The social structure and interactions within groups of horses (*Equus caballus*) containing stallions

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Author: Sandra Magdalena Granquist
Supervisor: Hrefna Sigurjónsdóttir

THE UNIVERSITY OF ICELAND

DEPARTMENT OF BIOLOGY

Yfirlýsing

Hér með lýsi ég því yfir að ritgerð þessi er samin af mér og að hún hefur hvorki að hluta né í heild verið lögð fram áður til hærri prófgráðu.

Sandra Magdalena Granquist, (18 september 2008)

Abstract

The social behaviour of Icelandic horses was studied for total 525 hours in six groups containing stallions. Four of the groups are permanently living together under a semi-feral situation while two were temporary breeding groups. The effect of a stallion on the interactions of his harem members was studied and the results were compared to results of studies on groups without stallions. In addition, temporary and stable groups were compared, and it was investigated how different group compositions (age distribution of members, relatedness and familiarity) can affect social behaviour of horses in general.

Earlier research suggested that stallions might either prevent social interactions between mares in their herds directly or that their presence has this effect (Sigurjonsdottir *et al.*, 2003). The results show that the stallions do rarely intervene directly in social interactions. However, two findings support the hypothesis that the stallions have a suppressing effect on the behaviour of the mares and sub-adults. First, the number of preferred allogrooming partners was lower than what has been found in similar groups without stallions and second dominance hierarchies were less rigid.

The results show a significant difference in allogrooming rate, aggression rate and number of friends between the groups, which might be explained by differences in the composition of the groups, in respect of average age, familiarity, relatedness and the level of stability in the groups. Younger horses had a higher allogrooming- and intervention rate and a higher number of preferred allogrooming partners compared to the adult mares. Familiarity was the most important factor in deciding what horses made friends in the temporary groups, but relatedness was also important. The stability of the group was found to affect the aggression rate, since a higher rate was found in the temporary groups compared to the permanent groups. The number of preferred allogrooming partners of the horses was also affected to some extent, as a significantly lower number was found in the most unstable group compared to all the other groups. The results have significance for further research in the field of social structure of mammals, and may also be applied in the management of horses and other domestic animals.

Ágrip

Félagshegðun hesta var rannsökuð í samanlagt 525 klukkustundir í sex hópum sem inniheldu stóðhesta (fjórir stöðugir hópar í hálf-villtu stóði og tveir tímabundnir hópar).

Áhríf stóðhesta á samskipti hesta í hópnum var könnuð og niðurstöður bornar saman við rannsóknir á hópum án stóðhesta. Auk þess voru áhrif stöðugleika hóps á félagshegðun hrossa könnuð og skoðað var hvort mismunandi samsetning hópa með tilliti til aldurs, skyldleika og kunnugleika breyttu félagsgerðinni.

Fyrri rannsóknir benda til þess að stóðhestur getur haft bælandi áhríf á samskipti í hópnum með beinum hætti eða að nærvera stóðhests óbeint hafi þessi áhríf (Sigurjonsdottir *et al.*, 2003).

Niðurstöður sýna að stóðhestarnir trufluði sjaldan samskiptin á milli einstaklinga í hópnunum, en tvennt styður tilgátuna að stóðhestar geti haft hamlandi áhríf á samskipti í sínum hóp. Í fyrsta lagi sú staðreynd að hrossin mynduðu fremur fá náin vinatengsl í þessum hópum miðað við sambærilega hópa án stóðhesta (Sigurjonsdottir *et al.*, 2003) og í öðru lagi að virðingarraðir voru mun minna áberandi og aðeins marktækt línulegir í helmingi hópanna.

Marktækur munur í tíðni jákvæðra og neikvæðra samskipta fannst á milli hópa, sem reka má til munar á hópasamsetningu með tilliti til aldurs, kunnugleika og skyldleika hrossa ásamt stöðuleika hópsins. Niðurstöður sýna að í tryppin kljáðust meira en fullorðnu hryssurnar, þau trufluðu hegðun annarra meira og þau áttu fleiri vini. Kunnugleiki var sá þáttur sem réði mestu um hvaða hross mynduðu tengsl sín á milli þegar hross voru sett saman í tímabundna hópa, en skyldleiki skipti líka máli. Stöðugleiki hóps hafði áhríf á ógntíðni þar sem hærri ógntíðni fannst í óstöðugu hópunum miðað við þá stöðugu. Fjöldi vina var líka marktækt minnstur í öðrum óstöðuga hópnum .

Niðurstöður þessarar rannsóknar hafa hagnýtt gildi fyrir hrossaræktendur og aðra húsdýraeigendur. Niðurstöðurnar geta einnig haft gildi fyrir framtíðar rannsóknir á félagshegðun spendýra.

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1. Introduction

The domesticated horse (*Equus caballus*), belongs to the family Equidae. There are, besides the domestic horse, six wild species in the genus which is the only surviving genus of this once big family: takhi (*Equus przewalskii*), plains zebra (*Equus burchelli*), mountain zebra (*Equus zebra*), grevy´s zebra (*Equus grevyi*), african wild ass (*Equus africanus*) and asiatic wild ass (*Equus hemionus*) (Linklater, 2000).

The big predation pressure on the ancestors of the horses, living on the prairie, where it was not possible to hide, led to many different adaptations for escaping predators. For example, the ability to run fast evolved (McFadden, 1992) and another anti-predator adaptation was to live together in a herd. The group cohesion of horses can be explained by Hamilton’s selfish herd theory, built on that when living together in a group, each individual tries to improve their own odds of surviving at some other individuals expense, as there are a smaller chance for each individual to be selected by a predator when many individuals stay close together (Hamilton, 1971 in Alcock, 2005 p. 204). The horses of today are social animals and the complicated social structure of their herds is a consequence of thousands of years of evolution (see Anna Guðrún Þórhallsdóttir and Hrefna Sigurjónsdóttir, 2005).

The many breeds of the domestic horse that exists in the world today reflect intensive breeding for 2-3 thousand years. In Iceland, the only breed kept on the island is the Icelandic horse. When the first human settlers came to Iceland from Norway more than 1100 years ago, they brought their horses and other animals with them. Horses have been a big part of the Icelandic culture ever since then (Gísli B. Björnsson and Hjalti J. Sveinsson, 2004 p. 20).

In Iceland, the horses usually get a lot of freedom growing up. The foals are often kept with their mother from the time that they are born and the whole next winter, but on other occasions they are taken away from the mother in December. If so, the foals are put in stables where they are given hey until the spring (Gísli B. Björnsson and Hjalti J. Sveinsson, 2004 p. 40, 43). The immature horses are mostly kept outside in relatively big herds all year long, with little influence of humans, given the possibility of social learning from a young age. They are not trained until at an age of 4-5 years, which is late compared to other breeds. If the training begins at the age of 4, the horse is usually only trained for a short time and then no training is performed for a couple of months or longer (Gísli B. Björnsson and Hjalti J.

Sveinsson, 2004 p. 58). This gives them longer time than most other breeds for social development. Most horses that are ridden are kept in stables for five months a year (over the winter). They are often kept in pairs and most horses are let outside once a day, together with other horses (Hrefna Sigurjónsdóttir, 2005). Horses that are not kept inside in the winters are kept in enclosures where they can graze and where they are able to use a good windshield (manmade or natural). Nowadays they are also given supplementary hey. The remaining part of the year, the ridden horses are kept outside as well, often in big herds and many farmers have the possibility to drive their herds up in the mountains in the summer (Gísli B. Björnsson and Hjalti J. Sveinsson, 2004 p. 38-41). Hence, the Icelandic horses have more freedom and more possibilities to socialize than most other breeds. They are therefore ideal for studying the social behaviour of the species.

1.1 Mating system and social organization

The mating system of equids is polygyny and among the equids two types of polygyny systems have been defined; Type I and Type II (Klingel, 1975). The first system (Type I) characterizes domestic horses (*Equus caballus*), takhi (*Equus przewalskii*), plains zebra (*Equus burchelli*) and mountain zebra (*Equus zebra*) and is female defence polygyny, meaning that males fights for being able to monopolize females. Type II on the other hand is resource defence polygyny, meaning that the males defend territories. This system characterizes the remaining species of equids; grevy´s zebra (*Equus grevyi*), african wild ass (*Equus africanus*) and the asiatic wild ass (*Equus hemionus*) (Klingel, 1975; Alock, 2005 p. 390).

What mating system evolves in different species depends on ecological factors like for example predation pressure and food distribution, which affect the distribution of the females and thereby the males’ ability to monopolize the receptive females. When the resources the females need are clumped in space or time, it is likely that the mating system is resource defence polygyny. As the size of a territory grows the cost of defending it increases (Emlen and Oring, 1977 in Alcock, 2005 p. 390). If females group together in a defensible cluster, which for example often is the case when predation pressure is high, males will instead compete directly for those clusters. Female defence polygyny will then be the result (Feh *et al*., 1994; Alcock, 2005 p. 390), and such a system is typical for horses (Linklater, 2000).

Wild horses live together in herds, where the stallions divide the other herd members into small groups, called harems. The harems are composed of one stallion and mares with their foals and 1-3 years old immature offspring. The harems do sometimes also contain one or two (occasionally up to 5) low ranking young males (Berger, 1986 p. 131; Linklater, 2000; Waring, 2003 p. 318). The harem-stallions defend the space around their harems against other stallions and also against horses that are not members of the harem (Feist and McCullough, 1976). The stallions also defend their harems against danger, such as predators (Rees, 1993). Sometimes, submissive males help the harem-stallion to defend the harem and it has been suggested that in cases like that, the harem-stallion might allow submissive males to mate occasionally (Feh, 1999).

Both sexes disperse from the harem after they have reached sexual maturity at the age 1-3 years old (Berger, 1986 p. 129-130; Linklater, 2000). Young mares mostly join another harem soon after dispersal, while young males often form bachelor groups, as they are usually not able to form a harem of their own until they grow older and stronger (Berger, 1986 p. 131; Waring, 2003 p. 318). The composition of the bachelor groups has been found to be unstable, as the members in bachelor groups change frequently (Linklater, 2000). The harems, on the other hand, are stable and the stallion never abandons his harem, except if another stallion takes over the harem by fighting the harem-stallion (Berger, 1986 p.136-142; Linklater, 2000).

The average reproductive success is always equal in both sexes, since every successful mating involves one male and one female. Males can potentially fertilize many females at a very short time and their reproductive success is tied to the availability of females, while females often fertilize all her available eggs with only one male. In polygynous mating systems, the variance in reproductive success is higher for males than for females, since some stallions monopolize many females, while other males obtain no mates at all. Males are usually able to keep a harem for a few years only (4 years on average). On the other hand, almost all females get to mate their whole life (Krebs and Davies, 1993; Waring, 2003 p. 321; Dugatkin, 2004 p. 223). Among horses it has been measured that a harem-stallion that lives for 15 years leaves on average 16,2 offspring, while mares produce only 10 offspring on average (Berger, 1986 p.219; Waring, 2003 p. 321-322).

The reproductive success of stallions depends on many factors. Because it is usually only stallions with harems that have the possibility to mate, factors that give them high rank compared to other stallions, such as size, weight, fight ability and high age matters. High ranking stallions are also thought to have more access to the best grazing sites and good foraging possibilities for all harem members gives the stallion direct and indirect fitness (Waring, 2003 p. 320-321). The reproductive fitness of mares is influenced by their weight and also by the availability of resources, such as access to good foraging sites, since these factors influence the number of offspring and how well they can provide milk for their foals (Berger, 1986 p. 110-111, 114; Krebs and Davies, 1993).

Linklater (2000) compared 56 reports on studies of groups of feral horses from all over the world. He found that even though the size and compositions of harems varied a lot between populations and the environmental factors were found to be very different, the mating system, social structure and behaviour of the horses were found to be very similar in all groups. This indicates that different environment does not affect the social behaviour of horses to any significant extent.

The domestic horses’ closest relative is the takhi horse. Takhi horses used to be common in Mongolia and China, but the last wild takhi horse was seen in 1968. Takhi horses were nevertheless still living in zoos and therefore it was possible to reintroduce them into the wild in the 20th century (van Dierendonck and de Vries, 1996). It is interesting that studies of takhi horses, both of groups living in controlled pastures and groups that have been reintroduced into the wild, show that they have a very similar ethology as the domestic and feral horses (Feh, 1988; Keiper, 1988; Boyd 1991; van Dierendonck *et al*., 1996; Linklater, 2000). This indicates that domestication of horses has not had a big effect on their social behaviour (Feist and McCullough, 1976; Linklater, 2000).

1.2 Social behaviour

Many studies on the nature of the social behaviour of wild and feral horses, as well as horses in captivity have been made. Research on hierarchy-formation and how horses bond to each other have for example been carried out in many places.

Both natural groups with stallions (Feist and McCullough, 1976; Berger, 1977; Wells and van Goldschmidt-Rothschild, 1979; Miller 1981; Keiper and Sambraus, 1986; Keiper, 1988; Feh, 1988; Rutberg and Greenberg, 1990; Stevens, 1990; Monard and Duncan, 1996; Kimura, 1998) and groups without stallions (Tyler,1972; Clutton-Brock *et al*., 1976; Ellard and Crowell-Davis, 1989; van Dierendonck *et al*., 1995; Krueger and Heinze, 2008; Sigurjonsdottir *et al*., 2003, Lehmann *et al*., 2006) have been studied. Also, Christensen *et al* (2002) studied the social behavior in two groups composed of stallions only.

