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Effects of individual versus group stabling on social behaviour in domestic stallions

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Abstract

Domestic horses (*Equus caballus*) are typically kept in individual housing systems, in which they are deprived of physical contact. In order to study the effects of social restrictions on behaviour in young horses, nineteen 2-year-old stallions were housed either singly ($n = 7$), or in groups of three ($n = 12$) for 9 months. Subsequently, the stallions were released into two separate 2 ha enclosures according to treatment, and recordings were made on social interactions and nearest neighbours during a 6-week-period, 28 h per week. Previously group stabled stallions frequently had a former group mate as their nearest neighbour ($P = 0.001$), whereas previously singly stabled stallions did not associate more with their former box neighbours, to whom physical contact was limited by bars during the previous treatment. The nearest neighbour was more frequently recorded to be within one horselength of singly stabled than of group stabled stallions ($P = 0.005$). More aggressive behaviour was recorded in the group of previously singly stabled stallions, i.e. bite threats ($P = 0.032$), whereas group stabled stallions tended to make more use of subtle agonistic interactions (displacements, submissive behaviour). Singly stabled stallions also responded to the 9 months of social deprivation by significantly increasing the level of social grooming ($P < 0.001$) and play behaviour ($P < 0.001$), when subsequently interacting freely with other horses. The increased occurrence may relate to a build-up of motivation (a rebound effect), as well as to external factors, such as playful pasture companions and the increased space allowance of the pasture. It is concluded that 2-year-old domestic stallions are sensitive to social deprivation and that stabling has long-term effects, lasting 6 weeks at least, on the social behaviour in stallions.

Keywords: Horse; Individual stabling; Group stabling; Social behaviour

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1. Introduction

Many housing systems for husbandry species restrict space and often do not allow the animals to perform activities that are seen under natural conditions, e.g. locomotion and social behaviours. In assessing the effects of confinement on behaviour and welfare, knowledge of how specific behaviours are motivated is important. One way of measuring an animal's motivation is to give it opportunity to perform a response and then see how much or for how long the behaviour is performed. An increased occurrence of specific behaviours (a rebound) after a period of prevention has been shown in a variety of species, e.g. play and locomotion behaviour in calves by Dellmeier et al. (1985) and Jensen (1999); dustbathing, wingflapping, etc. in laying hens by Vestergaard (1980) and Nicol (1987); social play in rats by Hole (1991). This phenomenon, often referred to as 'rebound effect', may indicate that the behaviour is influenced by internal causal factors, which build-up during times of prevention (Manning and Dawkins, 1998). Work by Mal et al. (1991) showed a rebound in locomotion behaviour in an open-field test after short-term confinement of mares, whereas only little focus has been on the effects of restrictions on social behaviour in horses.

In its natural environment the horse is a social animal, spending most of its time in close contact with conspecifics. The most common groups of horses are harem groups, consisting of one stallion and several mares with offspring. Young stallions leave their natal herd at approximately 2 years of age and group into bachelor groups. Solitary horses are only rarely seen as even older stallions with breeding experience, which have lost their herd in an encounter with another stallion, tend to join bachelor groups (Tyler, 1972; Klingel, 1975; Feist and McCullough, 1976; Waring, 1983; Boyd and Houpt, 1994; Kaseda et al., 1997; Khalil and Kaseda, 1997). Under domestic conditions, the predominant housing system is individual stabling, which limits contact between horses. Especially stallions are regarded as aggressive towards one another and are therefore often kept individually in stables and paddocks. However, Luescher et al. (1991) state that a lack of social contact may be one of the most serious stressors in horses, and that if normal social behaviour is prevented, this behaviour may be redirected towards less suitable objects. Canali and Borroni (1994) reported a higher frequency of abnormal behaviour in stallions than in mares and suggested this to be due to stallions being kept in single stables in fear of injury. Houpt (1983) and Houpt and McDonnell (1993) reported that self-directed aggression almost exclusively occur in stallions. They further report that all stallions showing the behaviour were confined in stalls and that releasing the stallion to pasture conditions or providing it with a stall companion reduce the incidence of the behaviour.

The aim of the present study was to investigate the effects of long-term individual stabling on the social behaviour in young, domestic stallions.

2. Materials and methods

2.1. Animals

Nineteen 2-year-old stallions, offspring from four nationally approved Danish Warmblood breeding stallions, were used in this experiment. The experimental stallions were

born in the spring of 1997, weaned at approximately 4 months of age and housed in the same stable, either individually or in groups at the Danish Institute of Agricultural Sciences as part of a larger project on the effects of handling and social environment. In the summer of 1998 all stallions were allowed unlimited social contact on pasture during a 3-month-period, whereupon they returned to the stable and were housed as previously, either singly (limited social contact, $n = 7$) or in groups of three (unlimited social contact, $n = 12$) for the following 9 months. Animals were assigned randomly to treatment, but balanced according to sire and age.

