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Exploring aggression regulation in managed groups of horses *Equus caballus*

Abstract. Horses are highly social animals that have evolved to live in social groups. However, in modern husbandry systems, single housing prevails where horses experience social isolation, a challenge-to-welfare factor. One major reason for this single housing is the owners' concerns that horses may injure each other during aggressive encounters. However, in natural conditions, serious injuries due to aggressive encounters are rare. What could therefore explain the claimed risks of group living for domestic horses? Basing our questioning on the current knowledge of the social life of horses in natural conditions, we review different practices that may lead to higher levels of aggression in horses and propose practical solutions.

Observations of natural and feral horses mostly indicate a predominance of low frequencies and mild forms of aggression, based on subtle communication signals and ritualized displays and made possible by group stability (*i.e.* stable composition), dominance hierarchy and learning of appropriate social skills by young horses. Obviously, adults play a major role here in canalizing undesirable behaviours, and social experience during development, associated with a diversity of social partners, seems to be a prerequisite for the young horse to become socially skilled.

Given the natural propensity of horses to have a regulation of aggression in groups, the tendency to display more aggression in groups of domestic horses under some management practices seems clearly related to the conditions offered. We therefore review the managing practices that could trigger aggressiveness in horses. Non social practices (space, resource availability) and social practices (group size, stability of membership, composition and opportunities for social experiences during development) in groups of domestic horses are discussed here.

Finally, we propose simple practical solutions leading to more peaceful interactions in groups of domestic horses, based on the knowledge of horses' natural social life which therefore should be enhanced (*e.g.* ensuring roughage availability, favouring group stability,, introducing socially experienced adults in groups of young horses;...). The state of the art indicates that many questions still need to be answered. Given the importance of the associated welfare issues and the consequences on the use of horses, further research is required, which could benefit horses... and humans.

Key-words: horses; social behaviour; aggression regulation; coping in group; management; social development

1. Introduction

Horses (*Equus caballus*) are highly social animals that have evolved to live in groups (*e.g.* Linklater, 2000; Waring, 2003). However, group housing remains limited in the domestic situation, especially in the case of valuable sport horses.

One reason is the owners' concerns that horses may injure each other during aggressive encounters (*e.g.* Grogan and McDonnell, 2005; Hartmann et al., 2009; Hartmann et al., 2011; McDonnell and Haviland, 1995). Thus, in modern husbandry systems, single box housing prevails where horses experience both social isolation and confinement. The prevalence of weaving especially has been shown to relate to lack of social contact (Benhajali et al., 2010; Cooper et al., 2000), and a mirror or a poster of a horse have proved to diminish the frequency of this undesirable behaviour (McAfee et al., 2002). Social deprivation also leads to aggressive behaviours when horses are confronted again to conspecifics, and to undesirable behaviours at work (*e.g.* biting, kicking humans during training, Rivera et al., 2002; Sondergaard and Halekoh, 2003; Sondergaard and Ladewig, 2004).

Given the importance of the practical and welfare issues associated with social isolation, an evaluation of the costs and benefits of group housing in domestic horses is needed. Inspections of a semi-feral herd of ponies on 4 occasions over a period of 28 months revealed that all injuries and blemishes were minor, most likely from glancing contact of hooves or teeth rather than frank bite or kick wounds (Grogan and McDonnell, 2005). In Feist's (1971) 6-months study of Pryor Mountain horses, 35 out of 270 animals died from infected injuries, only three of which were potentially due to complications of injuries from aggressive interactions. In 509 hours of observation on 78 feral horses, Berger (1977) revealed that nearly half of the 20 inter-band agonistic interactions did not even lead to a fight. In natural conditions, serious injuries due to aggressive encounters are rare even in bachelor male groups or during encounters between family stallions and intruders (Feh, 2005; Tilson et al.,

1988). Low levels of injury are also reported in domestic horses in semi-natural conditions (*e.g.* kept in stable social groups in appropriately spacious fields with foraging opportunities and watering sites), even if there are less quantitative data in these populations. For instance, McDonnell and Haviland (1995) kept together in pasture groups of 3 to 20 mature pony stallions and reported remarkably few and generally minor injuries despite sometime “spectacular” inter-male interactions (see also Christensen et al., 2002a).

In light of the relatively low levels of aggression in naturally living horses, how can the perceived risks of group living for domestic horses, especially stallions, be explained? Basing our questioning on the current knowledge of the social life of horses (wild, feral and domestic) in natural conditions, we thereafter review the different factors that may lead to higher levels of aggression in some domestic situations and propose practical solutions.

2. The social organization of horses in natural conditions

Horses are group-forming equids, with a long lasting bond observed between adults (*e.g.* Waring, 2003) and a constant type of social organization across populations despite different environmental and demographic characteristics (*e.g.* Linklater, 2000). The socioecology of horses has been extensively described and we are just giving a brief account here. Feral and Przewalski horses are organized in long-lasting non-territorial reproductive associations, the so-called family band. Family band size has been reported to vary from 2 to up to 30 individuals, the most common size being 4-6 individuals (Waring, 2003). Under natural conditions horses (including non breeding stallions) tend to associate in groups characterized by their high stability. Overall, aggression rates are rather low in natural conditions (Table 1) and as mentioned above, wounds are rare. Four factors can be indentified that may contribute to explain these findings.