In Iceland, research on social behaviour of the Icelandic horse has been carried out since 1996. Until now, only groups without stallions have been studied. The first study was made in Skorradalur (Hrefna Sigurjónsdóttir *et al*., 1999), where the social behaviour and the time budget of Icelandic horses were studied. A similar study was made in Skáney the years 1997 and 1999 (Sigurjonsdottir *et al*., 2003; van Dierendonck *et al*., 2004, Hrefna Sigurjónsdóttir and Anna Guðrún Þórhallsdóttir, 2005). In 2001 and 2002 both social behaviour and the use of shelters in the wintertime was studied in Hólar (Hrefna B.Ingólfsdóttir, 2004; Ingolfsdottir and Sigurjonsdottir, 2008). In 2001, the nature of aggression and dominance behaviour was studied in one year old colts and fillies in Heggstaðanes (Vervaecke *et al*., 2007) and the effect of relatedness on social interactions was studied in Hólar in 2003. A summary of all these studies was published in Fræðaþing 2005 (Hrefna Sigurjónsdóttir and Anna Guðrún Þórhallsdóttir, 2005).

The most important findings from these earlier studies are described here below.

1.2.1 Negative interactions and hierarchies

There are many factors that are thought to affect the aggression rate between individuals in a group, such as different environments and the amount of food and water available (Rutberg and Greenberg, 1990; Hrefna Sigurjónsdóttir and Anna Guðrún Þórhallsdottir, 2006). The age of the individuals in the group can have an effect on the aggression rate, as shown by Rutberg and Greenberg (1990) where young mares tended to be more aggressive. Newly dispersed mares are also more likely to be the targets of aggressive behaviours (Monard and Duncan, 1996) and aggression has been found to be more frequent between females during male competition for mates than at other times (Linklater, 2000).

Many mammals form dominance hierarchies. The hierarchies are formed by individuals living together interacting aggressively to be able to sort themselves out from the top-ranking individual and all the way down to the bottom of the hierarchy. Once every individual knows its own rank, they do not have to fight with someone that has a higher rank, as high ranking individuals are likely to win the fight. Instead, only small dominance signals shown by a dominant individual are enough for the submissive individuals to respond and show submissive signals. Because of the dominance hierarchy, the aggression needed in the group is kept at a minimum level and thereby the individuals gain fitness (Alcock, 2005 p.332; Waring, 2003 p. 211, 245). Among horses, linear hierarchies have often been found (see Tyler, 1972; Clutton-Brock *et al*, 1976; Ellard and Crowell-Davis, 1989; van Dierendonck *et al*., 1995; Sigurjonsdottir *et al*., 2003; Hrefna Sigurjónsdóttir and Anna G. Þórhallsdóttir, 2005; Lehmann *et al*., 2006; Vervaecke *et al*., 2007; Ingolfsdottir and Sigurjonsdottir, 2008). Perfectly linear hierarchies are transitive; meaning that one top-ranking individual in the dominance hierarchy (often called "alpha") dominates all other group members. The second-ranking individual ("beta") dominates all group members, except for the alpha and the third-ranking individual dominates all individuals except for alpha and beta, and so on down the hierarchy. Perfectly linear hierarchies are unidirectional and no circular relationship (that is; A is dominant to B, B is dominant to C, but C is dominant to A) exists. On the other hand, even though a hierarchy is unidirectional, it might contain some reversals, meaning that a subordinate can win an occasional encounter with a dominant individual. Perfectly linear unidirectional hierarchies are nevertheless relatively rare (Lehner, 1996 p. 332-3).

It might be a costly effort to achieve a high rank in the dominance hierarchy, but once a high status is established, the individual gets advantages in many aspects (Alcock, 2005 p. 332). Horses do usually not have to compete about their food resources, as they are herbivores and feed on rather evenly dispersed resources. If their food or other resources on the other hand are somehow limited, their feeding strategy is affected by their social status (see Krueger and Flauger, 2008). Horses with the highest rank have been seen getting more access to water and food (van Dierendonck *et al*., 1996; Krueger and Flauger, 2008) and in the study made in Skorradalur, the three top ranking individuals were heaviest, even though spending less time grazing, indicating that horses with high rank get access to the best grazing spots (Hrefna Sigurjónsdóttir *et al*, 1999). In the study made in Hólar in 2001-2002 low ranking horses lost more weight than high ranking ones during the winter. In the same study, it was found that when the weather was bad, the horses kept close together and the highest ranking horses got access to the centre of the group or a place, which was most protected from the wind (Ingolfdottir and Sigurjonsdottir, 2008).

Factors that are thought to influence the rank that an individual has in the hierarchy in herds of horses are for example; age (Clutton-Brock *et al*., 1976; Houpt and Keiper, 1982; Keiper and Sambraus, 1986; Feh, 1988; Ellard and Crowell-Davis, 1989; Rutberg and Greenberg, 1990; Keiper and Receveur, 1992; van Dierendonck *et al*., 1995; Kimura, 1998; Sigurjonsdottir *et al*, 2003, Hrefna B. Ingólfsdóttir, 2004; Vervaecke, 2007), social experience (Rutberg and Greenberg, 1990) and size (Berger, 1977; Ellard and Crowell-Davis, 1989; Rutberg and Greenberg, 1990). Weight has been found to correlate with rank in some studies (Clutton-Brock *et al*., 1976; Houpt *et al.*, 1978; Ellard and Crowell-Davis, 1989; Hrefna Sigurjónsdóttir *et al*, 1999; Hrefna B. Ingólfsdóttir, 2004). The temperament of the horse can also be a factor that has an effect on rank, since higher ranking horses have been found to be more aggressive (Rutberg and Greenberg, 1990; van Dierendonck *et al*., 1995; Hrefna Sigurjónsdóttir *et al*. 2000; Vervaecke *et al*., 2007). For geldings, the rank can depend on the age of castration (van Dierendonck *et al*., 1995). Residence in the group also seems to have an effect on the rank, as newcomers in the group often gets a low rank at first (Clutton-Brock *et al*., 1976; Keiper and Sambraus, 1986; Rutberg and Greenberg, 1990; van Dierendonck *et al*., 1995). In the study at Skáney it was found that mares that had a relatively high coefficient of relatedness had a similar rank, indicating that relatedness also can have an effect on the rank that an individual gets in the dominance hierarchy (Sigurjonsdottir *et al*., 2003).

Figure 1: One of the harem stallions fighting a sub-adult.

1.2.2 Positive interactions

Social animals do also interact in positive ways, for example by social grooming (allogrooming) and playing. In for example primates, allogrooming is often found to be the most frequently observed behaviour (Dugatkin, 2004 p. 298) and allogrooming has been considered as an important factor for primates to bond and to keep primate groups together (Zuckerman, 1932 in Dugatkin, 2004 p. 298). Allogrooming is also an important behaviour in horse groups and it has been found to strengthen friendship bonds between the horses, as it does among primates. By grooming the skin the horses remove parasites and dead skin cells (Feist and McCullough, 1976; Sigurjonsdottir *et al.*, 2003) and allogrooming also lowers the heart rate and calms the horse (Feh and Mazieres, 1993).

It has been shown that horses that have the opportunity to allogroom in their stables are less likely to develop stereotypic behaviour than others (Hrefna Sigurjónsdóttir, 2005).
The intensity of allogrooming is affected by social factors, such as newcomers in the group (Hrefna Sigurjónsdóttir and Anna G. Þórhallsdóttir, 2006) or by the season, for example because of winter coat shedding and changes in weather and density of parasites and flies (Wells and van Goldschmidt-Rothschild, 1979; Hrefna B.Ingólfsdóttir, 2004).

It has often been found that horses of similar rank are more likely to allogroom (Clutton-Brock *et al*., 1976; Wells and van Goldschmidt-Rothschild, 1979; Monard and Duncan, 1996; Kimura, 1998; Sigurjonsdottir *et al*., 2003; Hrefna B.Ingólfsdóttir, 2004). In addition, horses of similar rank often stay close together and make friends (Clutton-Brock *et al.*, 1976; Wells and van Goldschmidt-Rothschild, 1979; Ellard and Crowell-Davis, 1989; van Dierendonck *et al*., 1995; Kimura, 1998; Sigurjonsdottir *et al*., 2003). This will probably decrease the aggression rate between horses that are close in rank.

In some studies where the group did not contain a stallion, the horses preferred to allogroom with horses of their own sex (Tyler, 1972; Clutton-Brock *et al*., 1976; Sigurjonsdottir *et al*., 2003, Hrefna B.Ingólfsdóttir, 2004). In many studies a correlation between age and allogrooming has been found, in the sense that individuals prefer others of similar age as allogrooming partners (Tyler, 1972; Clutton-Brock *et al*., 1976; Monard and Duncan, 1996; Sigurjonsdottir *et al*., 2003; Hrefna B. Ingólfsdóttir, 2004), but in the studies of Feist and McCullough (1976) and Wells and van Goldschmidt-Rothschild, (1979) on natural harems containing stallions, mares allogroomed mainly with their own offspring.

Monard *et al*. (1996) found that when young feral mares disperse, they are more likely to choose a new harem where familiar individuals are members (Monard *et al*., 1996). Also, in newly formed groups of domesticated horses, individuals that had encountered each other earlier were more likely to allogroom and form bonds (Hrefna Sigurjónsdóttir and Anna Guðrún Þórhallsdóttir, 2006). Sigurjonsdottir *et al*. (2003) found a correlation between positive interactions and relatedness in the study at Skáney 1997 and this was also the case in a small study in Hólar in 2003. On the other hand, when the home group at Skáney was made instable by adding new individuals, familiarity was more important than relatedness when new bonds were formed (Hrefna Sigurjónsdóttir and Anna G. Þórhallsdóttir, 2005) (see also Tyler, 1972).

It is well known that horses sometimes intervene in social interactions of others. In the study made on groups without stallions in Skáney, the horses intervened in play and allogrooming of others. When intervening in allogrooming the interfering horse was significantly more often a preferred allogrooming partner of one of the allogrooming horses than not (van Dierendonck et al, in press). Mares, sub-adults and geldings were also seen preventing herd members approaching foals (Hrefna Sigurjónsdóttir and Anna Guðrún Þórhallsdóttir, 2006, van Dierendonck *et a*l, in press).

1.2.3 Do stallions have an effect on the interactions of other harem-members?

Feist and McCullough (1976) studied several feral harems including stallions. In their study, the stallions were seen to intervene in the interactions of others and they controlled the movements of other harem members to be able to keep the harem in an ordered and thereby defendable group. Feist and McCullough suggested that by doing this the stallion minimizes the risk of extra-group fertilization. By preventing the harem members to move between harems, the stallion indirectly disrupts allogrooming preferences of the harem members, as they might have chosen to allogroom with an individual in another harem if the stallion had not been present. A significant hierarchy was found only in the bachelor groups in their study. The result of Feist and McCullough (1976) therefore suggests that stallions might either prevent social interactions between mares in their harem directly, by intervening in the interactions, or that their presence has this effect. The consequence might be that the harem members forms less stable bonds and have a less rigid social hierarchy than what can be found in groups without stallions.

Data from other studies supports this idea to some extent. Dominance relationships in horses have been studied by many authors as mentioned earlier. In groups of horses not including stallions, authors have been able to detect a hierarchy in one way or another in many studies (Tyler, 1972; Clutton-Brock *et al*, 1976; Ellard and Crowell-Davis, 1989; van Dierendonck *et al*., 1995; Lehmann *et al*., 2006-only geldings included in this study). This has also been the case in 10 of 12 groups of Icelandic horses without stallions, where hierarchy analyses have been carried out (Sigurjonsdottir *et al*., 2003; Hrefna Sigurjónsdóttir and Anna G. Þórhallsdóttir, 2005; Vervaecke *et al*., 2007; Ingolfsdottir and Sigurjonsdottir, 2008). The two groups which were exceptional had fewer members (6) than the other groups and were composed of unfamiliar immature horses. Those two groups had only stayed together for four weeks and the hierarchy in those groups was thought to not yet have been formed, as a significant linear hierarchy was present in a similar group after six weeks (Hrefna Sigurjónsdóttir and Anna G. Þórhallsdóttir, 2005).

In groups containing stallions, a hierarchy was found in some studies, but not in others. In the study of Wells and van Goldschmidt-Rothschild (1979), a stallion was introduced to a stable group of mares and young horses when the study started and the hierarchy remained among the mares. Keiper and Sambraus (1986) found a hierarchy in all bands that were examined in their study and so did Rutberg and Greenberg (1990). Keiper (1988) found a linear hierarchy in a harem of Prewalsky horses, and in the study of Kimura (1998) on one feral harem, a linear hierarchy was found in the winter, summer and fall, but not in the spring. On the other hand, in accordance with the findings of Feist and McCullough (1976), a hierarchy was only found between the males in some studies (Goldschmidt-Rothschild and Tscanz, 1978; Berger, 1986; Feh, 1988).

Data of interaction rates and bonds between horses in groups without stallions supports the idea of Feist and McCullough to some extent as well. For example in the study of Kimura (1998), no strong friendship bonds were formed between the horses. Wells and van Goldschmidt (1979) found that the mares had few friendly contacts and a low allogrooming rate (0,06-0,13 times/horse/hour) and the same was found in a study on a harem of takhi horses, also including a stallion (0,07) (Hrefna Sigurjónsdóttir, unpublished results). In groups of horses without stallions, allogrooming rates have been higher. For example Clutton-Brock *et al.* (1976) found the rate 0,64 and in studies on Icelandic horses in groups not containing stallions allogrooming rates between 0,25 and 0,63 have been found (Sigurjonsdottir *et al*, 2003; Hrefna B. Ingólfsdóttir, 2004). These findings suggest that mares and sub-adults might enjoy more freedom to interact and to form hierarchies when no stallion is present, compared to typical harems (Sigurjonsdottir *et al*. 2003; Hrefna Sigurjónsdóttir and Anna G. Þórhallsdóttir, 2006). This supports the idea of Feist and McCullough (1976). To our knowledge, no study has until now been carried out where the effect of the presence of stallions has been analyzed in this context.

1.3 The aim of the study

In Iceland, the social behaviour of horses has, until recently, only been studied in groups without stallions. Since this group composition is not natural, it is of interest to find out if the members of a herd behave differently when a stallion is present. Of special interest is the question if the stallion either directly or indirectly suppresses the social activities of his herd-members as earlier research suggests (Sigurjonsdottir *et al.*, 2003). A deeper knowledge about the social behaviour of horses is important not only for people interesting in the social organization of mammals, but also for people involved in education and horse-breeding. In addition this knowledge can have a consequence for the welfare of horses.