2.2. Experimental design

Singly stabled stallions ($n = 7$) were kept in 3.6 m × 2.5 m boxes with vertical bars spaced 0.08 m apart separating neighbouring horses. The bars allowed visual and auditory communication between stallions, and tactile communication through the bars with at least one neighbour, but no full contact interactions. The stallions had access to 20 m × 40 m paddocks for 3 h every day, one stallion per paddock, separated by an electric wire fence system allowing no physical contact between horses. Group stabled horses ($n = 12$) were kept in groups of three in 5.6 m × 4.8 m boxes with vertical bars spaced 0.08 m apart separating the boxes. The stallions had access to 40 m × 90 m paddocks for 3 h every day, one group per paddock.

The two treatment groups were housed on straw bedding and fed a mixture of grass silage, barley straw, hay, concentrate and molasses ad libitum. As part of the other project, three of the seven singly stabled and six of the twelve group stabled stallions were handled systematically three times per week for 10 min, whereas the others received a minimum of handling prior to the study. Since nearly the same proportion of animals in each treatment group were handled, handling is not included in the statistical analysis. Prior to the observations, all horses were marked with hydrogen peroxide on the barrel on both sides for recognition.

In May 1999, the horses were released in two separate 2 ha enclosures with the previously singly stabled stallions grouped in one enclosure, and the previously group stabled stallions in another (first grouping). A 1.5 m high and 0.5 m wide electric wire fence separated the enclosures. The pasture contained abundant and evenly distributed grass, human disturbance was minimised, and the horses received no additional food or attendance. Water and minerals were available ad libitum. On day 48, the two groups of stallions were joined by removal of the fence, resulting in one common 4 ha enclosure (second grouping) (Table 1).

2.3. Data collection

The effects of individual versus group stabling on social behaviour were measured by recording the frequency of social interactions between stallions from the two treatment groups when allowed unlimited social contact on pasture. Associations between stallions as well as group spacing were studied using nearest neighbour recordings. Behavioural data were collected during 192 h of direct observation, using check sheets, in which initiator and recipient were identified (Martin and Bateson, 1993), and following a pre-determined

Table 1
Experimental design and data collection

Period	Event	Observations
May–August 1998	All stallions at pasture	
Treatment period (September 1998–May 1999)	Stallions stabled either singly or in groups	
Immediate responses to social novelty (first grouping)		
Day 1	Stallions released in two separate	Social interactions (3 h per group)
Day 2	enclosures according to treatment	Social interactions (3 h per group)
Long-term responses (6-week-period)		
Days 5–47		Social interactions (72 h per group) Nearest neighbours (12 h per group; 144 recordings per horse)
Immediate responses to social novelty (second grouping)		
Day 48	Joining of the two treatment groups	Social interactions (3 h per group)
Day 49		Social interactions (3 h per group)

observation plan with separate observations of social interactions and nearest neighbours. Immediate responses to social novelty were measured by recordings on social interactions the first 3 h following grouping (day 1), and again for 3 h, 24 h after grouping (day 2). These recordings were repeated on days 48 and 49 after removal of the fence between the two treatment groups (Table 1). The recordings for the 6-week-period began in the morning of day 5, that is the horses had time to get accustomed to their new environment and establish the dominance hierarchy, which normally happens within a few days (Waring, 1983; Tilson et al., 1988). During the 6-week-period, recordings were made on social interactions and nearest neighbours (Table 1). The observer easily recognised horses by numbers, coat colour, size and individual marks from an observation caravan situated just outside the enclosure.

Social interactions were 'displacement' (the approaching behaviour of one horse, which causes another to retreat without overt aggression, also termed 'supplant'), 'mouth clapping' (submissive behaviour, also termed 'snapping'), 'threat to bite', 'threat to kick', 'bite', 'kick', 'push', 'play fight' (high intensity; includes rearing, boxing, circling, dancing, chasing, kneeling), 'play' (low intensity; includes nipping and grasping), 'social (or mutual) grooming', 'mounting', 'nasal sniff', 'genital sniff', 'body sniff', and 'greeting behaviour' (a sequence of olfactory investigation, described in Estes, 1991); all other definitions are based on desorptions in McDonnell and Haviland (1995). According to Waring (1983), displacements and submissive behaviour are defined as subtle or mild agonistic interactions, threats are defined as mid level, whereas high level agonistic interactions are those involving direct physical contact, such as bites and kicks. Social interactions were recorded by continuous recording for three successive hours per group per day. Activity patterns of horses vary during the day (Boyd and Houpt, 1994; Berger et al., 1999) and to ensure an even distribution of observations, each week in the 6-week-period contain observations between hours 6–9, 10–13, 15–18 and 19–22; 12 h per group per week.

Nearest neighbours were recorded by focal sampling, in which the nearest (first neighbour) and second nearest neighbour (second neighbour) of each horse were recorded every 10 min for 1 h, 4 days per week; in total 144 recordings of neighbours for each horse. As recordings on neighbours in an active group of horses can be very difficult to obtain, the recordings were carried out during the mid-day hours, between 13 and 15 h, which usually is a time of inactivity in horse groups (Boyd and Houpt, 1994; Berger et al., 1999). The first neighbour of a particular horse was defined as the horse with any part of its body closer than any other animal to the head of the focal animal; the second neighbour was likewise the second nearest horse (Wells and Goldschmidt-Rothschild, 1979). The distance between neighbours was estimated as within one horselength (<1.5 m), more than one horselength but less than 5 m (1.5–5 m), or more than 5 m away (>5 m). At a distance of less than a horselength horses can interact physically without moving. Within a distance of 1.5–5 m a neighbour horse is likely to respond to for instance a threat, whereas horses are less likely to interact at distances of more than 5 m. The recording interval of 10 min was chosen in accordance with results from Wells and Feh (unpublished, quoted by Feh, 1988), showing that the probability of having the same nearest neighbour drops drastically after 8 min. An interval of 10 min should therefore guarantee a certain independence of the samples.