2.1. Stable group composition

Family bands are made up of one to several unrelated adult mares, one to a few stallions (long term stable nucleus), and their immature offspring (foals and one- to three-year old young horses) (*e.g.* Berger, 1986; Boyd and Keiper, 2005; King, 2002; vanDierendonck et al., 1996; review in Boyd and Keiper, 2005 and Feh, 2005). In family groups where more than one stallion is present, one is dominant with a privileged access to breeding and the others are subordinate (*e.g.* Linklater and Cameron, 2000; Salter and Hudson, 1982). However, tolerance between them is high and some authors have suggested that they form alliances to protect the group (Berger, 1986; Feh, 1999; Keiper, 1976) although this remains controversial (Linklater et al., 1999). Adult horses tend to form dyadic social bonds (mare-mare, stallion-mare and stallion-stallion, Feh, 1999) mostly characterized by spatial proximity (preferential closest neighbours) but also reciprocal positive interactions (*e.g.* allogrooming). Young horses of both sexes leave their natal band at sexual maturity, usually around 2-3 years old, thus remaining with their mares beyond physical dependence. Non-breeding males can be solitary but are more often observed in bachelor groups of 2 to more than 15 stallions (*e.g.* Berger, 1986; Feh, 1999). Bachelor groups are less stable than family bands. To our knowledge, the age at the time of first acquisition of a harem is around 5 years (reviewed in Boyd and Keiper, 2005); suggesting that non-breeding males are prone to stay 2-3 years in a bachelor band. However, long-term dyadic associations between stallions have been reported (*e.g.* Berger, 1977; Bourjade et al., 2009a; Feh, 1999; Salter and Hudson, 1982). Finally, family bands may group temporarily with other bands, especially in winter when risks of predation may increase. The stability of group membership (at least between adults) allows each horse to know the social status of others and to behave accordingly, sometimes without the need for a dominant to give any aggressive signal (Berger, 1977; Heitor et al., 2006; Wells and Goldschmidt-Rothschild, 1979).

2.2. Stable dominance hierarchy

Another major factor involved in the regulation of aggression is the dominance hierarchy, where the knowledge of each other's dominance status makes novel challenges useless (Berger, 1977; Heitor et al., 2006; Wells and Goldschmidt-Rothschild, 1979). As much broadly defined, the function of dominance would be to regulate conflicts over coveted resources of any kind, lowering aggressiveness and social tensions as the result of the predictability of contest outcomes (Rutberg and Greenberg, 1990), thus reducing the risk of injury while interacting (Bourjade et al., 2009a; Keiper and Sambraus, 1986).

In natural horse societies, stable linear dominance hierarchies are formed with occasional reversals and triangles (Feh, 2005; feral horse: Houpt and Keiper, 1982; Keiper and Sambraus, 1986; Tyler, 1972; Wells and Goldschmidt-Rothschild, 1979; Przewalski horse: Boyd and Houpt, 1994; Feh, 1988). Dominance gives a priority of access to limited resources (water, food...) and therefore may be difficult to observe in environments where food (*e.g.* grass) is uniformly distributed or water easily accessible. Moreover, once established, the dominance relationships are maintained by both spontaneous avoidances by subordinates and low intensity threats by dominants (Berger, 1977; Wells and Goldschmidt-Rothschild, 1979). Behaviours such as "bite-threats", "head-threats" and "avoid" appear as better indicators of dominance than actual "attack", "kick" and "kick threats" which show more rarity or directional inconsistency (Heitor et al., 2006; vanDierendonck et al., 1995).

Dominance rank in horses does not depend upon size or weight (Feh, 1990). Age and anteriority in the group (*i.e.* higher length of residency in the group) seem to be major determinants (Monard et al., 1996). Stallions may or may not be dominant over mares (*e.g.* Berger, 1977; Keiper and Sambraus, 1986; Stevens, 1988; Wells and Goldschmidt-Rothschild, 1979). Stallions' herding behaviour, where they chase back their females to the group, has been interpreted as an aggressive act and sign of dominance by some authors (Mc

Donnell and Haviland, 1995; Miller, 1981) but rather as a sexual behaviour by others (Keiper and Sambras, 1986). As in other species (*e.g.* pigs: Bolhuis et al., 2005, carnivorous: Sands and Creel, 2004, birds: Poisbleau et al., 2006; Verbeek et al., 1999), dominance rank is not or very weakly correlated with the relative aggressiveness of horses (*e.g.* Berger, 1986; vanDierendonck et al., 1995; Wells and Goldschmidt-Rothschild, 1979; Przewalski horse: Bourjade et al., 2009b; Feh, 1988), meaning that dominant horses are not necessarily the most aggressive individuals. Dominance rank differs from “leadership” where some individuals are more followed than others towards resources (Bourjade et al., 2009b; Wells, 1978) and are not related.

2.3. Ritualised communication

Given this long term associations between group members, horses have developed a complex social and communication system based on close associations between few partners (Feh, 2005). Field observations suggest individual recognition (*e.g.* Feh, 1999; Feist and McCullough, 1976), an ability now supported by experimental data on domestic horses (Lemasson et al., 2009; Proops et al., 2009). Horses have a repertoire of graded visual signals that enable other animals to assess the intentions of the emitter (Feh, 2005; Kiley-Worthington, 1976; Waring, 2003). Examples of displays and their gradations are given in Waring (2003), while an ethogram of aggressive behaviours has been proposed by McDonnell and Haviland (1995). Ritualized displays may, as in other species (*e.g.* Sebeok, 1979), be useful substitutes to real aggressions. This is especially the case for stallion-stallion encounters that involve ritualized interactive sequences (McDonnell and Haviland, 1995; Waring, 2003).

Aggression in horses varies from low to high intensity and takes the forms of non-contact aggressions represented by threats to bite or threats to kick, and physical aggressions such as

bites, kicks, chases or attacks. Patterns of aggressive interactions are characterised by a fixed ears backward position, sometimes reaching the flattening of ears against the top of the neck (Feist and McCullough, 1976). Agonistic interactions act at increasing distance between two opponents either through a spontaneous displacement of one of them or through the aggression of one opponent upon the other (Berger, 1986; Feist and McCullough, 1976). Displacements, which can be either spontaneous or a response to aggressions, take the forms of avoiding by moving a part of the body away, moving away by walking or fleeing by trotting or cantering.

On the basis of the available literature, Waring (2003) concludes that horses usually display the minimal amount of aggression the situation requires. Threats are hence the most common channel used to direct aggression towards conspecifics in long-term stable groups (Table 2).