The main aim of this study was to find out what impact stallions have on the interactions of the individuals in their harems and to what extent the stallions intervene in the interactions of their group members. The aim was also to deepen the present knowledge about the natural social behaviour of the horse in general, by investigating how factors like stability and composition of a group can affect the nature of the social behaviour and what factors can have an effect on the formation of dominance hierarchies. Therefore, the following questions were asked:

1. What effects do the stallions have on the interactions of their harem-members?

1.1 Are there significant linear dominance hierarchies in the groups?

H_0: The stallions do not have any effect on the formation of hierarchies in the groups.

1.2 What are the rates of allogrooming and the number of friends in the groups?

H_0: The stallions do not have a suppressing effect on the positive interactions of their harem members.

1.3 Do the stallions intervene in the interactions of their harem members or prevent interactions between their harem members and horses from other harems?

H_0: The stallions do not intervene in the interactions of others.

2. What factors affect the nature of the interactions in a group of horses?

2.1 How does the stability in the sense of how long the members have been in the group affect the interaction in the groups?

H_0: The stability of the group does not have any effect on the interaction rates and the average number of preferred allogrooming partners in the group.

2.2 Does the age of an individual have an effect on the interactions?

H_0: Age does not have any effect on the interaction rates, the number of preferred allogrooming partners or the rank of an individual.

2.3 Do familiar horses choose to allogroom when put together in a new temporary group?

H_0: Familiar horses do not prefer to allogroom with each other.

2.4 Does relatedness have an effect on the interactions?

H_0: Related horses are not close in the hierarchy and do not prefer to allogroom with each other.

2.5 How are the intervention rates in groups affected by the group composition?

H_0: There is no difference in intervention rates between temporary and permanent groups and horses do not intervene more often in allogrooming when their own preferred allogrooming partners allogroom with others.

2.6 Do the stallions behave differently in a temporary group compared to a permanent group?

H_0: The stability of the group does not have any effect on the behaviour of the stallions in respect of time-budgets and frequency of herding their harems.

2.7 Does the stallion interact differently than the other harem members?

H_0: The stallion does not behave different from the other harem members in respect of positive and negative interactions.

It was predicted that the stallions would have an effect on the interactions of others in the sense that less rigid or insignificant linear hierarchies, lower rates of allogrooming and fewer preferred allogrooming partners (friends) would characterize groups with stallions compared to groups without stallions. We predicted that the stallions would be seen to intervene when their harem members were interacting. It was also predicted that there would be more positive and negative interactions in temporary- and unstable groups where new bonds were being formed, compared to permanent groups. We predicted that different group compositions would have an effect on the social behaviour, as the interactions would be more in groups where immature horses were included and also that familiar and related horses would chose to allogroom more often than unfamiliar and unrelated horses. It was predicted that the horses would be seen to intervene more in the allogrooming of others, when the allogrooming horses were preferred allogrooming partners (one or both) of the intervener. The stallions in the temporary groups were predicted to spend less time foraging and more time herding their groups as more effort would be needed to keep the not yet established groups together, compared to the permanent groups. The stallions were predicted to allogroom less and to show more aggressive behaviour than the mares and young horses, due to more time spent in mating and defending the group.

2. Methods

2.1 The study groups

In Iceland, the common practice in horse husbandry is control breeding, where the mares and their newborn foals are put together with a stallion in a pasture (Mortel and Gunnarsson, 2000). The mares are often unfamiliar and they are usually only temporary put together to breed with a certain stallion (4-6 weeks). The interactions and behavior of the horses in two such temporary breeding groups were studied in the north west of Iceland: in 2004 the stallion Númi from Þóroddsstöðum and his temporary harem (H6) were observed at Þóreyjarnúpi in west Húnaþing (preliminary study, see Granquist, 2005) and in 2006, Adam from Ásmundarstöðum and his temporary harem (H5) were observed at Þingeyrar in east Húnaþing (Table 1 and Figure 2) .

Free roaming of stallions is not allowed in Iceland, but due to unusual circumstances we had the opportunity to study a natural herd of semi feral horses at Seli in Landeyjar in the south of Iceland. The herd was kept together in a 200ha pasture and in 2007 when the study was done the herd consisted of 68 adult mares with their newborn foals, 21 sub-adults and 4 stallions. The herd had been minimally managed for almost 30 years and had therefore developed a close to natural social system. The four stallions had divided the herd between them into one harem each (group H1-H4). The harems were of different sizes, but each harem consisted of adult mares, their newborn foals and some young horses (Table 1 and Figure 2). Most of the horses had lived their whole life in the pasture, but some had previously been in an adjacent pasture. These four groups were considered as permanent groups.

The only human contact with the semi-feral herd is when the horses are treated against worms (when they are 1 year old) and when farmers take blood from the mares in the autumn, which is sold to a factory for pharmaceutical purpose. At the same time, most of the foals are removed from the group to prevent overcrowding. Usually, some fillies are kept to maintain the group and occasionally one of the present stallions is replaced. The horses are given hey during the coldest months, to complement grazing.

Table 1: Total time that each group was studied, total number of horses in the groups (including the stallion) and number of adult mares and immature horses (8months-2 years old). Newborn foals are not included in the table.

Groups	Total time studied (hrs)	Total number	Adult mares	Immature horses (female/male)
H1	81	20	16	3 (1/2)
H2	77	31	21	9 (8/1)
H3	81	12	8	3 (3/0)
H4	77	30	23	6 (3/3)
H5	133	33	32	-
H6	76	28	27	-

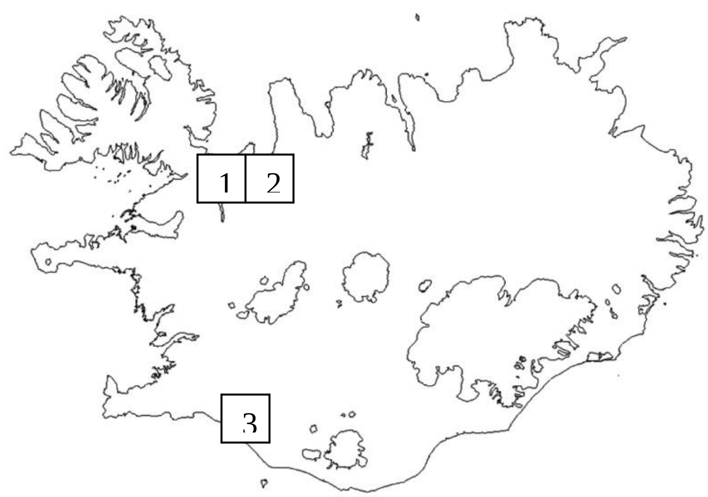

Figure 2: Map of Iceland with the observation sites marked. 1; Þóreyjarnúpur, west Húnaþing, 2; Þingeyrar, east Húnaþing and 3; Sel, Landeyjar.

The pastures that the temporary groups and the big herd were kept in were of similar vegetation type (small tussocks) and the land was flat in all of the pastures. All of the groups had access to water in the pastures (Figure 3).

Figure 3: The vegetation type was small tussocks and the land was flat in all pastures.

In the two temporary groups, some mares were added to the study groups by the farmers during the study. In H6, seven horses were added to the group ten days after the group had been put together. In H5, five horses were added to the group at different times during the study. The study of the semi-feral herd in 2007 was part of a bigger research project supervised by Hrefna Sigurjónsdóttir. Because of an experiment included in that research (not described in this thesis), six mares and one foal were taken from the adjacent pasture and they joined H2 shortly before the observations started. The farmers in Landeyjar had also transferred seven mares from the same adjacent pasture a week before the study started and those mares had already joined H1. In three of the four semi-feral groups (H1-H3), natural changes in the group composition also occurred during the study (see results: 3.3).

The fact that the individuals in the groups were observed for a different amount of time was taken into account (corrected for) when the results were analyzed.

2.2 Data sampling and analysis methods

In the two temporary groups, observations started the day after the group had been put together and both groups were then observed for the whole breeding period by the author. In 2004, observations were made from the 29^{th} of June until the 23^{rd} of July and in 2006 observations were made from the 5^{th} of July until the 9^{th} of August. In both years observations were distributed from 05.00 until 00.00. In 2007 observations were made from the 9^{th} to the 31^{st} of May. This year, observations were distributed from 04.00 until 00.00. Since the study in 2007 was part of a bigger research project 3 persons beside me sampled the data. By working in pairs, it was possible to study two groups at once. One person in each pair studied the groups H1 and H2 and the other person studied the groups H3 and H4. Each group was studied for five hours a day and the order of which of the two groups that were observed first was altered. All the results published in this thesis were analyzed by the author. Each horse in every group was identified individually, either by colour or body size and some horses were marked in the mane with plastic tape of different colours for easy identification. Binoculars were used when necessary to identify the horses and see clearly what was happening. To collect data of interactions to analyze the social structure, the method "all occurrence of some behaviour" was used (Lehner, 1996 p. 197) and definitions of different behaviours made by horse ethologists were used (McDonnell, 2003). Agonistic and submissive behaviours were recorded, as well as allogrooming. If a horse intervened in an interaction of other horses, this was recorded as a direct intervention. What individual was the intervener and which individuals were disturbed was recorded, as well as the type of interaction that the horses were intervened in (aggression, allogrooming, sexual behaviour or other behaviour) (see ethogram in Appendix I).

To be able to estimate time-budgets of the stallions, their behaviours were recorded once every 10 minutes by instantaneous scanning (Lehner, 1996 p. 205).

The Observer 4.0 © (Noldus, 2002) was used to make interaction matrices for different behaviours (for example aggression), where it is possible to see the specific interactions of all dyads (pairs) in every group.

To calculate correlations between those interaction-matrices and different factors, test-matrices were made, where each dyad got the relevant value. It was then calculated if there was any correlation between the two matrices (Kendalls $\tau_{rw.xy}$). If a correlation was found, partial correlation tests (Kendalls $\tau_{rw.xy,z}$, Lehner, 1996 p. 429) were made in cases when it was necessary to control for the effect of other factors on the correlation.

For the two temporary groups (H5 and H6), it was possible to find out information about relatedness in World Fengur (www.worldfengur.com). Using that information, an inbreeding coefficient was calculated by a population geneticist (Theodór Kristjánsson) and that coefficient was then put into a relatedness-matrix. Information about relatedness is not yet present for the groups in the semi-feral herd, but a DNA analysis of the horses in those group will be made in the future. Familiarity matrices were made for the temporary groups (H5 and H6) by giving dyads where the horses were familiar from before the study the number 1 and others the number 0 in the matrix. Age-difference matrices were made by giving every dyad the number that their age differed in years. This was only done for the temporary groups, since information about the exact age of the horses in the other groups was not available. However, for those groups it was possible to divide the individuals into 5 age-groups;

1) Born in 1997 or before
2) Born between 1998 and 2000
3) Born between 2001 and 2004
4) Born in 2005
5) Born in 2006

It was not possible to do any age-analysis for the group H1, as information about the age of some individuals in the group was missing. For information about the age of the horses (H5 and H6) and the distribution in the age groups (H1-H4), see Appendix II.

2.2.1 The analysis of negative interactions and hierarchies

Aggression rate was calculated for all groups, using the agonistic behaviours: aggressive push, bite, attack, aggressive chase, kick with hind legs and strike with forelegs. These behaviours are very clear to the observer and data should therefore be comparable between different observers. Statistic tests were made, using Systat, to find out if there were any significant differences in aggression rate between the groups, between sub-adults and adult mares or between different periods (Mann-Whitey U-tests and Kruskal-Wallis, Lehner, 1996 p. 396, 408).

The software MatMan© (de Vries *et al*., 1993) was used to calculate if there were significant linear hierarchies in the six groups. The hierarchy calculations were built on interaction matrices for aggression on one hand and for submission on the other hand. According to van Dierendonck *et al*. (1995) an aggressive behaviour can be either *offensive* aggressive or *defensive* aggressive. The latter can be used by a subdominant horse as a defence and therefore not all aggressive behaviours should be used when a dominance hierarchy is calculated. van Dierendonck *et al*. (1995) further argue that when a dominance hierarchy is calculated, submissive behaviours should have twice the weight as aggressive behaviors, since there is always a possibility that a aggressive behaviour is defensive. To calculate the hierarchies in this study, all submissive behaviours (see ethogram, Appendix I) were used. The agonistic behaviours that were considered as offensive aggressive behaviours and therefore were used in the calculations were: bite, threat to bite, strike with foreleg, ear threat, aggressive push, aggressive chase and attack. Kick with hind leg was on the other hand not used, as that behaviour was considered as a possible defensive aggressive behaviour (van Dierendonck *et al*., 1995; McDonnel, 2003). The program (MatMan) then makes new matrices, built on the original interaction matrices, but in this case the horse that was more often aggressive in each dyad got the number 1 in the aggression-matrix, and the horse that more rarely showed submissive behaviour in every dyad got the number 2 in the submission-matrix. In that way, the submissive interactions are let to be twice as important as the aggressive ones. The aggression matrix and the submission matrix were then added together. In this way, if horse A in a dyad (A-B) was more often aggressive than B and B was more often submissive than A, then A got the value 3 (2+1) and B the value 0. If there were no observed interactions for a dyad, the number was 0 for both parties in the summed matrix.

The rank for every individual in each group was then calculated by the program, using the number of horses that each individual dominates over (that is: has a higher value in the matrix). To find out if the hierarchy was significantly linear, Landau's h was calculated. The corrected Landau's h´, where unknown and tied relationships had been corrected, was used (de Vries, 1995) and the directional consistency and the number of unknown relationships in the groups was taken into consideration. In a completely linear hierarchy, the Landau’s *h´* is 1 and a low number therefore indicates that the hierarchy is flat and that some circular relationships exist. The value of the directional consistency index gives an indication of the uni-directionality of submissive behaviour within the dyads in the group and ranges from 0 (completely equal exchange) to 1 (complete uni-directionallity) (van Dierendonck *et al*, 1995). A low value therefore indicates that submissive behaviours do not only go in one direction in the dyads, but that reversals might exist, meaning that both of the horses in the dyad show each other submissive behaviour. A low value could therefore indicate that the dominance hierarchy has not yet been established. If the percentage of unknown relationships is high in a group, that will lower the significance of the linearity, since the higher the percentage of unknown relationships is, the more the value of h' resembles the expected value of the linearity index (de Vries, personal communication).