2.4. Data analysis

Data from social interactions were analysed by use of the *t*-test (*t*-values are given with degrees of freedom, *t*(d.f.)). In cases where data failed normal distribution, and for neighbour test data, non-parametric methods were applied, such as Mann–Whitney *U*-test (MWU), Wilcoxon signed rank test (WSR), Kruskal–Wallis test (KW) and Spearman rank order correlation (SRC) (Siegel and Castellan, 1988), calculated in the computer software SAS 6.12 (SAS Institute, 1996) and SigmaStat 2.0 (SPSS Inc., 1997). For non-parametric test results the test abbreviation is given.

Data on social interactions in the 6-week-period was adjusted for potential time of day effects by summing data into weeks, i.e. for each group 'week 1' contains data from the 12 observation hours on that group during the first week after release; that is hours 6:00–9:00, 10:00–13:00, 15:00–18:00 and 19:00–22:00. Likewise, 'week 2' contains the behavioural data from week 2 and so forth.

3. Results

3.1. Immediate responses to social novelty (first grouping)

The previously singly stabled stallions engaged in more interactions than did the previously group stabled stallions (Table 2). Singly stabled stallions investigated more; nasal sniff ($t(17) = 7.10$; $P < 0.001$) (Fig. 1, first grouping), body sniff (MWU, $P < 0.001$), and greeting behaviour ($t(17) = 3.97$; $P = 0.001$). They also showed an increased level of aggressive behaviour; threat to bite (MWU, $P < 0.001$), threat to kick (MWU, $P = 0.031$), and play fighting (MWU, $P < 0.001$) (Fig. 2, first grouping). For the remaining behaviours, no significant differences were found between the treatment groups (Table 2).

Table 2
Mean occurrence of recorded behaviours by treatment group[a]

	Immediate responses of first grouping (6 h/treatment group)		Period of 6 weeks summed (72 h/treatment group)		Immediate responses of second grouping (6 h/treatment group)	
	Singly	Group	Singly	Group	Singly	Group
Behaviour						
Displacement	2.0 ± 1.7	4.0 ± 2.9	14.7 ± 8.0	33.6 ± 23.8	0.6 ± 0.2	10.6 ± 10.1
Mouth clapping	1.1 ± 1.1	2.9 ± 0.9	8.0 ± 7.7	23.8 ± 9.3	3.3 ± 1.6	1.3 ± 0.7
Bite threat	5.7 ± 1.8	0.2 ± 0.1**	36.0 ± 8.8	17.2 ± 3.5*	1.3 ± 0.5	0.5 ± 0.3
Kick threat	6.3 ± 2.1	2.3 ± 0.6*	20.9 ± 5.0	19.8 ± 3.3	1.6 ± 0.7	0.6 ± 0.2
Bite	1.4 ± 0.8	0.8 ± 0.5	19.0 ± 5.7	10.9 ± 3.2	2.9 ± 1.1	1.3 ± 0.4
Kick	1.0 ± 0.4	1.2 ± 0.7	4.3 ± 1.5	6.2 ± 1.2	0.7 ± 0.3	0.4 ± 0.2
Push	0.6 ± 0.4	0.1 ± 0.1	4.1 ± 1.9	2.2 ± 0.5	0.3 ± 0.2	0.2 ± 0.2
Play fighting	35.1 ± 4.8	3.2 ± 0.6**	80.3 ± 5.7	62.8 ± 5.0*	6.6 ± 1.5	2.5 ± 0.8*
Social grooming	0.0	0.2 ± 0.1	81.7 ± 9.4	9.2 ± 2.7**	0.1 ± 0.1	0.1 ± 0.1
Play	0.0	0.3 ± 0.2	117.1 ± 14.9	59.8 ± 3.8**	5.3 ± 1.0	2.9 ± 0.6*
Mounting	0.7 ± 0.7	0.3 ± 0.2	2.9 ± 0.9	7.3 ± 2.2	0.1 ± 0.1	0.3 ± 0.2
Nasal sniff	76.9 ± 4.5	30.5 ± 4.2**	89.1 ± 7.8	93.2 ± 6.4	25.6 ± 2.2	14.4 ± 1.3**
Body sniff	16.7 ± 2.1	3.3 ± 0.7**	85.0 ± 10.6	69.3 ± 7.0	9.9 ± 1.2	6.3 ± 1.1
Genital sniff	1.1 ± 0.6	0.0	8.7 ± 2.3	7.4 ± 1.3	0.6 ± 0.3	0.3 ± 0.3
Greeting	8.3 ± 1.3	3.0 ± 0.7**	3.1 ± 0.8	5.8 ± 1.0	2.4 ± 0.5	1.4 ± 0.5

[a] Values listed are mean ± S.E.M.
* Significant difference between groups at $P < 0.05$.
** Significant difference at $P < 0.01$.