2.4. Development of social skills

As other social species, horses need social experience in order to develop appropriate social skills (*e.g.* Bourjade et al., 2009a). Of course, the first social bond a foal forms is with its mother: a short time before giving birth, the mare stays away from the group for one to a few days in a place where the mare will give birth (Estep et al., 1993; vanDierendonck et al., 2004) and establishes an exclusive bond with her foal. The mother remains a foal's preferred partner for quite a long time (*e.g.* at 6 months of age, foals are still spending 40% of the time with their dam as closest neighbour, Crowell-Davis and Weeks, 2005; Tyler, 1969). However, the foal starts interacting with other foals and its father after 2-3 weeks (Feh, 2005; Tyler, 1969). There is a switch of interest over time with more and more time spent with other foals or other family members (Boyd, 1988; Crowell-Davis, 1986; McDonnell and Poulin, 2002; Tyler, 1972). Weaning occurs on average 15 weeks (but up sometimes to 24 hours) before the

birth of the next foal, when the mother generally prevents the foal from suckling (Welsh, 1975). The young remains nevertheless close to the dam, paying special attention to the newborn.

After weaning, interacting with peers becomes even more frequent, and Tilson et al. (1988) reported that the dominant stallion tended to stay close to the 1-2 year old other males and protect them from other group members.

Young horses receive overall little aggression. Foals rarely get injured when they approach other adult mares (Crowell-Davis and Weeks, 2005; Grogan and McDonnell, 2005). One mechanism may be the use of snapping. In this particular display, the foal pulls the lips back and clasps rhythmically the teeth, often with an arched back and a tucked in tail (Feh, 2005; Waring, 2003). Snapping has been considered as a “submission” display (*e.g.* McDonnell and Haviland, 1995) or a sign of conflict of motivation (approach/withdraw from this impressive adult; Waring, 2003), the result being apparently that little aggression is observed towards young individuals (as in juvenile signals of dogs puppies, Bekoff, 1977). Data are lacking on this potential appeasing effect of snapping but more than 60% of snapping directed to mares occurred after she threatened the foal and most snapping displayed by foals towards stallions occurred without any threat from the adult in Wells and von Goldsmith-Rothschild’s study (1979).

However, behaving appropriately in group (with regards to aggressiveness here) clearly also relates on acquisition of social skills. For instance, while adult feral horses displayed only 0.3% of their threats towards a dominant conspecific (see also Clutton-Brock et al., 1976: 4.9%; Keiper and Sambraus, 1986: 7.3%), the proportion of “inappropriate” threats directed up the hierarchy reached up 10-20% of yearlings’ threats, and 50% of foals’s threats (Wells and Goldschmidt-Rothschild, 1979). These results suggest a major role of experience on social competences acquisition. At all developmental stages, the young horses are confronted

to a variety of social partners: siblings, peers, related and unrelated adults, including mares and stallions. Social experience and especially adult modelling, as in other social species (*e.g.* West et al., 2003), appear therefore to play a crucial role in order for the young to develop the typical low level/low rate of aggression typical of natural social groups. In a study performed on natural family bands of Przewalski horses, Bourjade et al. (2009a) found that the overall rate of aggression towards peers in 1 and 2 year old horses was negatively correlated with the adult-young ratio. When this ratio was low (less adults present), the young horses showed more aggressiveness, more segregation from adults and more bonding with same age partners. Moreover, the mother's rank tends to have an influence on its offspring's rank both prior and after weaning (Tyler, 1972; Wells and Goldschmidt-Rothschild, 1979).

2.5. Conclusion

Mild forms and low frequencies of aggression have valuable advantages for horses, since physical aggression involves energetic costs, increases the risk of injury and is known to decrease reproductive success, by reducing rates of conception and increasing rates of foetal and foal mortality (*e.g.* Berger, 1986; Linklater et al., 1999). The predominance of low frequencies and mild forms of aggression, based on subtle communication signals and ritualized displays is made possible in natural horses populations thanks to group stability, dominance hierarchy and learning of appropriate social skills by young horses. Obviously, adults play a major role in canalizing socially undesirable behaviours of the immature horses.

3. Impact of management on aggression and its regulation in the domestic / captive situation

3.1. Horses' aggressiveness in the domestic situation: myth or reality?

Studies of feral horses living under natural conditions indicate that the species-specific behaviour of equids has remained relatively unaffected by the domestication process (*e.g.* Klingel, 1982; Linklater, 2000; Tyler, 1972). Nevertheless, rates of aggression may be affected by the domestic life (Table 1). A consequence of increased aggressiveness may be an increase of injuries (Haupt et al., 1978). Thus, in a survey involving 58 Thoroughbred and Quarter Horse farms that managed 1987 weanlings and yearlings, Gibbs and Cohen (2001) observed that injuries were reported in 64% of the farms and mostly attributed by owners to horses “playing too hard”, which probably corresponds to the interpretation given by owners of aggression, confused with play fighting. Although a few studies are sufficiently precise to enable a correct evaluation of aggression rates, environmental conditions offered to domestic horses, rather than being a domestic animal *per se*, may be at stake when high level of aggression are reported. Indeed, many domestic horses are kept in restricted conditions of space, food and social opportunities and these factors can trigger aggression. Note that feral populations experiencing for instance modifications of their group composition (due to human management) may show temporary higher levels of aggression, while stable domestic horses kept in semi-natural conditions show low frequencies of aggression (*e.g.* islandic horses studied by Sigurjonsdottir et al., 2003 and vanDierendonck et al., 1995) (Table 1). Thus, non social and social factors may explain some high levels of aggressions sometimes encountered.

3.2. Non social factors

3.2.1. Space

Confinement, including forced proximity and and/or high density may increase aggressions in domestic animals (Archer, 1970). Stebbins (1974) observed that aggressions were more frequent and intense in Appaloosa horses when kept in paddocks rather than in

pastures. According to Skiff (1982, cited in Keiper, 1986), the number of aggressions shown by Przewalski horses increased as the size of the enclosure decreased. Limited space (*i.e.* limited resources?) on Assateage Island may explain the higher rates of aggression observed by Keiper and Sambras (1986) in feral ponies (Table 1). An increase of aggressions and derived injuries may be observed in Przewalski horses kept in captivity in zoos (Boyd, 1988), sometimes leading to abnormally high aggressiveness (Keiper, 1986).