In case that the hierarchy was found to be significant linear, correlation analyses (Kendalls τ, Lehner, 1996 p. 429) between a) a matrix where the rank differences between each dyad were used as values and b) matrices containing behavioural data or c) test matrices (see above), were made in MatMan© (de Vries *et al*., 1993).

Spearman correlation test (Lehner, 1996 p. 426) was used to find out if there were significant correlation between the rank and the age of the individuals.

2.2.2 The analysis of positive interactions

Bonding between horses has been studied, using different methods. For example, factors like play, allogrooming and staying close together have been used as indicators of positive attachments (Waring, 2003). As the mares in our study did not play at all, we were not able to use play as a friendship-indicator. An association between allogrooming and staying close together has been found in some studies (Clutton-Brock *et al*., 1976; Whitehead & Dufault, 1999; Hrefna Sigurjónsdóttir and Anna G. Þórhallsdóttir, 2006). In this study, allogrooming interactions alone were therefore used to find out what individuals were friends, or more precisely preferred allogrooming partners. This was calculated by finding out if the horses allogroomed with some individuals more often than expected by chance (χ^2 -test, Rohlf og Sokal, 2001).

Allogrooming rate was calculated for all groups and statistic tests were made, using Systat, to find out if there were any significant differences in allogrooming rate between the groups, between the immature horses and adult mares or between different periods (Mann-Whitey U-tests and Kruskal-Wallis, Lehner, 1996 p. 396; 408). The same tests were used to find out if there was any significant difference in number of preferred allogrooming partners between the groups, between young horses and adult mares or between different periods.

Correlation tests (Kendalls τ, Lehner, 1996 p. 429) were made in MatMan© (de Vries *et al*., 1993) to see if there were any correlation between interaction matrices (allogrooming matrices) and test-matrices (see above).

Spearman´s rho correlation test (Lehner, 1996 p. 426) was used to calculate if there were significant correlations between age and allogrooming rate in the groups.

Because of the natural changes that occurred in the group composition of three of the semi-feral groups, the data were split into two periods for each group, before (T1) and after the changes occurred (T2). The periods were than compared according to positive and negative interactions (Mann-Whitney U-test, Lehner, 1996 p. 396) to see if the change had an effect on the nature of the interactions.

χ^2 –tests (Rohlf og Sokal, 2001) were made to see if the horses were more likely to intervene in allogrooming of others, when one or both of the interacting horses were preferred friends of the intervener.

2.2.3 The analysis of the time budget

Time-budgets were made for all of the six stallions, to be able to compare their behaviour. Calculations were made in Microsoft® Excel. Five different behaviour-classes were used: foraging, standing, laying, walking and other behaviours. χ^2 –tests (Rohlf og Sokal, 2001) were made to compare time spent foraging for the stallions in the different groups.

3. Results

3.1 Negative interactions

3.1.1 Aggression rates

The average aggression rate was between 0,03 and 0,08 aggressions per hour for each horse. The aggression rate was higher in the two temporary groups, compared to the permanent groups, except for group H3. The stallion had the highest aggression rate in all groups, except for group in H6. In the four groups containing sub-adults (H1-H4), the young horses had a higher aggression rate than the adult mares in two groups (H1 and H3) (Table 2, Figure 4 and 5).

Table 2: A. Average aggression rate (aggression/horse/hour) for the entire group (stallions included) and the highest rate found in each group (stallions not included). B. Aggression rate for the stallions in each group and the average aggression rate for adult mares and young horses in H1-H4 (8 months- 2 years old).

	A.		B.		
Groups	Entire group	Highest rate	Stallion	Adult mares	Young horses
H1	0,039	0,081	0,111	0,034	0,037
H2	0,029	0,143	0,155	0,034	0,030
H3	0,077	0,172	0,222	0,050	0,103
H4	0,052	0,130	0,286	0,044	0,043
H5	0,062	0,173	0,233	-	-
H6	0,078	0,297	0,224	-	-

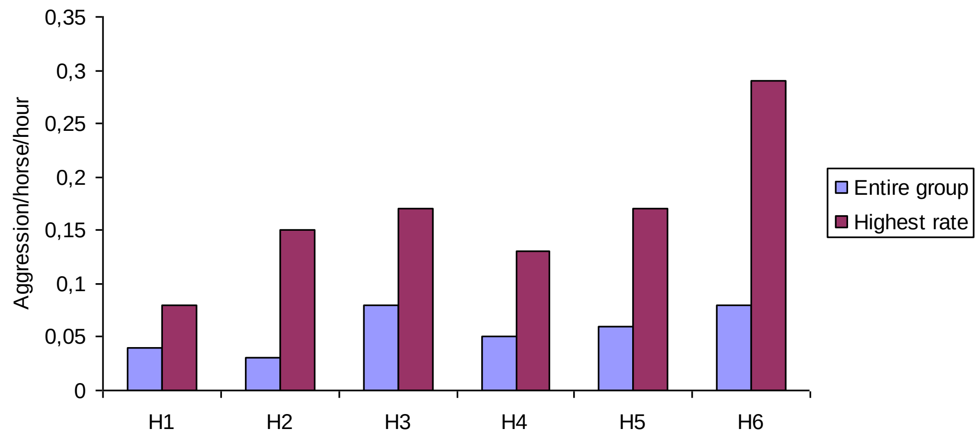

Figure 4: Average aggression rate (aggression/horse/hours) and highest rate for all groups.

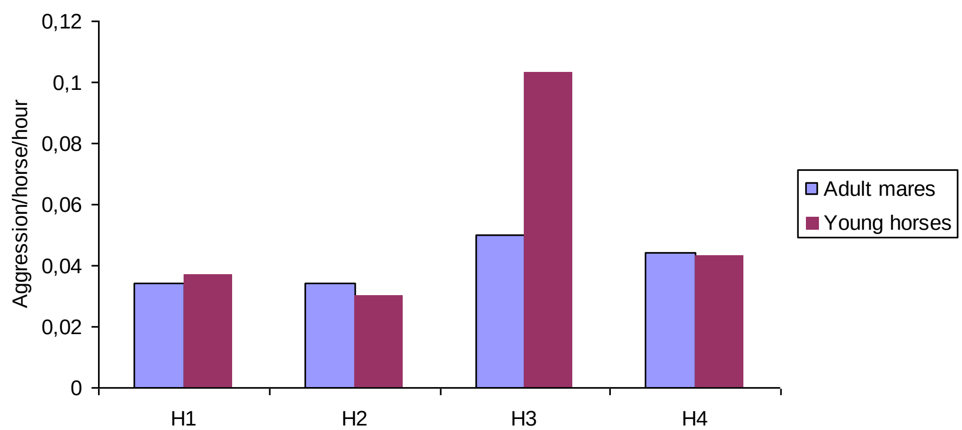

Figure 5: Average aggression rate for adult mares and sub-adults (8 months- 2 years old

There was a significant difference in aggression rate between the groups (Kruskal-Wallis: K=11,697; d.f. = 5; p= 0,039). The rate was significantly lower in H2 than in all the other groups (Table 3).

Table 3: Results from Mann-Whitney U-tests of the differences in aggression rate between the groups (df= 1).

Groups	MWU	*p*
H1-H2	412	0,047
H1-H3	92	0,275
H1-H4	279	0,676
H1-H5	238	0,091
H1-H6	195	0,075
H2-H3	102	0,022
H2-H4	290	0,011
H2-H5	272,5	0,001
H2-H6	171,5	0,000
H3-H4	219	0,275
H3-H5	215	0,662
H3-H6	163	0.882
H4-H5	443,5	0,922
H4-H6	297	0,055
H5-H6	442,5	0,777

There was not a significant difference in aggression rate between the young horses in the 4 groups (Kruskal-Wallis: K= 4,079; d.f.= 3; *p*= 0,253), nor between the adult mares of those groups (Kruskal-Wallis: K= 4,275; d.f.= 3; *p*= 0,233). When the sub-adults of all the 4 groups were compared to the adult mares of those groups, there was no significant difference in aggression rate (Mann-Whitney U-test: MWU= 608,00; d.f.= 1; *p*= 0,349).

3.1.2 Hierarchies

Significant linear hierarchies were found in three of the six groups (H1, H3, H5) and the linearity (Landau's *h´*) was low in all of the groups. The directional consistency index was high in all the permanent groups, but rather low in the temporary groups. The percent of unknown relationships (Table 4) in all of the groups, except H3, was rather high.

Table 4: Results from hierarchy-tests. Calculated Landau´s h´ is corrected for unknown and tied relationships.

Groups	Landau's *h´*	d.f.	χ^2	Directional consistency	% of unknown relationships	*p*
H1	0,26	26,7	31,2	0,99	66,3%	0,04
H2	0,13	21,7	37	0,99	81,3%	0,18
H3	0,52	20,6	37,1	0,93	30,3%	0,02
H4	0,14	36,0	24,3	0,97	78,2%	0,14
H5	0,15	38,9	44	0,68	58,3%	0,02
H6	0,11	34,1	10,8	0,55	75,9%	0,49

In H5 where the exact age of the individual was available, the oldest mare (23 years old) was found to be the top-ranking individual. In the semi-feral harems, where the exact age of the horses was not known, the top ranking individuals in the groups where a significant linear hierarchy was found were also amongst the oldest in their groups (information from the farmer). The stallions were not in top of the hierarchy in any of the three groups with significant linear hierarchies; in H1, the stallion, Huginn, was number 4 out of 20 horses, in H3, the stallion, Svartur, was number 7 of 12 horses and in H5, the stallion, Númi, was number 11 of 33 horses.

Calculations of what factors were correlated with rank were made for the three groups where a significant linear hierarchy was present. There was a significant negative correlation between rank difference and allogrooming rate in all of the 3 groups, meaning that the horses allogroomed significantly more with other horses of similar rank. In H5, where there was a possibility that the familiarity had an effect on the allogrooming rate, partial correlation test was made to control for that effect. The correlation between rank difference and allogrooming rate was significant even after the correlation had been made, indicating that familiarity did not have a big effect on the correlation (Table 5).

Table 5: Correlation analyzes (Kendall's $\tau_{rw.xy}$) for rank difference and allogrooming between dyads and partial correlation test (Kendall´s $\tau_{rw.xy.z}$) to control for the factor familiarity.

Groups	$\tau_{rw.xy}$	p	$\tau_{rw;xy.z}$	p
H1	-0,106	0,042	-	-
H3	-0,28	0,010	-	-
H5	-0,065	0,028	-0,066	0,033

Information about relatedness was only available for one of these three groups (H5) and therefore it was only possible to analyze if there were any correlation between rank difference in the hierarchy and relatedness for this one group. The correlation between rank difference and relatedness was not found to be significant (Kendall's $\tau_{rw.xy}$ = -0,04647, p = 0,1085), meaning that horses that were more related did not have a similar rank.

A statistically significant correlation was found between the factors age and rank for group H3, meaning that older horses had a higher rank in that group. This was not the case for group H5 (Table 6). It was not possible to analyze the effect of age on the rank in H1, as not enough information about the age of the individuals was available for that group.

Table 6: Correlation analyzes (Spearman's rho) for age and rank.

Groups	ρ_S	N	p
H3	0,783	11	<0,05
H5	0,276	32	>0,05

3.2 Positive interactions

3.2.1 Allogrooming rate

The average allogrooming rate was between 0,28 and 0,38 times per hour per horse in all of the groups except for H3, where the rate was higher or 0,60. The stallions had a lower allogrooming rate than average in all of the groups. In the groups containing sub-adults (H1-

H4), differences in allogrooming rate between the young horses and adult mares were analyzed. The young horses had a higher average allogrooming rate than the adult mares in all of the four groups (Table 7, Figure 6 and 7).

Table 7: A. Average allogrooming rate (allogrooming/horse/hour) for the entire group (stallions included) and the highest rate (stallions not included). B. Allogrooming rate for the stallions in each group and the average allogrooming rate for adult mares and young horses (8 months- 2 years old).

	A.		B.		
Groups	Entire group	Highest rate	Stallion	Adult mares	Young horses
H1	0,278	0,513	0,037	0,275	0,373
H2	0,380	0,829	0,194	0,315	0,552
H3	0,601	1,023	0,431	0,605	0,645
H4	0,329	0,716	0,299	0,268	0,568
H5	0,306	0,677	0,203	-	-
H6	0,289	0,719	0,013	-	-

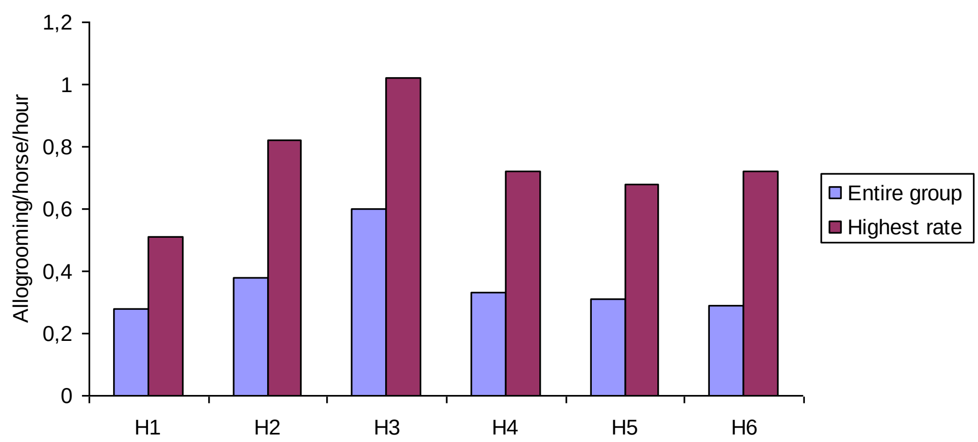

Figure 6: Average allogrooming rate (allogrooming/ horse/ hour) and highest allogrooming rate for the six groups.

