenced by the mere presence of conspecifics in different test situations (Boissy and Le Neindre, 1990; Christensen et al., 2008; Færevik et al., 2006). However, in the case of social separation, no benefit of starting the training with a companion was found, as the horses tested by Hartmann et al. (2011a) seemed to have to relearn being in the training situation in the absence of the partner when switching to the individual training. Nevertheless, the pair training was probably experienced as less stressful (according to lower heart rate measurements), which confirms the overall calming effect of a companion.

In modern horse husbandry, there are many situations in which horses need to be separated from peers, e.g. for training purposes, veterinary treatments, transport, etc. It seems, therefore, important to identify appropriate tools to train horses to separation in the least stressful, but most efficient way possible.

6. Housing design

Group composition and stability, group size, space allowance and feeding regime are all variables that influence the functioning of any group housing system in any species. Some of these aspects have already been discussed, but will be reviewed in the following paragraphs with specific reference to the design of group housing systems and to management aspects, such as the feeding regime. We will not discuss the semi extensive, free ranging systems used for parts of the year in some countries.

There are numerous housing systems in which horses can be managed in groups. Many horses are kept in groups during the daytime and stabled singly in boxes during nights. If they spend the entire 24-h period together, horses can be kept indoors in group boxes, indoors with access to an outside paddock or pasture, or outdoors (Pirkelmann, 1991; Arnemann, 2005). The so called 'Active stable®' takes the concept of group housing a step further

in that it stimulates activity in horses by dividing the home area into functional areas for roughage and concentrate intake, water intake, resting and open areas for locomotion (Gieling et al., 2007; Rose-Meierhöfer et al., 2010a).

Aggressive social interactions resulting from competition over limited resources remain a concern in all group housing systems; in farm animals specifically because of the clear link between feed intake and productivity, but also in horses. As in other social species, high ranking horses in a group might have prioritised access over restricted feed sources and may monopolise feeding places (Ellard and Crowell-Davis, 1989; Fleege, 1990; Ingólfsdóttir and Sigurjónsdóttir, 2008; Lehmann et al., 2003). Lower ranked horses are at a disadvantage and may not be able to satisfy their nutritional demands. Furthermore, if horse groups are heterogeneous with regard to age and exercise levels, the provision of individually calculated feed rations may be required. The latter has been partly solved by using automatic feed dispensers, where animals are electronically recognised via a transponder in a head collar (Bockisch et al., 2007; Vervuert and Coenen, 2002). But with automatic feeding stations, usually only one or very few animals are able to feed at a time and it is known that synchronisation and social facilitation of feeding are important facets of group life (Nicol, 1995; Sweeting et al., 1985; Rifá, 1990). Alternatively to automatic feed dispensers, horses may be tied up individually during concentrate feed intake or fed in stalls.

What is well accepted from research in farm animals is that sufficient feeding space per animal is paramount to limit competition. In cows, increased space allowance at the feeding place reduced competition and increased feeding activity, especially in subordinate cows (DeVries et al., 2004; Huzzey et al., 2006). Conversely, the horses studied by Kreimeier et al. (2005) showed less synchronised behaviour and occupied the feeding area even when no roughage was available when there was less than one feeding place per horse.

To further reduce competition at feeding sites, the installation of head barriers has been suggested to provide some physical protection from neighbouring feeding animals, in particular feeding in subordinate horses (Holmes et al., 1987). A wire barrier was regarded as most effective as it allowed horses to see at all times the reactions of the neighbouring conspecific compared to a wooden barrier that blocked visual contact (Holmes et al., 1987).

The use of barriers, in general, has been suggested as a way to structure barren environments and allow individuals to retreat and avoid escalation of aggression. Yet, the effects in farm animals are contradictory and are confounded with space, and the effects of partitions of various kinds on behaviour have yet to be evaluated in horses kept in groups.

Another aspect frequently discussed in group housing systems for farm animals is their lying behaviour. This has received comparatively little attention in horses and the welfare consequences of reduced lying times are not clear (Chaplin and Gretgrix, 2010). Reduced lying times have been associated with low ranked animals and reduced space allowance in horses (Fader and Sambraus, 2004; Zeitler-Feicht et al., 1998), but also in ewes (Bøe et al., 2006) and calves (Færevik et al., 2008). Reduced space, in turn, was correlated with an increased number of displacements in the lying area and less synchronised lying behaviour (Bøe et al., 2006; Færevik et al., 2008). Some low ranked horses were not seen to lie down at all for several days when kept together in a loose housing system (Fader and Sambraus, 2004). Young horses generally lie down more than older horses (Hoffmann et al., 2009; Rose-Meierhöfer et al., 2010b; Zeitler-Feicht et al., 1998) and they are also likely to lie closer together.

A final area related to housing that would potentially benefit from more research is the fencing design, especially around the gate area, to ease handling and increase safety measures. A common assumption is that accidents to humans happen near the gate of the paddock when a horse is being released into a group or is being removed from the paddock. Horses do occasionally manage to escape at the same time as a horse is being led out (Jørgensen et al., 2011; Hartmann et al., unpublished results), thus installing a sluice may be one practical solution (Jørgensen et al., 2011).

Although innovative housing designs for horses exist in practice, little experimental work has addressed how well they function. Feeding regimes and resting behaviour in permanently group housed horses remain areas of concern and would clearly benefit from more empirical and controlled investigation.

7. Conclusions and perspectives

The authors argue that the domestic environment should, whenever possible, offer horses the opportunity to socialize with other horses. This can best be achieved by keeping horses in groups. There may not be one best method that should be chosen in practice, because factors such as available space, feeding regime or individual horse characteristics must be taken into account. However, this review has revealed that, despite the ample work done in other species related to keeping animals in groups, there is insufficient scientific data on horses. This lack of knowledge may hinder objective decisions in practice that could optimize management and thereby ultimately improve and safeguard horse welfare and human safety. It is a particular problem when, unlike the people responsible for the majority of other farm animals species, who have farm animal management as their profession, the majority of people with responsibility for horses are keeping them for leisure purposes.

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