Group density could also affect social behaviour (see Benhajali et al., 2008). Observing groups of horses in paddocks of about 100 m² per horse up to 75,000 m² per horse, Jorgensen et al. (2009) reported that horses with the smallest space allowance showed the highest mean number of aggressive interactions (4.6 h⁻¹) as compared to all other batches (1.3 h⁻¹). Invasion of another horse personal space is a common source of aggression (Heitor et al., 2006; Keiper and Sambras, 1986; Tyler, 1972). Davidson (1999, cited by Christensen et al., 2002b) noted that when living in a herd, conflicts are typically avoided through spatial distribution of the horses since individuals spread out and allow only a few others to be within their personal space. Tight spaces, that do not allow submissive animals to escape, are more common in domestic group situations than in semi-feral groups (Grogan and McDonnell, 2005).

3.2.2. Resources availability

In general, limited access to resources induces social competition and increased levels of aggression (*e.g.* Berger, 1977; Clutton-Brock et al., 1976; Grogan and McDonnell, 2005; Montgomery, 1957; vanDierendonck et al., 1995). Thus, when additional food was brought to free ranging highland ponies, agonistic behaviours increased almost twofold, *i.e.* from 1.9 to 3.3 aggressive behaviours per hour per horse (Clutton-Brock et al., 1976). Note that, in natural conditions where foraging is possible on widely distributed food resources, competition can

nevertheless occur around water, shelters, branches... Deprivation of such resources may certainly lead to increased agonistic interactions when again made available.

Care must be given to the ways of providing food, minerals and water. With regard to the contexts in which aggression occurred, van Dierendonck et al. (1995) reported in a herd of Icelandic horses in captivity that aggression occurred on the pasture but was more common around the mineral supply, the drinking bowls, and in the transition corridor (see also Montgomery, 1957). In pastured domestic horses, it is more common to provide water from a single concentrated source than from a stream or pond and to provide supplemental feeds that are highly palatable. The resulting food- and water-related aggression seems much more frequent and intense than water- or forage-related aggression in naturally foraging herds (Grogan and McDonnell, 2005). The automatic feeding systems, by allowing only one horse at a time to enter the feeding box, seem also to trigger more aggressions, especially high level aggressions that may lead to injuries (Zeitler-Feicht et al., 2010).

Foraging is a major activity in a horse's life. In all populations studied, free ranging horses spent 60 - 80% of their time grazing (*e.g.* Boyd and Keiper, 2005; Waring, 2003). Conversely, domestic/captive horses daily receive a limited number of high energy meals and a limited amount of roughage (*e.g.* Harris, 2005; Nicol et al., 2002). When domestic horses are placed as a group in a bare paddock and given a variety of enrichments including straw, branches, object, they showed a time limited interest in objects and the only efficient enrichment appeared to be the straw (providing thus foraging opportunity) (Jorgensen et al., 2011). In this study, presence of straw was associated, amongst other aspects, with less agonistic and more friendly social interactions, while in all other cases (controls, poles, play objects...), horses exhibited more agonistic than friendly interactions.

The importance of foraging opportunities in regulating social interactions had been experimentally tested by Benhajali et al. (Benhajali et al., 2008; Benhajali et al., 2009). In a

first study, the authors drew up the behavioural repertoire and time-budget of a dense (200 mares/ha) group of 44 Arab breeding mares housed in individual boxes at night but kept 6 hours a day in a bare paddock. They found that the behavioural repertoire and the time-budget were affected: neither lying down, nor rolling were observed while locomotion was abnormally high. They also observed a very limited social life: no preferred partner, no allogrooming and only a few social interactions exclusively agonistic interactions (Benhajali et al., 2008). At that stage, both the high density and the lack of foraging opportunity could be responsible for these results.

The authors then tested the impact of foraging opportunity *per se* by dividing one hundred breeding mares from the same facility into two groups of fifty mares, kept in the same conditions as mentioned above (but with a density of 115 mares/ha). However one group was given the opportunity to forage in the paddock, as 50 hay nets were hung along the fences (Benhajali et al., 2009). All mares had the same total amount of hay, as the control group received the whole amount in the box at night. Therefore, only the temporal distribution varied. As expected, the experimental mares spent most of their time foraging at hay, but they also exhibited a larger overall behavioural repertoire. However, the most interesting was probably that they also showed higher rates of positive interactions (*e.g.* allogrooming), more social cohesion (preferred partners) as well as less aggression (0.9 ± 0.7 aggressions/mare/hour) than the control mares (0.2 ± 0.2 aggressions/mare/hour). Thus aggressive interactions dropped by half when foraging opportunities were provided in the paddock (Benhajali et al., 2009).

Two studies therefore converge towards a same major impact of roughage availability on the prevalence of agonistic behaviours. This is especially interesting as different breeds (Warmbloods / Purebred Arab horses) and types (riding – sport horses / breeding mares) of horses are involved, in very different climates (Scandinavia / Tunisia). This may well reflect a

species-specific trend due to the discomfort of an empty stomach for hours (Harris, 2005), making horses unfriendly or leading to an unfulfilled time-budget leaving time for undesirable behaviours.

3.3. Social factors

3.3.1. Group size

Domestic groups are often larger than natural social groups (vanDierendonck et al., 2004), which can be a potential source of social tensions and aggression. Indeed, frequencies of aggression per feral pony mare at Assateague Island were higher in larger bands than in smaller bands (Rutberg and Greenberg, 1990). Christensen et al. (2002b) reported an aggression rate of 1.46 per horse per hour in a group of 13 Przewalski stallions, which is twice as much than the rate observed in a small group of 4 Przewalski bachelor stallions in Feh's (1988) study (0.76 per horse per hour). Group size is highly variable in the domestic situation and its influence on the prevalence of aggressions would need worth further investigation, paying attention to the distinction between group size and density effects.

3.3.2. Group composition

In free ranging populations, mares tend to perform less agonistic behaviours than stallions, but both in feral and domestic situations, stallions are not necessarily dominant over females (Haupt et al., 1978; Wells and Goldschmidt-Rothschild, 1979). Groups of males do occur in natural conditions and grouping of stallions does not lead to increased injuries (*e.g.* Christensen et al., 2002a; Christensen et al., 2002b). Unfortunately in the domestic situation, stallions are generally kept in single boxes, which may impair their social skills (see further). More information towards horse owners is needed here. Allotting 66 adult horses into one mare group, one gelding group and one mixed gender group, Jorgensen et al. (2009) reported

no significant effect of gender composition on social interactions or on the very few observed injuries (all superficial).