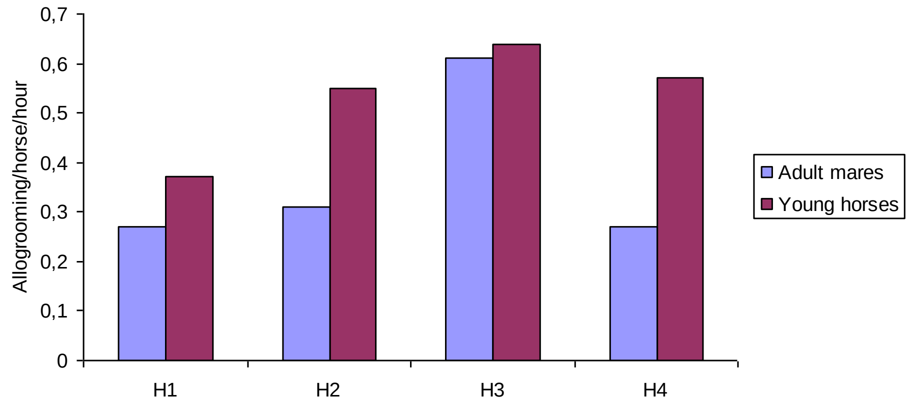

Figure 7: Average allogrooming rate for adult mares and sub-adults (8 months- 2 years old).

There was a significant difference in allogrooming rate between the groups (Kruskal-Wallis: K=11,927, d.f.=5 p=0,036). The allogrooming rate was significantly higher in H3 than all of the other groups except for H2. There was also a significant difference between H2 and H6 (Table 8).

Table 8: Result from Mann-Whitney U-tests of the differences in allogrooming rate between the groups (d.f.= 1).

Groups	MWU	p
H1-H2	213	0,060
H1-H3	57	0,014
H1-H4	265	0,488
H1-H5	314	0,769
H1-H6	284	0,933
H2-H3	123	0,088
H2-H4	532	0,334
H2-H5	633	0,103
H2-H6	562	0,052
H3-H4	264	0,019
H3-H5	300	0,009
H3-H6	255	0,010
H4-H5	537	0,563
H4-H6	457	0,565
H5-H6	480	0,794

There was no significant difference in allogrooming rate between the sub-adults in the 4 groups (Kruskal-Wallis: K= 5,501; d.f.= 3; p= 0,139), but the difference was significant between the adult mares of those groups (Kruskal-Wallis: K= 8,202; d.f.= 3; p= 0,042) because of a very high rate in H3. When the sub-adults of all of the of 4 groups were compared to the adult mares of those groups, it was found that the allogrooming rate of the adult mares was significantly lower than the rate of the sub-adults (Mann-Whitney U-test: MWU= 1182,5; d.f.= 1; p= 0,000) (see Table 7 and Figure 7).

A significant negative correlation between the age of the individuals and the allogrooming rate was found in H2, H4 and H5, meaning that in those groups the younger a horse was the higher allogrooming rate it had (Table 9).

Table 9: Results from Spearman´s rho correlation tests between age and allogrooming rate.

Groups	p_S	N	p
H2	-0,498	27	<0,05
H3	-0,169	11	>0,05
H4	-0,399	27	<0,05
H5	-0,392	32	<0,05
H6	-0,051	27	>0,05

In the groups where information about the exact age of the horses were present (H5 and H6), there was no correlation between the age difference matrix and allogrooming rate of those same dyads, meaning that horses of similar age did not allogroom significantly more than horses that differed a lot in age (Table 10).

Table 10: Results from analyzes of correlation (Kendall's $\tau_{rw.xy}$) between allogrooming and age difference.

Groups	$\tau_{rw.xy}$	*p*
H5	0,024	0,261
H6	0,019	0,641

In the temporary groups (H5 and H6), correlation analyses were made to find out if horses that were familiar from before allogroomed more often than unfamiliar horses. This was true for both groups (Table 11). In the two groups where information about relatedness was available (H5 and H6), it was possible to analyze if there was any correlation between relatedness and allogrooming. This was the case for H6, but not for H5 (Table 12). As a significant correlation between allogrooming and relatedness was found for H6, partial correlation was made to control for the effect of relatedness on the correlation between allogrooming and familiarity. The correlation was still significant for this group after the control had been made (Table 11). In H5, a significant correlation between allogrooming and rank difference was found (Table 5), but partial correlation analysis showed that the horses do indeed prefer to allogroom with familiar horses (Table 11). When a partial correlation test was made to control for the effect of familiarity on the correlation between relatedness and allogrooming H6, the correlation was not significant, indicating that when making friends in a new group it is more important for the horses to come from the same farm, than to be related (Table 12).

Table 11: Correlation analyzes for allogrooming and familiarity, and partial correlation tests (Kendall's $\tau_{rw.xy.z}$) to control for the factor relatedness for H6 and rank difference for H5.

			Control for relatedness		Control for rank difference	
Groups	$\tau_{rw.xy}$	*p*	$\tau_{rw.xyz}$	*p*	$\tau_{rw.xyz}$	*p*
H5	0,183	0,0005	-	-	0,183	0,0005
H6	0,27	0,0003	0,239	0,0003	-	-

Table 12: Correlation test (Kendall's $\tau_{rw.xy}$) for allogrooming and relatedness, and partial correlation test (Kendall's $\tau_{rw.xy.z}$) to control for the factor familiarity.

			Controlled for familarity	
Groups	$\tau_{rw.xy}$	*p*	$T_{rw.xyz}$	*p*
H5	-0,049	0,101	-	-
H6	0,136	0,005	0,037	>0,05

Figure 8: Two mares allogrooming.

3.2.2 Preferred allogrooming partners

The average number of preferred allogrooming partner for each group was between 2,00 and 3,06 in all groups except for one of the temporary groups, H5, where the average number was lower, or 1,30. The horses in the groups chose different numbers of preferred allogrooming partners (from 0 to 6) and they also differed in popularity as to how many horses chose them as a preferred allogrooming partner (from 0 to 7). The young horses (8 months-2 years old) had a higher number of preferred allogrooming partners compared to the adult mares in all of the four groups that contained young horses (H1-H4) (Table 13).

Table 13: A. Average number of preferred allogrooming partners (χ^2 –tests, *p*<0,05) and the lowest and highest number in all of the groups (stallions included). B. The number of preferred allogrooming partners of the stallion and the average number for adult mares and sub-adults (8 months- 2 years old).

	A.		B.		
Groups	Average in group	Lowest/highest number	The stallion	Adult mares	Young horses
H1	2,00	1/3	2	1,88	2,67
H2	3,06	1/6	2	2,76	3,89
H3	2,17	1/3	3	2,00	2,33
H4	2,50	1/5	1	2,35	3,33
H5	1,30	0/5	0	-	-
H6	2,18	1/5	1	-	-

There was a significant difference in the average number of preferred allogrooming partners between the six groups (Kruskal-Wallis: K= 34,737; d.f.= 5; p = 0,000). The horses in H5 had a significantly lower number of preferred allogrooming partners than all of the other groups. In H2 the horses had a significantly higher number of preferred allogrooming partners than in all of the other groups, except for H4 (Table 14).

Table 14: Result from Mann-Whitney U-tests of the differences in number of preferred allogrooming partners between the groups (d.f.= 1).

Groups	MWU	p
H1-H2	154	0,002
H1-H3	104	0,47
H1-H4	220	0,086
H1-H5	468	0,008
H1-H6	236	0,433
H2-H3	102	0,022
H2-H4	587,5	0,067
H2-H5	857	0,000
H2-H6	577	0,01
H3-H4	150,5	0,373
H3-H5	297	0,008
H3-H6	158,5	0,909
H4-H5	771	0,000
H4-H6	457,5	0,376
H5-H6	237,5	0,001

There was no significant difference in numbers of preferred allogrooming partners between the sub-adult horses in the four groups (Kruskal-Wallis: K= 6,406; d.f.= 3; p = 0,093), nor between the adult mares of those groups (Kruskal-Wallis: K= 7,637; d.f.= 3; p = 0,054). However, the sub-adults had a significant higher number of preferred allogrooming partners than the adult mares (Mann-Whitney U-test: MWU= 347,00; d.f. = 1; p <0,0001).

3.3 Natural changes in the group compositions

As described earlier, natural changes in the group composition occurred during the study in three of the four semi-feral groups. In all cases the changes included young mares that left their old groups and/or became members of other groups. The changes that occurred in the three groups were as following: One young mare, Vængja, was excluded from her group, H3, when the group had been observed for 33 hours. She had joined another group, H1, three days later and stayed in H1 throughout the study. She was pregnant and had a foal later in the summer. Another young mare, Dökk, who was also pregnant, left H1 voluntarily the day after Vængja had joined the group and joined H2 (when that group had been observed for 51,5 hours) and stayed there throughout the study. Rák, another young mare, was excluded from H2 the day before Dökk joined the group and she did not join any new group while observations of the herd were made. 2 weeks after the study she joined the group H4.

In H1 and H2 these changes occurred at the same time and in H3 there was only one change in the group composition. Therefore, it was possible (as described earlier) to split the data into two periods; T1 (before the changes occurred) and T2 (after the changes occurred) for each group (Table 15).

Table 15: Group compositions in the two periods (T1 and T2) for the three groups.

Group	Period	Change
H1	T1	Dökk is in the group, but not Vængja
H1	T2	Dökk has left and Vængja has joined the group.
H2	T1	Rák is in the group, but not Dökk.
H2	T2	Rák has been excluded and Dökk has joined the group.
H3	T1	Vængja is in the group
H3	T2	Vængja has been excluded

Comparison of the intervals before and after the changes occurred shows that the average aggression rate was lower in the second period in all of the groups. The difference between the two periods was however not significant in any of the three groups (Table 16).

Table 16: **A.** Average aggression rate for the two periods (T1 and T2). **B**. Results from Mann-Whitney U-test of the difference in aggression rate between T1 and T2 for the three groups.

	A.		B.		
Groups	T1	T2	z	N	*p*
H1	0,040	0,032	169	19	0,548
H2	0,030	0,022	578	30	0,079
H3	0,109	0,055	78,5	11	0,439

The allogrooming rate increased in the second period in two out of three groups (H1 and H3), but the rate decreased in H2. There was not a significant difference in allogrooming rate between the two periods in any of the groups, but in H1 the difference is almost significant (Table 17).

Table 17: A. Average allogrooming rate for the two periods (T1 and T2)**. B.** Results from Mann-Whitney U-test of the difference in allogrooming rate between T1 and T2 for the three groups.

	A.		B.		
Groups	T1	T2	MWU	N	*p*
H1	0,201	0,341	122,00	19	0,056
H2	0,387	0,353	485	30	0,773
H3	0,564	0,621	64	11	0,902

The average number of preferred allogrooming partners was higher in the second period for group H1 and H3, but lower for H2. The difference was only significant between the two periods in H2 (Table 18).

Table 18: A. Average number of preferred allogrooming partners for the two periods (T1 and T2). **B.** Results from Mann-Whitney U-test of the difference in number of preferred allogrooming partners between T1 and T2 for the three groups.

	A.		B.		
Groups	T1	T2	MWU	N	*p*
H1	1,368	1,600	162	19	0,395
H2	2,871	2,267	591	30	0,054
H3	1,667	1,909	56,5	11	0,514

3.4 Interventions

The stallions rarely intervened in ongoing interactions between members of their own herds, neither in the semi-feral herd, nor in the two temporary groups. The stallions in the six groups were only seen to intervene 9 times in total. In two of the groups (H1 and H2) the stallions were never seen to intervene and in the other groups the stallions intervened between 1 and 4 times. The 6 stallions intervened 4 times when a pair was allogrooming and 5 times when two horses were involved in an agonistic interaction. The interventions of the stallions 5 times had the effect that the interaction of others stopped (once in H3, once in H5 and three times in

H6). The stallion took over an interaction only once and that happened in H5, when the stallion took over a fight between two mares (Table 19 and Figure 9).

Adult mares and sub-adults intervened in the interactions of others in all of the groups (in total 106 interventions were observed). In all of the groups the mares and the sub-adults were seen to intervene in the allogrooming of others and it was more common to intervene in allogrooming than in aggressive behaviour in all of the groups (Table 19 and Figure 9). The horses were seen to intervene in the allogrooming of the stallion and another mare totally 6 times; once in H2, three times in H3 and, twice in H5.

In the two temporary groups (H5 and H6), intervening in sexual behaviour between the stallion and another mare occurred frequently (30 and 13 times respectively), which was not the case in the permanent groups (1-5 times). The group H3 had a higher intervention rate than the other groups for intervention in allogrooming, aggression and other behaviour, while the temporary groups (H5 and H6) had higher rates in intervention in sexual behaviour (Table 20, Figure 9).

Table 19: The number of interventions for each group, the number of times that the interactions between two horses stopped because of interventions and the number of times that the intervening horse takes over the interaction from one of the interacting horses (In parenthesis: The number of times that the stallion is the intervening horse).