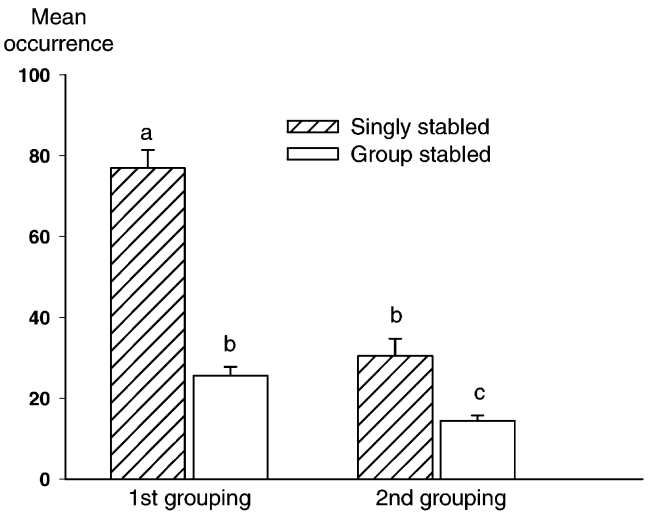

Fig. 1. Nasal sniffing (mean ± S.E.M.) in previously singly and group stabled stallions immediately after (first grouping) and 6 weeks after the release on pasture (second grouping). Group means with different letters differ at $P < 0.05$.

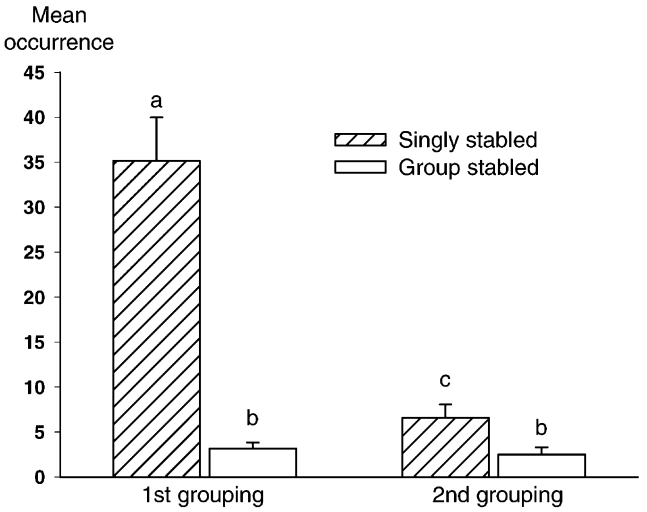

Fig. 2. Play fighting (mean ± S.E.M.) in previously singly and group stabled stallions immediately after (first grouping) and 6 weeks after the release on pasture (second grouping). Group means with different letters differ at $P < 0.05$.

3.2. Long-term responses (6-week-period)

3.2.1. Social interactions

Singly stabled stallions responded to the 9 months of limited social contact by increasing the level of interactions as compared to group stabled stallions. Data from the 6-week-period (Table 2) show that singly stabled stallions engaged in more friendly interactions, i.e. social grooming (MWU, $P < 0.001$) (Fig. 3) and play behaviour ($t(17) = 4.70$; $P < 0.001$) (Fig. 3). The higher level for singly stabled stallions remains throughout the 6-week-period. Likewise, an increased level of the higher intensity play fighting existed in singly stabled stallions over the weeks ($t(17) = 2.22$; $P = 0.040$) (Fig. 3). Group stabled stallions tended to make more use of low intensity agonistic interactions, i.e. 'displacements' and the submissive behaviour 'mouth clapping' (MWU, $P = 0.057$, Fig. 3). More mid- and high-intensity agonistic behaviour was recorded in the group of previously singly stabled stallions, i.e. threats to bite ($t(17) = 2.33$; $P = 0.032$) (Fig. 3), and a tendency towards bite ($t(17) = 1.36$; $P > 0.05$) (Fig. 3). No significant differences were found between the two treatment groups in the level of investigative behaviours (nasal sniff, body sniff, genital sniff, and greeting behaviour) (Table 2). There was no significant increase or decline in the occurrence of any of the recorded behaviours during the 6-week period.