Reproductive status of mares, and in particular foaling, can impact on aggressiveness towards conspecifics. Thus, mares tend to become aggressive after parturition, preventing the approach of herd members towards the foal (vanDierendonck et al., 1995; Wells and Goldschmidt-Rothschild, 1979). Van Dierendonck et al. (2004) investigated the social behaviour of mares before and after foaling in a herd of Icelandic horses consisting of adult mares, adult geldings and juvenile fillies, geldings and colts. Mares with foals separated off into a distinct subgroup and became more aggressive, but the presence of adult geldings in the herd during the foaling season did not prevent the expression of characteristic species-specific behaviour and allowed the development of long-term stable social relationships (vanDierendonck et al., 2004). Family groups of domestic horses, when kept in semi-natural conditions, seem to function as do feral families (see further). Breeding groups where stallions stay with the mares and foals are obviously not a source of risk (Grogan and McDonnell, 2005). Although infanticide has been mentioned in natural conditions, it remains a rare phenomenon, possibly restricted to major social changes (Feh, 1990).

As mentioned before, age is a crucial element in the dominance hierarchy and older individuals tend to have higher ranks than immature horses both in groups of domestic and feral/wild horses (Haupt et al., 1978; Haupt and Wolski, 1980, see part2). In general, aggressions are rare amongst young animals and in a food competition test, all yearlings shared food (Haupt et al., 1978).

There is no evidence that breed differences do occur in aggressiveness. Observational data in stable groups give similar low prevalence for different breeds (Table 1). However, according to Grogan and McDonnell (2005), Shetland ponies may be less injured during aggressive interactions, partly because of their appearance: being small, stocky and fat, means

that they may “cushion” the kicks and maybe give less powerful kicks. Although physical characteristics of horses (height, weight) cannot be used to predict dominance or aggressiveness (Houpt and Wolski, 1980), further studies are certainly needed to investigate the potential impact of some breed characteristics in group composition.

To our knowledge there is no experimental data testing aggressiveness as a temperamental trait in horses (Hartmann et al., 2011). Some horses are reported to have abnormally high levels of aggressiveness, but then this may be pathological (Keiper, 1986). In paired feeding tests, dominance (access to buckets) may be correlated with the frequency of aggressive behaviours (Houpt and Wolski, 1980), but observational studies mostly do not show such a correlation (see 2.3.). Hormonal status (*e.g.* gestation in mares) or age have been shown to influence both aggressiveness and dominance rank, suggesting low individual consistency over time and across situations, a pre-requisite for a temperamental trait (Hausberger and Richard-Yris, 2005).

Changes in herd composition can disrupt the social organisation of a herd (Keiper and Sambras, 1986), meaning that changes in individual status may occur. Illustrations can be extracted from a case study (Hausberger et al., unpublished data), in which we followed given individuals, and two especially in different group compositions (table 3). In period 1 (figure1), P and A appeared at the top of the hierarchy for aggressions given, avoidances received and success at the paired feeding test, while U was at the bottom of the hierarchy. One year later (period 2, figure 1), after the group composition had changed, P was still the most aggressive but he was less avoided than others and ranked only second in the feeding test. U went up and became the second most aggressive pony, the first to be avoided and the first to access the bucket, while A was still avoided but became less aggressive than before. Only P and A could be followed over a longer time period. In period 3 (figure 1), they had been with three other individuals for four years, living all year round, night and day, together

on a pasture. In this situation, A has clearly become a subordinate, whatever the parameter chosen, while P has an intermediate status. The relative status of P and A has also changed over time (*e.g.* feeding test in period 1 / period 3), showing that despite a long term relationship, status was not definitively acquired. The results show that the stability of an individual's status may depend upon group stability rather than on intrinsic individual characteristics.

3.3.3. Group stability

In the domestic situation, group composition often changes according to the use of horses (Grogan and McDonnell, 2005). In stable groups of domestic horses, the dominance relationships are mainly maintained by spontaneous avoidances by subordinates like in natural populations (*e.g.* Arnold and Grassia, 1982; Jorgensen et al., 2009). Subordinates rarely “contest”: Heitor et al. (2006) report for instance that most offensive interactions (84.8%) elicit an avoidance/withdrawal reaction and adult horses display only 1.9% of aggression directed up the hierarchy. Therefore, a stable group hierarchy has been reported to be an important factor in prevention of kick and bite injuries (Furst et al., 2006; Knubben et al., 2008). Actual scientific data are scarce and further work is needed.

In free ranging groups, aggressive displays are most likely directed towards the newcomer in a group (Rutberg, 1990; Rutberg and Greenberg, 1990; Wells and Goldschmidt-Rothschild, 1979). Young transitional females have been reported to suffer from higher injury/blemish grades than long-time resident harem mares (Grogan and McDonnell, 2005). Arnold and Grassia (1982) observed in a group of domestic horses that the horses that received the most of aggression were all horses introduced in the paddock later than the rest of the group. A horse's dominance rank tends to be inversely correlated to its length of residency in the herd (*e.g.* Heitor et al., 2006; McDonnell and Haviland, 1995). When adult stallions were

introduced with young colts, Tilson et al. (1988) observed an increase of offensive behaviours (threats, bites, kicks) from the stallions, which generally decreased or even vanished after one hour.

Artificially inducing familiarity by exposing resident horses to newcomers in adjacent boxes may reduce aggressive interactions (Hartmann et al., 2009), although more studies are needed here as the very limited time of pre-exposure (5 minutes in this study) may have led to underestimate the potential relevance of such a familiarization. Introducing the unfamiliar animal with two rather than one resident does not seem to change the aggressive behaviour and this introduction does not seem to modify the frequency of social interactions in the group (Hartmann et al., 2011). Further work is clearly needed on all these aspects but prior familiarization seems to be a promising line to help reducing aggression towards newcomers.

3.3.4. Developmental issues

As mentioned in part 2, the developmental trajectory of young horses in natural conditions involves the acquisition of social skills throughout a development that implies a diversified social environment (mother but also other adults). The domestic situation is highly different: foals develop in a restricted social environment (no stallions, no older peers), which becomes even more impoverished as they grow older (same sex and same age groups). They undergo human management that involves early handling and early weaning (both alimentary and social). All these procedures may have an impact on the development of the young's social skills and therefore its later abilities to regulate aggressions.