	H1	**H2**	**H3**	**H4**	**H5**	**H6**
Interventions in allogrooming	2 (-)	5 (-)	12 (1)	5 (1)	9 (1)	8 (1)
Take over allogrooming	-	-	5 (-)	-	6 (-)	2 (-)
Interaction stops	2 (-)	2 (-)	9 (1)	1 (-)	1 (-)	1 (-)
Interventions in aggression	1 (-)	-	3 (1)	-	3 (1)	3 (3)
Take over aggression	-	-	-	-	1 (1)	-
Interaction stops	-	-	-	-	2 (1)	3 (3)
Interventions in sexual behaviour	1 (-)	-	3 (-)	5 (-)	30 (-)	13 (-)
Take over sexual behaviour	-	-	-	-	2 (-)	-
Interaction stops	1 (-)	-	1 (-)	1 (-)	10 (-)	3 (-)
Interventions in other behaviour	-	-	3 (-)	4 (-)	2 (-)	2 (-)
take over other behaviour	-	-	-	-	-	-
Interaction stops	-	-	1 (-)	-	1 (-)	-
Sum of interventions	**4 (-)**	**5 (-)**	**21 (2)**	**15 (1)**	**44 (2)**	**26 (4)**

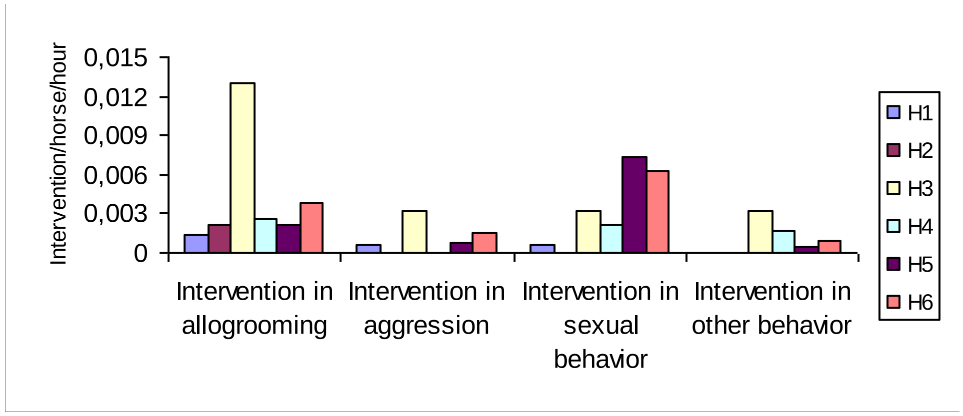

Figure 9: Average number of interventions (intervention/horse/hour) for each group in different types of behaviour.

Table 20: Total number of observed interventions in sexual behaviour and the rate for each of the six groups.

	H1	H2	H3	H4	H5	H6
Total	1	0	3	5	30	13
Rate	0,0007	0	0,0032	0,0022	0,0073	0,0063

The immature horses had a higher average intervention rate than the adult mares in all four groups where immature horses were included (H1-H4). The mares of the group H3 had a higher intervention rate than the mares of all of the other groups and the immature horses in H3 had a higher rate than all of the other immature horses. The mares in the two temporary groups had a higher average intervention rate than the permanent groups, except for the group H3. The stallion of one of the temporary groups (H6) had a far higher intervention rate than all of the other stallions (Table 21).

Table 21: Average number of interventions (intervention/horse/hour) (in parenthesis: total number of interventions) for immature horses, adult mares and the stallions of each groups.

Groups	Immature horses	Adult mares	The stallion	Total
H1	0,009 (2)	0,002 (2)	0	0,003 (4)
H2	0,003 (2)	0,002 (3)	0	0,002 (5)
H3	0,033 (8)	0,018 (11)	0,025 (2)	0,023 (21)
H4	0,022 (10)	0,002 (3)	0,001 (1)	0,006 (14)
H5	-	0,011 (44)	0,015 (2)	0,011 (46)
H6	-	0,011 (22)	0,053 (4)	0,013 (26)

In two of the six groups, horses were found to intervene more often than expected in allogrooming of others, when one or both of the interacting horses were preferred allogrooming partners of the intervening horse (Table 22).

Table 22: Results from χ^2 –tests which tests if horses intervene more often than expected in allogrooming of others, when one or both of the interacting horses are preferred allogrooming partners of the intervening horse.

Groups	χ^2	*P*
H1	8,028	<0,05
H2	0,0005	>0,05
H3	2,715	>0,05
H4	0,0445	>0,05
H5	16,352	<0,05
H6	0,694	>0,05

3.5 The stallions

There was almost no contact between individuals from different harems, except for the interactions between the stallions, who were seen to seek contact on several occasions. The stallions were often seen approaching each other, typically while vocalizing. They were then often seen to stand side by side to assess each others size (and strength) and showing each other agonistic behaviour. On the other hand, serious fighting between two stallions did not occur. The stallions were also seen to mark dung and urine of mares and other stallions with their own dung and urine. This behaviour resulted in large piles of dung where the stallions had met. The stallions of all six groups were seen to herd their harem members frequently. In the semi-feral herd, the stallions were seen to defend their harems against the other stallions and they often herded their whole harem away from another harem or stallion. The stallions in all groups were also seen to herd their harems on other occasions, for example when a harem member did not follow the harem. The herding rate observed for the different stallions ranged from 0,29-1,43 times per hour, except for the stallion in H3, Svartur, who were only seen to herd his harem five times during the study (0,06 times per hours). In one of the temporary groups (H5), the rate was 0, 29, which is lower then observed for any of the other stallions (except for the stallion in H3), while the stallion in the other temporary group (H6) had a higher rate than all of the other stallions (1,43). The stallion in H4, Blesi, had the highest rate in mount with ejaculation, mount (without ejaculation) and also in mount attempts. The lowest rate for mount with ejaculation and mount (without ejaculation) was found in H1 and H6, and the lowest rate of mount attempts was found in H6 (Table 23, Figure 10 and 11).

Table 23: Average rate (times/hour) in herding, mount with ejaculation, mount without ejaculation and mount attempt for each of the six stallions. (In parenthesis; total number that the behaviours were observed).

Groups	Herding	Mount w. ejaculation	Mount	Mount attempt
H1	1,037 (84)	0,025 (2)	0,049 (4)	0,086 (7)
H2	0,726 (56)	0,078 (6)	0,156 (12)	0,117 (9)
H3	0,062 (5)	0,037 (3)	0,074 (6)	0,025 (2)
H4	0,651 (50)	0,091 (7)	0,300 (23)	0,169(13)
H5	0,278 (37)	0,090 (12)	0,143 (19)	0,113 (15)
H6	1,434 (109)	0,026 (2)	0,053 (4)	0,013 (1)

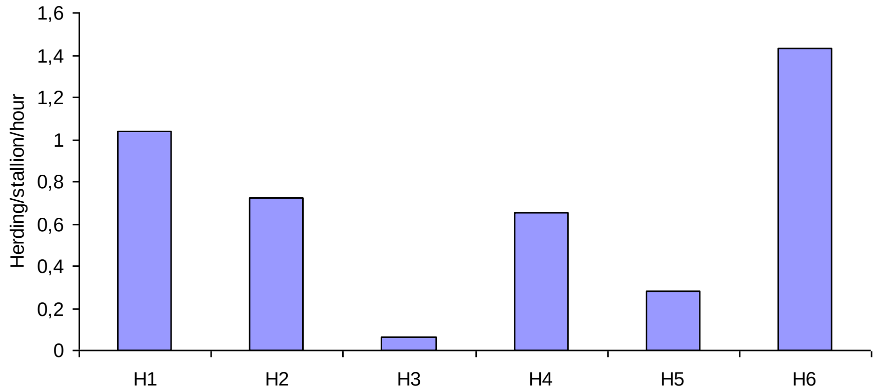

Figure 10: The herding rate (per hour) of the stallions of all the groups.

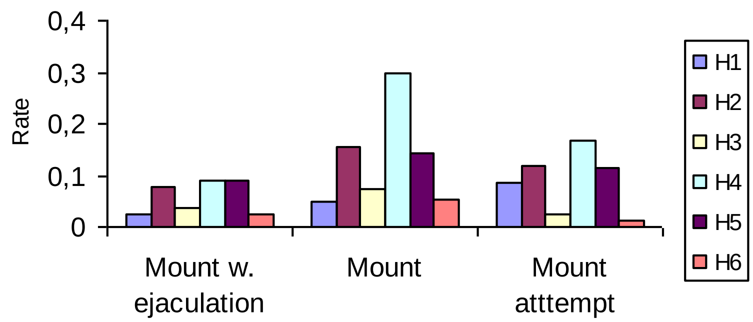

Figure 11: Rate of different sexual behaviours performed by the stallions in all groups.

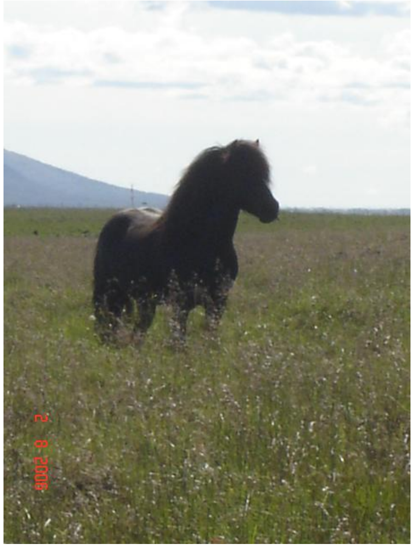

Figure 12: The stallion of the group H5, Adam from Ásmundarstöðum.

A time budget was made for all of the six stallions (Figure 13). The stallions all spent most of their time foraging (48-70%), but the individual difference was rather big. The stallions in the permanent groups (H1-H4) used more time foraging, or 55-70%, compared to the stallions in the two temporary groups (H5 and H6), which used 48% and 51% of their time foraging. The time spent foraging was found to be significantly lower for the stallions in the temporary groups compared to the stallions in the permanent groups, except for the stallion in H1 (Table 24). The horses in the temporary groups, on the other hand, used more time to stand (34% and 28%) then the horses in the permanent groups (13-24%) (Figure 9).

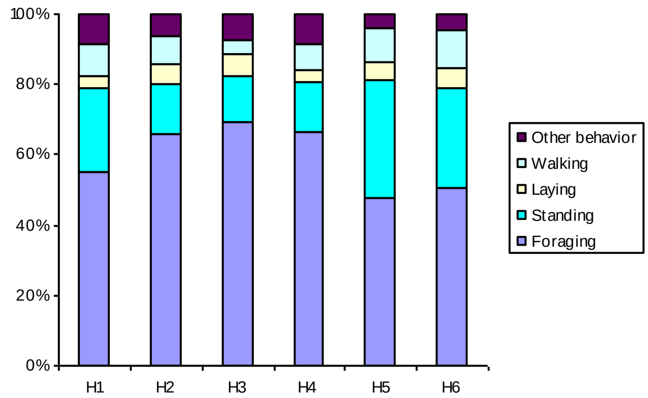

Figure 13: Time budgets for the stallion in each group.

Table 24: Difference in time spent foraging between the six stallions (χ^2 –test).

Groups	χ^2	*P*
H1-H2	2,93	>0,05
H1-H3	4,85	<0,05
H1-H4	3,17	>0,05
H1-H5	2,38	>0,05
H1-H6	0,55	>0,05
H2-H3	0,11	>0,05
H2-H4	0,01	>0,05
H2-H5	11,7	<0,05
H2-H6	5,06	<0,05
H3-H4	0,15	>0,05
H3-H5	15,89	<0,05
H3-H6	7,19	<0,05
H4-H5	12,11	<0,05
H4-H6	5,33	<0,05
H5-H6	0,3	>0,05

4. Discussion

The results from this study give some support to the hypothesis that stallions have an effect on the interactions of others. Differences in interactions between temporary- and permanent groups were also found and the composition of the groups was found to have an effect on interactions to some extent. Below the results are discussed in light of the questions put forward in the introduction.

4.1. What effect do the stallions have on the interactions of their harem-members?

4.1.1 Are there significant linear dominance hierarchies in the groups?

A significant linear hierarchy was found in three of the six groups (Table 4). Compared to similar groups of Icelandic horses without stallions, where a linear hierarchy is the rule (with an exception of two small temporary groups) (Sigurjonsdottir *et al*., 2003; Hrefna Sigurjónsdóttir and Anna G. Þórhallsdóttir, 2005; Hrefna B. Ingólfsdóttir, 2004; Vervaecke et al., 2007), the difference is clear.

One of the groups where a significant linear hierarchy was found was a temporary group (H5) and the other two groups were permanent groups (H1 and H3). The lack of a linear hierarchy in one of the temporary groups might be due to the instability of the group and that no hierarchy had yet been formed, while the fact that we did not find a strong linear hierarchy in two of the permanent groups most likely indicates that the presence of the stallion does indeed influence the establishment of a clear dominance hierarchy. In addition, the linearity (Landau's h´) in the three groups where the hierarchy was found to be significantly linear was relatively low, compared to what has been found in groups without stallions (Sigurjonsdottir *et al*., 2003; Hrefna B. Ingólfsdóttir, 2004). The percentage of unknown relationships were rather high in H1 (66,3%) and H5 (58,3%), but lower in H3 (30,3%), which can explain why the linearity index was higher in H3 than in the other groups. This can be due to the size of the groups H1 and H5, as horses in groups this big do not have the same possibility to interact with every individual of the group, as horses in smaller groups do (as in H3). The directional consistency within the dyads was high in H1 (99) and H3 (93), but lower in H5 (68). This suggests further that the dominance relationships were not stable during the observation period in the temporary group H5 (Table 4).

4.1.2 What are the rates of allogrooming and the number of friends in the groups?

The allogrooming rate found in this study (0,28-0,6 per hour per horse) was similar to what have been found in groups of Icelandic horses without stallions (Table 7, Figure 6). In the study at Skáney the rate was 0,25; 0,54; 0,44 in the different groups (Hrefna Sigurjónsdóttir and Anna G. Þórhallsdóttir, 2006) and in a study at Hólar on five groups the rate was between 0,17 and 0,31 the second year, but more the first year (0,45 and 0,63), which was thought to be due to heavy load of parasites. The pregnant mares in that study allogroomed less, or 0,08 (Hrefna B. Ingólfsdóttir, 2004). In groups of horses including stallions, very low allogrooming rates have been reported. In the study of Wells and van Goldschmidt (1979) the allogrooming rate was 0,06-0,13 and in a study on a harem of thaki horses in S-France, the rate was 0,07 (Hrefna Sigurjónsdóttir, unpublished results). The results presented here do not support the idea that stallions have an effect on the allogrooming rate of the harem members.