3.2.2. Neighbour relationships and group spacing

A former group mate was frequently the nearest neighbour of previously group stabled stallions (median (25–75% quartiles); known 32 (22–42) versus unknown 9 (7–11); WSR, $P = 0.001$), whereas previously singly stabled stallions did not associate more with their

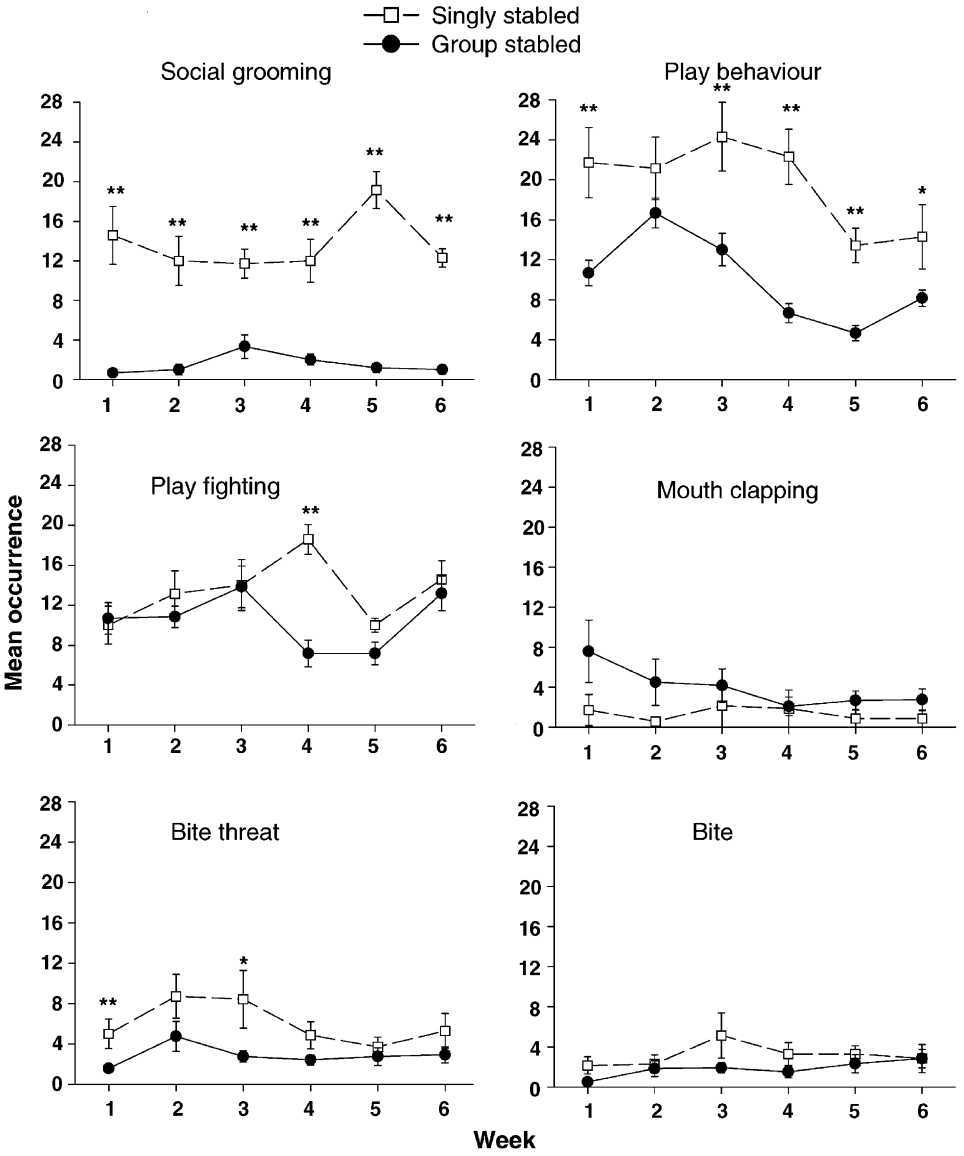

Fig. 3. Mean occurrence (±S.E.M.) of six social interactions in previously singly and group stabled stallions in 6 successive weeks on pasture: (∗) significant difference between groups at $P < 0.05$; (∗∗) significant difference at $P < 0.01$.

former box neighbours (median (25–75% quartiles); known 24 (22–47) versus unknown 24 (19–25); WSR, $P = 0.844$), whom they had been able to see and smell, but not interact with during the previous treatment (Fig. 4).

The nearest neighbour was more frequently recorded to be within one horselength of singly stabled than of group stabled stallions (median (25–75% quartiles); singly 101

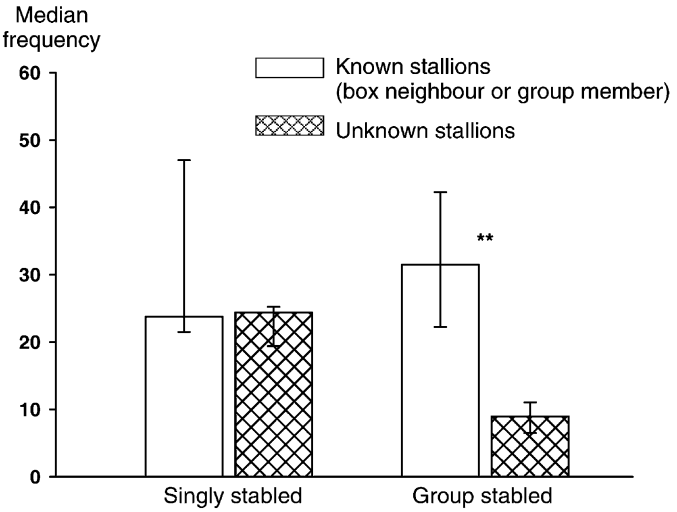

Fig. 4. Associations between stallions. Frequency of nearest neighbours being 'known stallions' (previous box neighbour for singly stabled, and previous group member for group stabled) or 'unknown stallions'. Medians and 25–75% quartiles are given: (**) significant difference between 'known' and 'unknown' at $P < 0.01$.