3.3.4.1. The mother-young bond

As in free managed horses (Wells and Goldschmidt-Rothschild, 1979), domestic mares have a major influence on their offspring, influencing their foals' dominance rank (Haupt and

Wolski, 1980; vanDierendonck et al., 1995) and their offspring's aggressiveness (Araba and Crowell-Davis, 1994; Weeks et al., 2000). Although genetic influence is possible, it is likely that the mother has a modelling influence on the foal's behaviour through her behaviour. Thus, the dam also influences the foal's choice of preferred associate: foals tend to associate with the offspring of their mother's preferred partner (Weeks et al., 2000). Human interferences with the mare-foal bond are numerous and of course a characteristic of the domestic situation. Human interventions are especially crucial at two time periods (events): birth and weaning.

It has become popular to handle foals at birth, with the belief that it would create a long-term memory of humans' "dominance" or partnership or of objects being harmless, until scientific studies converged to show little or no such effects (*e.g.* Simpson, 2002; Williams et al., 2002). A more recent study has revealed that this so-called "imprinting procedure" (handling the foal intensively on the ground for the first hour after birth) had a series of negative consequences, one of them being an insecure attachment to their dam (Bowlby, 1969). These foals tended to stay close to the dam, had less social interactions with their peers and reacted very strongly to weaning. When later observed at 2 years, these young horses exhibited social withdrawal, but also a higher frequency of aggressive behaviour towards peers as compared to control horses (Henry et al., 2009). Early experience, even limited (see also Hausberger et al., 2007), may therefore have long term consequences on a horse's social profile.

Human intervention is also most influential at weaning. Under domestic conditions, weaning can differ from the natural process in several important ways: it is often abrupt and tends to take place earlier, typically between 4 and 6 months of age when the foal is still in close relation with its dam (for a review: Crowell-Davis and Weeks, 2005). Weaning of foals results not only in the breaking of the mare-foal bond and deprivation of maternal care, but

feeding practices, housing and social environment may be deeply altered. Under such conditions, weaning results in high levels of stress (Waran et al., 2008) and increased aggressiveness may be visible for several days after weaning.

Environmental conditions, either physical or social, do have a strong influence on stress reactions of foals. The highest reactions are observed for foals weaned singly in a box. When paired with a peer, foals exhibit less stress reactions but aggressions do arise and can lead to injuries (Hoffmann et al., 1995). Other practices, such as the progressive retrieval of mares from the group (Holland et al., 1996), keeping foals at pasture in groups (Heleski et al., 2002) or still more so introducing adults with the weanlings (Henry et al., in press) all lead to lowered expressions of stress, including lowered levels of aggression. Space, dispersed resources (grass) and social diversity may help foals go through this forced and artificial separation from the dam without developing higher levels of aggressiveness. Since foals, before weaning, associate with their dam's preferred partner's offspring, it may also be interesting to observe groups and preserve bonds when preparing weaning groups (Waran et al., 2008).

3.3.4.2. The importance of social diversity

As other social species, horses need social experience in order to develop appropriate social skills (Waran et al., 2008). Anecdotal reports mention that motherless foals or foals raised only with their dam may lack the snapping behaviour (which could be a mechanism involved in regulation of aggression towards young horses, see part 2). They also often mention that these same foals may lack appropriate social skills and be either excessively withdrawn or aggressive when placed in groups. As mares are tolerant towards their young, young may then not learn from her how to respect social rules and adult's dominance, a general feature in natural conditions (*e.g.* Bourjade et al., 2009a).

Christensen et al. (2002a) have showed that young stallions deprived of social contact during their development exhibited more agonistic behaviours towards other young stallions when regrouped at the age of two years than peers raised in a group all along. They may need to learn not only to produce appropriate social signals but also to produce them in an appropriate context. It is likely that keeping stallions with the family, a very rare practice nowadays, would further help the foal's social development, as family stallions tend to interact a lot with their offspring in field situations (see part 2).

In most farms, young horses are kept in same-age and same-sex groups. Observations of such groups of 1 and 2 year-old horses revealed that these animals had restricted behavioural repertoires, little social cohesion but high frequencies of agonistic interactions (Bourjade et al., 2008). The introduction of two unknown/unrelated adults in such groups resulted in an enlarged behavioural repertoire, in particular the emergence of adult-like behaviours, a higher social cohesion between the young animals and an increase of affiliative behaviours, associated with a decrease of aggressiveness (Bourjade et al., 2008). Interestingly, snapping was only observed after the arrival of adults.

Many questions still need to be answered and further research is required. Given the importance of the adult-young ratio on free ranging young animals, further research should investigate what would be the ideal proportion of adults in social groups, whether the adults' sex or age are important and whether they should or should not be familiar to the foals. In any case, the importance of adults in promoting the use of appropriate skills, regulating aggression and promoting social cohesion has been demonstrated enough, both in field and domestic conditions, to deserve immediate consideration in breeding facilities. Experimental research is also needed on the potential appeasing function of snapping.

4. Conclusion: towards better practices

Given the natural propensity of horses, as a social species, to have a regulation of aggression in groups, the higher level of aggressiveness that can sometimes be observed under given management conditions (see part 3) seems clearly related to the conditions offered. This is especially the case if interactions become injurious, which “may indicate deficits in stable design, space allowance and management” (Furst et al., 2006).

Practices based on a better knowledge of horses’ natural social life are not necessarily time consuming or difficult to apply. Some inappropriate situations may rather be a consequence of insufficient knowledge. One example is stallion management, where the predominant belief is that stallions are naturally aggressive towards other horses. As they are generally kept singly and only occasional attempts are made to put them in a group, the belief becomes reality... Stallions raised in familial or bachelor groups develop normal dominance hierarchies, overall low aggression levels and may be very protective of their foals. Of course, in non breeding contexts (*i.e.* no mating necessity), separation from mares may be a necessity as they would then, as a limited resource, be a source of aggressiveness. Breeders or riders may benefit from keeping stallions in families or bachelor groups, which in turn would increase their welfare and make them more manageable (see also Rivera et al., 2002; Sondergaard and Halekoh, 2003; Sondergaard and Ladewig, 2004). Group stability should be enhanced, leading to more peaceful interactions. Although this may seem a constraint for riding centers, keeping horses which work regularly as a group outside work may also favour easier management of horses and riders during lessons. As hierarchy and familiarity are established outside work, much less attention has to be given to the regulation of aggression at work, which may lower the attention to the riders’ action and therefore the horses’ welfare (Lesimple et al., 2010). This in turn may also be a source of aggression from horses ... to humans (Fureix et al., 2010).