In groups of horses containing stallions, it has been found that the number of friends is low or that no stable relationships are present in the groups (Wells and vanGoldscmidt, 1979; Monard and Duncan, 1996; Kimura, 1998). In groups of Icelandic horses without stallions on the other hand, a high number of friends have been found. In the study at Skáney the average number of preferred allogrooming partners was 3,3-5,3 (Sigurjonsdottir *et al.*, 2003) and in a study at Hólar, the average number of preferred friends was 2-3 (except for one group, where the number was lower or 1,3). In this study, the average number of preferred allogrooming partners was between 1,3 and 3,06 (Table 13), which is lower than what was found in the comparable groups of Icelandic horses without stallions at Skáney. H5 had a significantly lower number than the rest of the groups (1,3) and H2 had a significantly higher number than the rest of the groups (3,06), except for H4 (2,5). The other groups had on average 2,0-2,5 friends. The relatively low number in this study therefore indicates that the stallions might have some effect on the number of preferred allogrooming partners of their harem members.

4.1.3 Do the stallions intervene in the interactions of their harem members or prevent interactions between their harem members and horses from other harems?

The stallions rarely intervened directly in social interactions, or stopped the behaviour of others in their own harems (table 19 and 21). These results indicate that stallions do not have a big direct effect on the interactions of others. On the other hand, indications that the presence of the stallions might have an indirect effect on the interactions of others was found, since the mares and young horses only rarely seek contact with members of other harems. These findings might be due to the herding behaviour of the stallions (see 4.2.6), giving them less opportunities to move freely in the pasture.

Encounters between the stallions were on the other hand seen on several occasions, but few direct attempts to steal mares from other harems were observed. This was also found in the study of Feist and McCullough (1976).

4.2. What factors affect the nature of the interactions in a group of horses?

4.2.1 How does the stability (in the sense of how long the members have been in the group) affect the interaction in the groups?

Earlier studies in Iceland show that interaction rates (both positive and negative interactions) increase when group composition changes, especially among younger horses (Hrefna Sigurjónsdóttir and Anna G. Þórhallsdóttir, 2006). This is thought to be because horses are getting to know each other and new bonds and hierarchies are being formed. In accordance with this, a significant difference in aggression rate between the groups was found in this study, which was due to higher aggression rate in the two temporary groups (H5 and H6) and one of the permanent groups (H3) (Table 2 and 3, Figure 3).

Allogrooming is thought to be an important behaviour to stabilize the group and to form new bonds (Feist and McCullough, 1976; Waring, 2003. p. 158; Sigurjonsdottir *et al*., 2003). The allogrooming rate in this study was though not higher in the temporary groups than the permanent ones (Table 7 and 8, Figure 6). That finding might be explained by the fact that the temporary groups did not contain sub-adults which were found on average to allogroom more than the adult mares (Table 7, Figure 7).

The number of preferred allogrooming partners was affected to some extent by the instability of the group. It is interesting that the horses in the group where most changes in the group composition occurred during the study (the temporary group H5), had a significantly lower number of preferred allogrooming partners than all of the other groups (Table 13 and 14).

The groups in the semi-feral herd were, as described earlier, considered as permanent and even though some mares had recently joined H1 and H2, this did not seem to affect neither the interaction rates or number of preferred allogrooming partners nor the intervention rates to any significant extent (Table 2, 7 and 13, Figure 4 and 6). In fact, a significantly lower aggression rate and a higher number of preferred allogrooming partners was found in H2 compared to all of the other groups (Table 3 and 14). The fact that some mares are added to an already established and stable group, does therefore not seem to have as much effect on the interaction rates in a group as when a whole new group is constructed (see H5 and H6).

The natural changes that occurred during the study in H1, H2 and H3 (Table 15) were all due to a young female leaving and/or joining a group. This was also found in the study of Feist and McCullough (1976). No significant differences between the periods before and after the changes occurred was found in any group, except for H2, where the number of preferred allogrooming partners was lower after the change (one young mare, Rák, left and another, Dökk, joined the group) had occurred (Table 15 and 18). This can probably be explained by the individual difference between the young mares, rather than the effect of the change it self, as the mare that left the group (Rák) was the most popular individual in the group (chosen by 6 horses as their preferred allogrooming partner), while none chose the mare that joined the group (Dökk) as a preferred allogrooming partner. The small differences in interaction rates between the two periods, suggests even further that small changes in an already established harem have hardly any effect on the interactions of the other group members.

4.2.2 Does the age of an individual have an effect on the interactions?

Rutberg and Greenberg (1990) found that younger mares tend to be more aggressive. In this study, the immature horses were found to have a higher aggression rate in two (H1 and H3) of four groups tested (Table 2, Figure 5), but over all there was no significant difference in aggression rate between the immature horses and the adult mares.

In many studies it has been found that older horses have a higher rank (Clutton-Brock *et al.*, 1976; Houpt and Keiper, 1982; Keiper and Sambraus, 1986; Feh, 1988; Ellard and Crowell-Davis, 1989; Rutberg and Greenberg, 1990; van Dierendonck *et al*., 1995; Kimura, 1998; Sigurjosdottir *et al*, 2003, Hrefna B. Ingólfsdóttir, 2004; Vervaecke *et al*., 2007). In our study, this was true for one of the two groups where this was examined (H3), while in the other group (H5) no significant correlation between age and rank was found (Table 6). Even though older horses are often found to have a higher rank, the oldest horses in a group have nevertheless not always been found to be the top-ranking individuals (Keiper and Sambraus, 1986; Sigurjonsdottir *et al*, 2003). In this study, the highest ranking horse was the oldest mare in the group where exact age was available (H5) and in the two permanent groups where the hierarchies were significantly linear (H1 and H3), the highest ranking individuals were also one of the oldest mares in the group.

Immature horses had a higher allogrooming rate compared to the adult mares in all groups containing immature horses (Table 7, Figure 7). A significant negative correlation between age and allogrooming rate was also found in 3 out of 5 groups (H2, H4 and H5) where the correlation was examined (Table 9). In H5 no immature horses were present, indicating that not only immature horses, but also young mares allogroom more than older mares. In addition, the immature horses had a significantly higher number of friends than the adult mares in all of the groups (H1-H4) (Table 13). The immature horses also had a higher intervention rate than the adult mares in all of the groups (table 21).

These findings give a strong indication that the age of the group members has a big effect on the nature of the interactions in a group of horses.

One of the harems in the semi-feral herd, H3, was different than the other groups in many aspects. The average aggression rate in this group was higher than in all of the other groups, except for one of the temporary groups (Table 2, Figure 4 and 5) and the linearity of the hierarchy was much stronger in this group than in the others (h'=0,52) (Table 4). Also, the allogrooming rate was almost twice as high as the rate in the other groups (Table 7, Figure 6 and 7). In addition, both the immature horses and the adult mares of that group had a higher average intervention rate than the horses of the other groups in all behaviour classes (interventions in allogrooming, aggression and other behaviour), except for intervention in sexual behaviour (Table 19 and 21, Figure 9). One explanation to this finding might be that a proportionally high number of immature horses characterized this group (see Appendix II) and the immature horses had, as mentioned before, both the highest rate of positive interactions, as well as interventions in all of the groups (Table 7 and 21). Other possible reasons for why horses in H3 behaved differently are discussed in 4.2.6.

4.2.3 Do familiar horses choose to allogroom when put together in a new temporary group?

Familiar horses groomed more than expected in both of the temporary groups (H5 and H6) and partial correlation tests showed that familiarity was the factor having the biggest effect on with whom the horses chose to allogroom (Table 11). This was also found at Skáney in unstable groups (Hrefna Sigurjónsdóttir and Anna G. Þórhallsdóttir, 2006). A preference for familiar individuals has also been found under feral conditions. Monard and Duncan (1996) observed that when young females were dispersing, they often chose a new harem that contained familiar horses that had earlier dispersed from the same harem. The familiar horses were also often related (Monard and Duncan, 1996).

4.2.4 Does relatedness have an effect on the interactions?

In the study at Skáney on a permanent group, Sigurjonsdottir *et al*. (2003) found that related individuals allogroomed more often than expected. In this study, this was the case in one (H6) of the two groups where information about relatedness was available (the two temporary groups) (Table 12). However, this correlation was found to be confounded by familiarity. Sigurjonsdottir *et al*. (2003) found that related horses in a permanent group had a similar rank. In this study, this was tested in the temporary group where a significant linear hierarchy was found (H5) and no such relationship was found. On the other hand, horses that were close in rank allogroomed more often than horses that differed much in rank, supporting findings from other studies (Table 5) (Clutton-Brock *et al*., 1976; Wells and von Goldschmidt-Rotschild, 1979; Monard and Duncan, 1996; Kimura, 1998; Sigurjonsdottir *et al*., 2003; Hrefna B. Ingólfsdóttir, 2004). Possibly if horses of similar rank make friends, it could help the groups to get more stable because frequency of aggressive interactions would drop.

Earlier studies suggest that adult mares in harems where stallions are present tend to allogroom more with their own offspring (Feist and McCullough, 1976; Wells and van Goldschmidt-Rothschild, 1979), while horses in groups where no stallion is present, rather choose to allogroom with individuals of the similar rank and the same sex and age as they are (Tyler, 1972; Clutton-Brock *et al*., 1976; Monard and Duncan, 1996; Sigurjonsdottir *et al*., 2003, Hrefna B. Ingólfsdóttir, 2004). This study supports this idea to some extent. In the two temporary groups where information about the exact age was available, the horses did not allogroom more with individuals in their own age class (Table 10), but instead they preferred familiar horses and the horses did only prefer to allogroom with the more related individuals (i.e. older than 1 year) in one of the two groups where it was tested. Regrettably in this study the frequency of mothers' allogrooming with their foals was not measured. As mentioned earlier, information about relatedness is unfortunately not yet present for the groups in the semi-feral herd. Correlations between relatedness and allogrooming and also correlations between relatedness and rank therefore need to be investigated further in the future.

4.2.5 How are intervention rates in the groups affected by group composition?

Mares and young horses were seen to intervene in interactions of others, which were also found in a study of groups without stallions (Hrefna Sigurjónsdóttir and Anna G. Þórhallsdóttir, 2006). It is interesting that the mares in both of the temporary groups intervened a lot in sexual interactions between the stallion and another mare, which was rare in the permanent groups in the semi-feral herd (Table 19 and 20, Figure 9). The possible explanation for this difference might be that some of the mares in the semi- feral herd had already mated successfully with the stallion when the observations started, while that was not the case in the temporary groups, as the observation started when the group was put together.

In this study, it was found that when a horse was intervening in allogrooming the interfering horse was significantly more often a preferred allogrooming partner of one or both of the allogrooming horses, than not (Table 22). This was also found by van Dierendonck *et al.* (in press).

4.2.6 Do the stallions behave differently in a temporary group compared to a permanent group?

Earlier studies suggest that stallions usually herd the mares when another stallion approaches the harem, to be able to secure the mares, but stallions also herd their harems on other occasions to be able to keep the harem together (Feist and McCullough, 1976; Keiper and Sambraus, 1986). In this study, herding behaviour was frequently observed in all groups. In the semi-feral herd it was observed that the stallion herded their harem to be able to move all the horses away from an intruding stallion. On the other hand, although no other stallion was anywhere nearby, the stallions in the two temporary groups herded their harem as well, for example when the mares got too dispersed over the pasture. The stallion then herded the harem into a smaller and more defendable group. The herding rate ranged from 0,29-1,43 (Table 23, Figure 10) times per hour, except for the small group H3 where the rate was 0,06. Except for the low value of H3, the lowest and also the highest value of herding rate were found in the temporary groups. Therefore the herding rate did not seem to be affected of the stability of the group. Nevertheless, the highest value of herding rate in the semi-feral herd was found for the stallions in H1 (Huginn) and H2 (Stjarni). This was thought to be because those stallions were actively involved in herding the new mares that joined their groups shortly before the observation started in the semi-feral herd. Especially Huginn was having trouble to keep his harem together due to the newcomers in the group. Since a very low herding rate was found in the smallest group (H3) (see Table 1), the size of the group seems to have an effect on the herding rate, which can probably be explained by less herding needed to defend and keep fewer individuals together compared to many individuals. Apart from the group size, different personalities of the stallions might have had an effect on the herding rate, while the stability of the group seems to have affected the rate less.

The stallion in H4, Blesi, who was the oldest stallion of all, was found to have the highest rate in performing sexual behaviour (all behaviour classes) of all of the stallions. A high rate was also found in one of the temporary groups (H5). The lowest rate was found in one of the permanent groups (H1) and one of the temporary groups (H6) (Table 23, Figure 11). The stability of the group did therefore not seem to have a big effect on the rate of the sexual behaviour performed by the stallions and the personality of the individuals probably plays a more important role in this case as well.

There was a big individual difference in the time budget of the stallions (Figure 13), but the stallions in the two temporary groups spent significantly less time foraging than the stallions in the semi-feral herd, except for the stallion in H1 (Table 24). This indicates that there is more pressure on the stallions when the breeding is controlled, compared to breeding in a natural herd, because of the unstable groups and the high number of mares that often characterizes the groups in controlled breeding. The big pressure on stallions under such circumstances might possibly, in the worst scenario, have a negative effect on the fertility of the stallion.

The findings that the horses in the semi-feral herd spent more time foraging can possibly partly be due to poor vegetation in the pasture earlier in the spring. A smaller difference between the six groups might have been found if the horses in the semi-feral herd had been fed more silage the winter before the study, as the stallions in the permanent groups then might have spent less time foraging.

The stallion in H1, Huginn, spent the shortest time foraging in the semi-feral herd. This finding did not come as a surprise, because the group H1 moved much around in the pasture during the study and as mentioned before, Huginn was actively involved in herding the new mares that he had newly gained to his harem.