(95–112) versus group 78 (74–89); MWU, $P = 0.005$), i.e. stallions that had been deprived of physical contact stayed closer together after regaining access (Fig. 5).

A positive and significant correlation was found between the frequency of being nearest neighbours and grooming partners in group stabled stallions (SRC, $r = 0.29$, $P = 0.02$), whereas for singly stabled stallions, the correlation was only weakly positive and not significant (SRC, $r = 0.16$, $P > 0.05$).

3.3. Immediate responses to social novelty after 6 weeks on pasture (second grouping)

When the two groups of differently stabled stallions were joined after 6 weeks of unlimited social contact on pasture, responses of the previously singly stabled stallions were less severe than upon the release from the stable (Table 2). There were still significant differences between the two treatment groups in the occurrence of play fighting ($t(17) = 2.66$; $P = 0.017$) (Fig. 2, second grouping) and nasal sniffing ($t(17) = 4.69$; $P < 0.001$) (Fig. 1, second grouping). The level of play fighting in the singly stabled stallions was, however, significantly lower than during the first grouping ($t(12) = 5.63$; $P < 0.001$), whereas there was no change in the level of play fighting in the group stabled ($t(22) = 0.66$; $P = 0.519$) (Fig. 2). For nasal sniffing, both groups of horses showed a significantly lower level after the 6 weeks on pasture (for singly stabled: $t(12) = 10.2$; $P < 0.001$; for group stabled: $t(22) = 3.64$; $P = 0.001$) (Fig. 1). In addition, a difference was found in the occurrence of play behaviour, as singly stabled stallions were more playful than group stabled ($t(17) = 2.14$; $P = 0.047$). For the remaining behaviours, no significant differences were found between the treatment groups upon the second grouping.

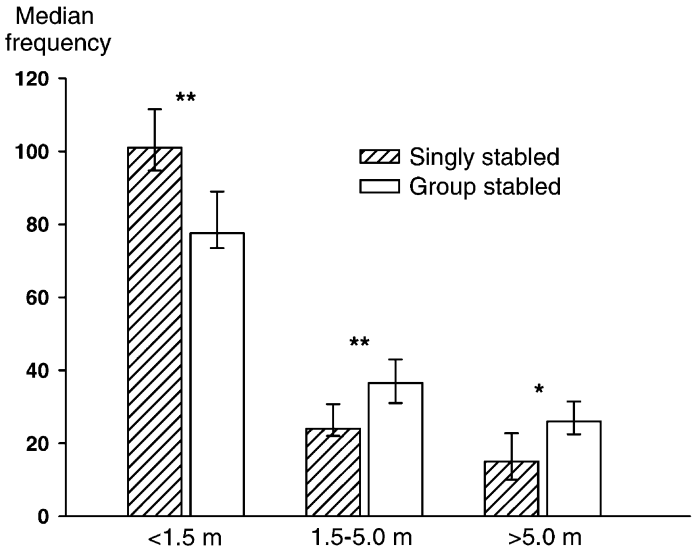

Fig. 5. Distance between nearest neighbours in previously singly and group stabled stallions. Medians and 25–75% quartiles are given: (∗) significant difference between groups at $P < 0.05$; (∗∗) significant difference at $P < 0.01$.

4. Discussion

4.1. Immediate responses to social novelty

Singly stabled stallions responded more strongly to meeting unknown stallions than did group stabled stallions. Apart from a higher level of investigative behaviours, they also showed a higher level of aggression and play fighting. Increased levels of play fighting after periods of social deprivation have also been reported in other species, for instance in rats and hamsters (Panksepp and Beatty, 1980; Ikemoto and Panksepp, 1992; Guerra et al., 1999), and has been suggested to be a response to a build-up of motivation during the deprivation period. In equids, play fighting is a high intensity behaviour, which includes elements of real fighting, such as rearing, boxing, and chasing. In the present study, most of the observed vigorous fighting is believed to be playful rather than agonistic, but on a few occasions it was observed that a seemingly playful interaction turned into real fighting. However, no distinction was made between the behaviours 'fight' and 'play fight' in the recordings. Although free-living equids rarely hurt each other seriously even in real combat (Klingel, 1967; Waring, 1983), the vigorous rearing, boxing and chasing, which characterises the behaviour, does carry a risk of injury, and the occurrence of play fighting is one of the main reasons why domestic horses are kept physically separated.

Results from the second grouping showed that the 6 weeks of unlimited contact with conspecifics on pasture reduced the responses to social novelty in singly stabled stallions, i.e. their level of play fighting was significantly lower, whereas the level in group stabled stallions had not changed significantly. This indicates that the previous stabling conditions

account for some of the more severe responses in singly stabled stallions during the first grouping.