Keeping horses in paddocks or pastures may make a difference. Grazing is a crucial element that may lower overall social interactions, including aggressions. An easy way of promoting such an effect in paddock is to provide roughage while the group stays in the paddock, ensuring at the same time appropriate time budgets and physiological well-being.

Food is clearly a central element of a horse's life and therefore a source of competition. Attention has to be given to apparatus that limit food distribution to one animal at a time, while simple devices, such as a partition or a line above buckets may enable subordinates to eat without receiving aggressions (Haupt and Wolski, 1980). Favouring pastures over paddocks when possible, ensuring roughage availability, multiplying the sources of food and ensuring a reasonable density are interesting ways of lowering the risks of aggressions.

Data are still missing on the ideal group composition and little is known about the impact of group size but it is likely that a limited size (4-6 in feral families) promotes a more harmonious social life. Preferred partnerships are a major feature of horses' sociability, and observing individual characteristics may also help ensuring an appropriate group composition, which may differ according to the horses' use. Individual observations of adult horses' affinities and behaviour may help determining group composition: for a same horse, the level of aggressiveness differs according to the individual encountered, which suggests an adjustment to each other's behavioural responses (Hartmann et al., 2009). Observation of affinities, spatial proximities and agonistic interactions (through repeated scan sampling of inter-individual distances, focal sampling of positive / aggressive social interactions) may thus reveal social partners that are better to keep together within a group, indicate withdrawn animals that may be kept in smaller groups or animals that do not get along over a longer time period. Group composition appears more a question of individual social characteristics than of gender or age.

Individual behaviour may vary over time and across situation as it is strongly influenced by life conditions. An altered welfare may be associated with a higher aggressiveness, as mentioned for instance in Benhajali et al. (2008)'s study. Horses may well develop tendencies for generalized aggressiveness when in poor welfare conditions, as riding school horses were found to generalize negative behaviours from familiar to unfamiliar persons (Fureix et al., 2009) but also from other horses to humans, both being correlated (Fureix et al. unpublished data). More convincing still is the finding that aggressiveness towards humans was higher in horses that suffered from vertebral disorders, probably leading to chronic pain (Fureix et al., 2010). Attention to social and non social management promoting welfare is crucial and group management would certainly be easier (*e.g.* lower risk of injury) if horses all benefitted from good welfare conditions. The opportunity for social contact is crucial, keeping in mind that social behaviour is both a source and consequence of welfare conditions.

In this context, developmental issues are essential and decreasing human interferences at some crucial points would be an easy way of diminishing some aggression problems. Choosing appropriate parents and especially the mother, as an important social model, may be interesting while ensuring better conditions of weaning seems crucial. The important and durable influence of mares on their offspring has been clearly demonstrated in experimental studies where they were used as a mediator for favouring human-foal relationships (Henry et al., 2005). Protective mothers induced distrust in foals: tendency to behave aggressively may therefore be transmitted the same way. However, attention and interest should also be given to the presence of unrelated adults in groups of young at all ages. They are essential for the development of appropriate social skills. Introducing (socially experienced) adults in groups of weanlings or yearlings appears as an easy way to ensure more aggression regulation in young animals. Diversifying the social environment of young horses may be an easy future development in breeding facilities.

There are broad lines for which studies converge and that seem to be reachable goals on a daily basis for a farm or a riding school. Many questions still remain to be investigated in more details and further studies should involve work on the limit in the grouping intervals that make a group stable or unstable, the appropriated group size and density, breed differences, the appropriated adult – young ratio amongst others. Future studies would undoubtedly reveal the whole set of factors that are involved in the regulation of aggression in domestic horses.

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Tables

Table 1: mean frequencies of agonistic behaviours (per horse per hour) and potential factors of variation of aggression rates in various horse populations gathered from multiple published studies. Studied horses are natural population, domestic groups of horses in natural conditions and domestic groups of horses in paddock. Standard errors are presented when available. Rates of aggression are low both in stable natural groups and domestic groups kept under semi-natural conditions. However, rates of aggression can be higher in large groups, under high density, experiencing modifications of the group composition and / or when access to resources is limited. Note that these conditions are not limited to domestic conditions but can be more common in domestic groups of horses, especially in paddock, compared with natural populations.

Study	Life condition	Rates of aggressive behaviour (per horse h ⁻¹)	Group size (number of horses)	Density (number of horses ha ⁻¹)	Group composition	Group composition modifications (human managing)	Restricted resources
Weeks et al. (2000)	Domestic - paddock	6.3 ± 4.1 h⁻¹	14	1.4 – 127.7	Breeding mares with foals		Part of the observations made during feeding of supplemental grain
Montgomery (1957)	Domestic - paddock	3.2 h⁻¹	11	Na	Mares and geldings	1 injured mare removed during the course of the study	
Benhajali et al. (2008)	Domestic - paddock	2.5 ± 1.4 h⁻¹	44	200.0	Arab breeding mares (without foals)		No foraging opportunities (no grass, no hay)
Keiper & Sambraus (1986)	Natural population	2.4 h⁻¹			Ponies from Assateague Island		Confined by artificial / topographical barriers → restricted resources?
Clutton-Brock et al. (1976)	Natural population	1.9 h⁻¹	17	Na	Highland ponies (mare with and without foals, juvenile mares and gelding)	1 mare removed during the course of the study	

Christensen et al. (2002b)	Natural population	1.5h⁻¹	13	0.2	Przewalski bachelor groups	
Heitor et al. (2006)	Domestic – semi natural	1.2 ± 0.7 h⁻¹	11	0.6 – 2	Family band of Sorraia horses	Stallion placed with mares for breeding at the beginning of the study
Wells & Goldschmidt-Rothschild (1979)	Natural population	0.9 ± 0.3 h⁻¹	≈ 20	≈ 0.1	Family band of Camargue horses	Herd stallion added to the group at the beginning of the study
Jorgensen et al. (2011)	Domestic – paddock	0.9 ± 0.8 h⁻¹	3 – 6	1.7 – 33.3	Mares and geldings	
Feh (1988)	Semi natural population	0.8 ± 0.2 h⁻¹	4 – 5	0.25 – 1.25	Przewalski bachelor group and family band	
van Dierendonck et al. (1995)	Domestic - semi-natural	0.7 h⁻¹	31	22.1	Icelandic horses (geldings, mares, juvenile stallions and mares) + a few ponies	Some adults absent for some weeks (breeding)
Haupt & Keiper (1982)	Natural population	0.2 ± 0.0 h⁻¹	7	Na	Family band of ponies from Assateague Island	
Bourjade et al. (2009c)	Natural population	0.2 ± 0.1 h⁻¹	9	0.02	Przewalski bachelor groups	
Hausberger et al. (unpublished)	Domestic – semi natural	0.2 - 1.1 h⁻¹	2-5	0.7 – 2.5	Stallions and geldings	
Sigurjonsdottir et al. (2003)	Domestic – semi natural	0.1 h⁻¹	34	4.25	Adult mares, immature horses, adult geldings in groups	

Table 2. Proportions of aggressive behaviours in agonistic interactions in function of their intensity in (a) feral populations and groups of domestic horses in semi-natural conditions and (b) domestic horses in paddock. Low intensity: displacement, non-contact aggressions (simple threats, *i.e.* ears backward only; threats to bite; to kick). High intensity: physical aggressions (bites; kicks). In long-term stable groups, low intensity aggressions appear to be the most common channel used to direct aggression towards conspecifics. Note that, even if numerous other studies mentioned such a result, quantitative data are not always available, especially in domestic populations.

	Displacement	Low intensity Simple threat, bite threats	Kick threat	High intensity Bite	Kick
a) Feral and semi-natural populations ^a					
Berger (1977)		71% (mares) 48% (stallions)			
Berger (1986)		92%		8%	< 0.01 %
Keiper and Sambraus (1986)		48%		27%	8%
van Dierendonck et al. (1995)	49%	27%	6%	12%	6%
Christensen et al. (2002b)	≈ 27%	≈ 27%	≈ 13%	≈ 27%	≈ 7%
Heitor et al. (2006)	33%	60%	3%	3%	0.6%
b) Domestic populations in paddock ^b					
Araba and Crowell-Davis (1994)		53%	18%	21%	2%
Montgomery (1957)	10%	≈ 50%	6% ^c	≈ 25%	6% ^c

^a Berger (1977, 1986): feral horses, Grand Canyon, band size range: 3-6 individuals, including 1 stallion; Christensen et al (2002b): Przewalski bachelor group (n = 13 stallions, Ukraine); Heitor et al. (2006): Sorraia horses, 10 adult mares and 1 adult stallion; Keiper and Sambraus (1986): feral ponies, Assateague Island, 3-28 individuals, including 1-2 stallion(s); van Dierendonck et al. (1995): 26 Icelandic horses (6 geldings, 16 mares, 2 juvenile stallions and 2 juvenile mares) and 5 ponies (breeds: Shetland, New Forest, Connemara).

^b Araba and Crowell-Davis (1994): 15 Belgian brood-mares and 10 foals, Georgia; Montgomery (1957): 11 pleasure riding horses (7 geldings, 4 mares)

^c kick threats and kick counted together in this study

Table 3: Characteristics of the populations studied by our research group.

Period 1: 9 ponies observed for 30 hours in August 1993 on a 2-ha pasture. The group had been stable for 2 years (except EZ, which arrived 6 months earlier); period 2: 10 ponies observed for 70 hours in October-December 1994 on a 2 ha paddock, with a round-baller of hay. The group had been stable for 6 months; period 3: 5 ponies observed for 110 hours between March and June 2001 on natural pastures (6 a to 2 ha). The group had been stable for 4 years. In all cases, water was provided *ad libitum*, natural shelters were available. Apart from the filly, the ponies worked either as riding school ponies (periods 1 and 2) or leisure horses (period 3). They were generally ridden together, mostly for 2 days in the week (4 to 6 hours in periods 1 and 2, 1 to 3 hours at the most for period 3).

Experiments involving these animals complied with current French laws (Centre National de la Recherche Scientifique) related to animal experimentation and were in accordance with the European directive 86/609/CEE. No licence/permit/institutional ethical approval was needed. Animal husbandry and care were under the management of their private owner, as this experiment involved only horses in the “field” (no laboratory animals).

	Horse	Breed	Sex ^a	Period 1 (1993)	Period 2 (1994)	Period 3 (2001)
				N = 9	N = 10	N = 5
			Age	Age	Age	
	A	Unregistered	G	5	6	12
	P	Fjord	G	6	7	13
	U	Welsh	G	7	8	
	PB	Unregistered	G	14	15	
	Q	Merens	F	11	-	
	S	Connemara	F	10	-	
	F	Unregistered	G	5	6	
	E	Pottok	G	17	-	
	EZ	Welsh x unregistered	F	1	2	
	B	Dartmoor	G		5	
	D	Haflinger x unregistered	G		10	

G	Haflinger	G	11	
V	Fjord	G	7	
T	Haflinger	M		15
H	Appaloosa x pony	M		6
Ha	Haflinger x Connemara	G		6

^aG = gelding, F = female, M = Male

Figure 1. Variations in individual's status function of group composition. Three studies were performed (in 1993: period 1, in 1994: period 2 and in 2001: period 3) where we followed several horses (in bold) and two especially (in bold and grey) in different group compositions. For each study, here are the sociograms based on (a) the number of aggression given, (b) the number of avoidance received and (c) the time spent eating in the bucket during paired feeding tests. Agonistic interactions were noted *ad libitum* during focal or group observation sessions performed in the horses' usual pastures. Paired feeding tests were performed in an outdoor limited enclosure (10 m diameter) where horses were confronted to a single bucket with barley. Results show that stability of an individual's status may depend upon group composition rather than on intrinsic individual characteristics.