4.2. Long-term responses (6-week-period)

4.2.1. Friendly contact behaviours

The increased level of friendly contact behaviours (play behaviour and social grooming) shown by stallions that had been deprived of physical contact (singly stabled) may indicate a build-up of motivation for performing these behaviours. Play behaviour is believed to play a major role in the behavioural, social and physical development of the individual, and it may serve to strengthen bonds between individuals (Fagen, 1981). Play behaviour has been suggested to be an indicator of good welfare and playing may have reinforcing properties, i.e. the performance may be associated with positive feelings (Fagen, 1981; Jensen, 1999). It has previously been found that animals deprived of the opportunity to play are highly motivated to play (Dellmeier et al., 1985; Jensen, 1999; Hole, 1991) and preventing animals from playing may therefore have implications for their welfare. Social grooming in horses is believed to serve at least two functions: coat care and social affiliation (Feist and McCullough, 1976; Waring, 1983; Crowell-Davis et al., 1986; Boyd and Houpt, 1994; Kimura, 1998). Feist and McCullough (1976) and Kolter and Zimmermann (1988) suggested that grooming may also be an appeasement gesture, and Hogan et al. (1988) found an increasing level of social grooming with decreasing enclosure size in Przewalski horses in zoos, and suggested that grooming may play an additional role as means of reducing stress. As the horses during this study were maintained in large (2 ha) enclosures with abundant and evenly distributed amounts of grass, it seems reasonable to exclude the possibility that the horses were stressed due to limited space or food resources during the observation period. Since social grooming also serves as a means of bonding, it seems possible that singly stabled stallions, which knew none of their new pasture companions, used grooming as a way of getting to know each other. If mainly used in establishing bonds between individuals, one would expect a decrease in grooming levels as the stallions got to know each other and dominance relationships got settled within the group, which normally happens within a few days (Tilson et al., 1988). However, no decrease in grooming levels occurred during the 6 observation weeks, indicating that social affiliation is not the major explanatory reason. Crowell-Davis et al. (1986) found that colts rarely groomed with other colts, which corresponds well with the observed low level of grooming in group stabled stallions in this study, and indicates that the high level in singly stabled stallions most probably is a consequence of previous restrictions.

Increased occurrences of specific behaviours after a period of prevention has been referred to as a ‘rebound effect’, that is when given the opportunity the animal ‘compensates’ for prolonged non-performance by increasing the performance of a behaviour (Nicol, 1987; Manning and Dawkins, 1998). Kennedy (1985) and Nicol (1987) stress the importance of distinguishing between the process of recovery, where the frequency of a behaviour returns to its original level but no higher, and cases of post-inhibitory rebound, where the level of performance of a behaviour is observed to rise above this initial level. In this experiment, the level of social grooming and play behaviour in singly stabled stallions

rose to a significantly higher level than that observed in non-deprived, group stabled stallions. The increase in occurrence may relate to a build-up of motivation (Dellmeier et al., 1985; Mal et al., 1991; Ikemoto and Panksepp, 1992; Manning and Dawkins, 1998; Jensen, 1999), to a higher sensitivity to external releasing stimuli or novelty responses (Murphy and Wood-Gush, 1978; Hughes, 1980; Mal et al., 1991; De Passillé et al., 1995; Jensen, 1999). As the increased levels of play behaviour and social grooming in singly stabled stallions lasted throughout the 6-week-period, a novelty response is not the major explanatory reason. External factors, such as playful pasture companions and other horses initiating grooming as well as the increased space allowance of the pasture probably affect the behaviour of stallions in addition to their motivation.

Most studies on rebound effects have been on locomotion behaviour and have focused on the immediate or short-term responses of the animals in, for instance, an open-field test (e.g. Dellmeier et al., 1985; Mal et al., 1991; Jensen, 1999). Traditionally, rebounds in behaviour are characterised also by their recovery process, but, unlike rebounds in locomotion and feeding behaviours which cease as the animals get satiated, elevated levels of social behaviour may persist for a longer period. Hole (1991) studied the effects of short-term deprivation of social contact on social play in rats in a 24 h post-deprivation period, and found elevated levels of play behaviour which, however, tended to be rather short-lived, in that the most dramatic increase in play persisted only for 40 min. It seems possible, though, that the decrease after 40 min may be due to fatigue in the observed animals, and as the study period lasted for 24 h only, the level of social play in the deprived animals on following days is unknown. In the present study, the increased levels of social grooming and play behaviour in singly stabled stallions do not decrease within the observation period of 6 weeks, suggesting that the effects are either long-term, that is, it takes more than a 6-week-period for the behaviours to return to a level seen in non-deprived, group stabled stallions, or that the deprivation has led to a lasting higher level in the affected animals.

4.2.2. Agonistic interactions

Group stabled stallions tended to make more use of mild agonistic interactions (displacements, submissive behaviour) than did stallions that had been deprived of physical contact. This supports the findings of Jensen (1984), who found an increasing level of submissive behaviour with decreasing level of confinement in sows. Broom and Leaver (1978) suggested that the retreating behaviour of calves, which had been spatially isolated for 8 months, in encounters with group-reared calves were due to their lack of skills in dealing with encounters. Warnick et al. (1977) likewise related competitive inability to a lack of experience in isolated calves as compared to group-reared calves. A well-developed social language in which dominance is communicated via subtle interactions may reduce the costs and risks of fighting, which is of importance to horses in fluctuating social environments. The tendency towards group stabled stallions making more use of low intensity agonistic interactions therefore calls for further research into the effects of social restrictions on the development and use of social behaviour in horses.

Possibly in accordance with a low level of subtle dominance interactions, more mid- and higher-level aggressive behaviour, bite threats and bites, were recorded in the singly stabled stallions. Confined sows have likewise been reported to be more aggressive towards

conspecifics than de-confined sows (Jensen, 1984), and dairy bulls to be less aggressive to other cattle and man if kept in groups rather than isolated during rearing or adulthood (Fraser and Broom, 1997).

4.2.3. Neighbour recordings

Authors studying associate relationships have reported that most horses show preferences for certain individuals, that is they spend more time in proximity with some horses than with others (Waring, 1983; Feh, 1988; Ellard and Crowell-Davis, 1989; Kimura, 1998). Group stabled stallions were found to associate more with their previous group members than with any other horses, whereas singly stabled stallions did not show preferences for their previous box neighbours, whom they could see and smell, but not interact with physically during the previous treatment. This indicates that unless full physical contact is obtained, neighbouring horses do not associate with one another, and thus full scale body contact seems to be a major component of social behaviour in horses, and in the building of relations.

4.2.4. Group spacing

The reduced distance between neighbours in singly stabled stallions indicates that horses, which have been deprived of physical contact, respond by gathering into tighter groups when regaining access to other horses. This result is in contrast to the findings of Broom and Leaver (1978), who found that when grouped, isolation-reared calves spent more time alone than group-reared calves. In contrast to this study, in which the stallions had unlimited contact to conspecifics on pasture prior to the deprivation period, calves were reared in isolation from an early age with possible ontogenic deficiencies.

There may be a strong coherence between the tighter group structure in singly stabled stallions and the increased level of interactions, as horses which stay close together are more likely to interact and vice versa (Wells and Goldschmidt-Rothschild, 1979; Ellard and Crowell-Davis, 1989).

4.2.5. Associate relationships

Both nearest neighbour and grooming relationships have been regarded as indicative of companionship, and Clutton-Brock et al. (1976) found that free-ranging Highland ponies spent more time close (<15 m) to the partner with which they most frequently exchanged grooming. Likewise, Dierendonck et al. (1995) found that proximity (less than two horselengths) and social grooming were strongly correlated. In contrast, Kimura (1998) found no correlation between nearest neighbours and social grooming partners in free-ranging horses, and suggested that the nearest neighbour relationship and social grooming relationship are independent features. In the present study, a positive correlation between frequency of being nearest neighbours and grooming partners existed for group stabled stallions, whereas these did not correlate for singly stabled stallions. However, in 42.9% of singly stabled stallions the most frequent nearest neighbour was also the preferred grooming partner, whereas the percentage in group stabled was slightly lower, 33.3%. The results should be interpreted with caution, however, since group stabled stallions groomed infrequently and the high level of grooming in singly stabled stallions may result from the previous treatment, that is, it may not reflect associate relationships.

4.3. Confounding factors

The number of individuals in a group may affect the level of interactions within groups, which is particularly important in comparisons between small and large groups. In the present study, however, both treatment groups exceed the most commonly recorded natural group size of four or five individuals (reviewed by Waring, 1983). Phillips (1998, 2000) discusses the constraints and possible inaccuracies of using individual animals of a social group in analyses of social behaviour compared to using group means. The behaviour of dominant animals probably influences the behaviour of others, and for behaviours such as displacement and mouth clapping, statistical results are influenced by a large source of variation, since dominant and high ranking individuals did not show submissive behaviour, and low ranking animals did not displace others. Included in the experimental design is also the confounding effect of singly stabled stallions knowing none of their new pasture companions, whereas group stabled stallions know their previous group members. The effect of this fact on the behaviour in stallions is unknown, but the effect is discussed for behaviours which are traditionally connected with social affiliation (Section 4.2.1). Likewise, the fact that a proportion of individuals of each group were handled systematically for 10 min; 3 days per week during the treatment period may contribute to variation within the groups, although there was no significant effect of human handling on social behaviour in the present study. The limited number of handled and non-handled individuals within the groups (for singly stabled; three handled versus four non-handled stallions) makes the design of the present experiment unsuitable for studying the effects of human handling on behaviour towards conspecifics.

5. Conclusions

Differences in social behaviour, lasting longer than should be expected for novelty reactions, was found in young domestic stallions following a 9-month-period of social deprivation due to individual stabling, compared to stallions which were group stabled in the same period. Previously singly stabled stallions stayed closer together after regaining access to other horses on pasture. Group stabled stallions were found to associate with their previous group members, whereas singly stabled stallions did not associate more with their previous box neighbours, indicating that full scale physical contact is necessary for the formation of associative relationships. Singly stabled stallions showed more aggressive behaviour towards other horses, but they also engaged in more friendly interactions. Six weeks of unlimited social contact on pasture reduced the responses to social novelty in singly stabled stallions when confronted with unknown horses. It is concluded that stallions are sensitive to social deprivation and that stabling has long-term effects, lasting 6 weeks at least, on the social behaviour in stallions.

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