The stallion in H3, Svartur, was the stallion that spent the longest time foraging, which may be explained by the fact that his small harem had to be herded less than the bigger harems as discussed above. The very low herding rate and the fact that Svatur seemed to control the harem members less than other stallions may, in addition to the young average age of the group, explain why interaction rates, number of preferred allogrooming partners and intervention rates in H3 is different. An additional explanation might be the experience of the stallion. Sigurjondottir *et al*. (2003) suggested that in harems where the stallion is young, inexperienced or has a low rank, the members might get more freedom to interact and in such groups interaction rates therefore might be similar to groups without stallions (Sigurjondottir *et al*. (2003). Svartur was one of the two youngest stallions in the semi-feral herd and he also had a low rank within his own harem, compared to the stallions in the other harems where a significant linear hierarchy was found (3.1.2.). In addition, the individual differences of the group members will have a bigger effect when looking at the average rate for different factors in small groups. It is clear that there might be many reasons why the group H3 is different from the other groups regarding interaction rates, hierarchy and interventions.

4.2.7 Does the stallion interact differently than the other harem members?

The stallions interacted on several occasions during the study (see also 4.1.3) and they were seen to assess each others size and fighting ability, by standing side by side (as described by Feist and McCullough (1976)), but serious fights never occurred. The stallions were also seen marking dung and urine of mares and other stallions with their own dung and urine. This behaviour resulted in large piles of dung where the stallions had met. This was found in all populations compared by Linklater (2000) as well.

The interactions of the stallions with others in their harems differed somewhat compared to the interactions of the mares and young horses. The stallion was the individual with the highest aggression rate in all groups, except for in H6 (Table 2) and stallions had a lower allogrooming rate than the average horse in all of the six groups (Table 7). In the study of Feist and McCullough (1976) on feral harems, the dominant stallion did not allogroom, but in the study of Christensen *et al*. (2002), where groups contained only stallions, the allogrooming rate was 0,24 and 0,53. This indicates that not only does the social behaviour of mares tend to be different under natural circumstances (in natural harems) compared to domesticated circumstances, but that a difference might as well be found in the social behaviour of stallions. This might be due to the time and energy that the stallion in a natural harem has to spend in mating and defending his harem to other stallions.

The stallion was not the top ranking animal in any of the three groups where a significant hierarchy was found. In other studies, different results as to whether males (geldings/stallions) or females are more often dominant have been found. Natural harems almost always obeys the stallion when he is herding, but the stallion is not necessary the top ranking individual in other contexts, such as in aggressive interactions within the harem (Wells and von Goldschmidt-Rotschild, 1979; Keiper and Sambraus, 1986; Waring, 2003; Sigurjonsdottir *et al*., 2003; Ingolfsdottir and Sigurjonsdottir, 2008). In the study of Berger (1977) males were more often dominant than females and Boyd (1991) suggests that in natural harems, stallions are more often dominant than the mares, because of age difference (Boyd, 1991). When young horses disperse from the natal group, the young mares often join another harem at a young age, while the young males often join a bachelor band at first. Because of that, the stallion of a harem is mostly older than many of the harem members. Still, stallions have been found to be subordinate to mares in some studies (Wells and von Goldschmidt-Rotschild, 1979; Keiper and Sambraus, 1986; Feh, 1988). In Icelandic studies, geldings have been found dominant over mares when controlled for age (Hrefna Sigurjónsdóttir and Anna G. Þórhallsdóttir, 2005; Ingolfsdottir and Sigurjonsdottir, 2008). It is therefore possible that the sex is not the most important factor in deciding the rank of an individual. Rather factors like age, size, temperament and personality seems to play a more important role.

5. Summary and conclusion

Some support to the prediction that the stallion does indirectly suppress social interactions of harem members was found. Thus, a lack of or less rigid dominance hierarchies suggests that the presence of a stallion gives the other harem members less freedom to interact (hypothesis 1.1). Also, a lower number of preferred allogrooming partners were found in all the groups in this study compared to other, similar groups not including a stallion, supporting this prediction even further (hypothesis 1.2). The results show that the stallions did not intervene as much in interactions between his harem members as expected (hypothesis 1.3). Still, the stallions have some direct effect on the interactions between their harem members, by not allowing interactions with individuals from other harems.

We found a significant difference in allogrooming rate, aggression rate and number of friends between the groups. The difference might be caused by differences in the composition of the groups, like for example whether the group is permanent or unstable, the average age in the groups, how familiar the horses are to each other and the size of the group. A clear difference in negative interaction rates was found between the permanent groups of the semi-feral herd, compared to the temporary and unstable groups (the temporary groups having higher rates, as expected), while the different was not as clear in rates of positive interaction rates. In addition, the number of preferred allogrooming partners was significantly fewer in the most unstable group than all of the other groups (hypothesis 2.1). However, some relatively small changes in an already established group did not have significant effect on the interactions in the groups.

Age of individuals in a group was found to have an effect on the interactions in the group (hypothesis 2.2), as immature horses were found to have significant higher rates of positive interactions (allogrooming) and significant higher number of preferred allogrooming partners. In addition, young adult mares allogromed more than older mares (in three of five groups). Immature horses of all groups had higher intervention rates than the adult mares. Age was also found to have a significant effect on the rank of the individuals in one of two groups tested. Familiarity was the most important factor deciding what horses formed bonds when the horses were getting to know each other in both of the temporary groups (hypothesis 2.3), but relatedness had a small effect on what horses allogroomed in one out of two groups tested (hypothesis 2.4). Relatedness did though not matter in relation to what rank the horses got in the dominance hierarchy.

The horses intervened more often than expected in allogrooming of others when one or both of the interacting horses were a preferred allogrooming partner of the interferer. How often the horses intervened in sexual behaviour of others, was also found to be affected by the stability of the group, as a much higher rate was found among the horses in the temporary groups compared to the permanent groups (hypothesis 2.5).

The stallions in the temporary groups did not have a higher herding rate than the stallions in the permanent groups. There was, on the other hand, a big difference in the time budgets of the stallions in the temporary groups compared to the stallions in the permanent groups, the stallions in the temporary groups spending less time foraging (hypothesis 2.6). The stallion was the individual with the highest aggression rate in all groups except for H6 and the stallions had a lower allogrooming rate than the average in all groups. The interactions of the stallions therefore differ somewhat compared to the interactions of the other harem members (hypothesis 2.7). The stallions were nevertheless not the top ranking individual in any of the groups where a significant linear hierarchy was found.

Results from this study give us an indication as to what factors other than environmental factors might affect the different interaction rates, since the habitats of the groups examined were very similar. Other studies performed in Iceland have also been carried out in similar environments and it is therefore possible to compare the results found in this study with other studies made in Iceland. On the other hand, comparison of interaction rates from other studies in different places of the world, with respect to different group compositions, may sometimes be questionable, since different environment probably often have a bigger effect on the rate than social factors. Also, methods used to estimate the different rates have varied a lot between different authors.

The results found in this study suggest that frequent changes in group compositions, as often occurs in the management of domesticated horses, can have a bad influence and be stressful for the animals, since the horses need to form new bonds and a new hierarchy each time that the group composition changes. It has been shown among other domestic animals (pigs, sheep and goats) that the instability in a group can affect the stress level in the animals, since a high aggression level is often found in unstable groups (Andersen *et al*, 1999; Boe *et* *al*, 2006; Joergensen *et al*, 2006; Andersen *et al*, 2008). Man-made changes of group compositions should therefore be handled with care. It might nevertheless sometimes be necessary to change the composition of a group and then it is important to make sure that the hierarchy is not too steep and rigid as that may lead to exclusion of subordinate individuals from the provided food. It should therefore be of great interest for every horse owner to know what factors can have an effect on the rank that an individual gets in the hierarchy, to be able to find out the best possible solution when constructing a new group.

Further studies on groups where stallions are included are necessary to find out if the results from this study are supported. All groups in this study were big, compared to groups found in nature (Linklater, 2000) and it is therefore of interest to find out in what ways stallions affect the harem members in groups of a more natural size. It is necessary to find out what consequences it can have to form the unnaturally big breeding groups that are the common practice these days. It is also of interest to perform studies on other non-permanent groups, where stallions are included. That would give us even more information about what are the best circumstances for horses to breed. To find out more about what effect the stability of a group has on the interaction rates, it is necessary to compare groups with more similar group composition (for example according to age), than what was possible in this study. Studying factors like this further would give us knowledge about the most preferable way to keep horses, which has a great value for horse owners and is an important factor for the welfare of horses.

The findings that the social structure can have a big effect on the social behaviour of horses, calls for further investigations on the importance of a natural social structure among other mammals. Findings from such research could be of value for farmers and others when planning how to manage group- and enclosure size of domestic animals, as well as for conservation agencies who work in the field of reintroducing endangered species back into the wild.

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7. Appendix

Appendix I: Ethogram

Behavioural class	Behaviour	Code
Meeting		
	Nose to nose	nn
	Nose to side	ns
	Nose to genitals	ng
	Flehmen	fh
	Approaching	ao
	Friendly bite	na
Aggression		
	Threaten with ears	te
	Threat to bite	tb
	Threat to strike	ts
	Threat to kick	tk
	Aggressive push	ap
	Bite	bi
	Kick with hindlegs	ki
	Strike with forelegs	sf
	Attack	at
	Aggressive chase	ac
	Fight upright	fi
Withdrawal		
	Flee (flee)	fl
	Supplant	su
	Move away	ma
	No reaction	nr
	Teeth clapping	tc

Behavioural class	Behaviour	Code
Interventions		
	Intervention in allogrooming	ia
	Take over allogrooming	ta
	Intervention in aggression	ir
	Take over aggression	tr
	Intervention in sexualbehaviour	is
	Take over sex	os
	Intervention in other activity	in
	Stops beh. because of intervention	sb
	Push in between 2 animals	pb
Grooming		
	Attempt to groom	ig
	Stops to allogroom	sg
	Allogrooming	ag
Sex		
	Presenting mare	pr
	Winking	wi
	Inspecting urine/dung	it
	Marking	mr
	Mounting attempt	mt
	Mounting	mo
	Mounting with ejection	me
	Herding	he

Appendix II: Horse table. The codes, names and numbers of the individuals, average age (H5-H6) or distribution in age groups (H1-H4) and foals born of horses in each group in the year of the study (*F= filles, C=colts, un= sex unknown and - = no foal*).* in H6 no information about the sex of the foals were available. **in H5 and H6 only mares were included (except for the stallion).

H1

Code	Name	Number	Age group	Foal born in the year
tv	Tvista	-	1	C
un	Ung	31	3	-
gr	Grey	-	5	-
sr	Stertur	-	5	-
lo	Löpp	S4	-	C
vi	Vinda	S9	-	C
ri	Rispa	S138	2	C
gl	Glóa	S139	2	F
ta	Tandra	-	-	C
ml	Molda	S8	-	C
la	Langa	-	-	C
st	Stutta	-	-	F
mo	Mósa	-	-	C
no	Nóra	-	-	C
va	Vængja	32	3	C
lb	Litla-Bleik	-	5	-
sj	Stjarna	S20	3	C
dk	Dökk	S144	-	-
bl	Blesa	S13?	-	F
hu	**Huginn (the stallion)**			**1**

Total number of horses: 20

Sex distribution (females/males): 85% / 15%

Age distribution:

Age group 1 (born 1997 and before): 2

Agegroup 2 (1998-2000): 2

Agegroup 3 (2001-2004): 3

Agegroup 4 (2005): 0

Agegroup 5 (2006): 3

H2

Code	Name	Number	Age group	Foal born in the year
do	Dómi	-	5	C
so	Sót	-	4	-
as	Aska	S57	1	F
st	Sterta	-	5	-
be	Bella	S70	2	C
sj	Skjóna	S86	1	C
sk	Skugga	S55	1	-
no	Nótt	S13	2	C
ga	Gamla	S112	1	C
go	Góð	S77	1	C
ta	Tagla	S113	1	C
rr	Rauða-rauð	S119	2	-
bl	Bleik	65	2	C
gy	Glóey	S101	2	F
dk	Dökk	S144	2	F
am	Aula-meri	S156	2	F
gl	Gláma	-	1	F
ns	Nös	22	3	F
ra	Rassa	S18?	-	un
gr	Gróa	S72	1	un
ak	Aula-Skjóna	-	4	F
gg	Gamla-Grána	S59	1	-
ab	Aula-Brún	-	4	-
aj	Aula-Stjarna	-	-	-
al	Aula-Blesa	-	4	-
ar	Aula-Rauð	-	4	-
rk	Rák	-	-	-
jo	Jörp	-	4	-
ba	Litla-Blesa	-	1	-
li	Lilla	0	-	-
si	**Stjarni (the stallion)**		**1**	

Total number of horses: 31

Sex distribution (females/males): 93,5% / 6,5%

Age distribution:

Age group 1 (born 1997 and before): 11

Agegroup 2 (1998-2000): 7

Agegroup 3 (2001-2004): 1

Agegroup 4 (2005): 6

Agegroup 5 (2006): 2

H3				
Code	**Name**	**Number**	**Age group**	**Foal born in the year**
bn	Brúnka	S94	1	F
tp	Toppa	-	4	-
sp	Stripa	-	4	-
fa	Faxa	S49	1	-
tg	Tigla	29	3	C
kv	Kverka	37	3	C
fe	Ferna	S117	2	F
bl	Blesa	76	2	F
vn	Vængja	32	3	C
sa	Sokka	-	5	-
ra	Rauðka	21	3	F
x3	**Svartur (the stallion)**		**1**	

Total number of horses: 12

Sex distribution (females/males):92% / 8%

Age distribution

Age group 1 (born 1997 and before): 3

Agegroup 2 (1998-2000): 2

Agegroup 3 (2001-2004): 4

Agegroup 4 (2005): 2

Agegroup 5 (2006): 1

H4				
Code	**Name**	**Number**	**Age group**	**Foal born in the year**
lp	Löpp	107	1	-
bu	Bumba	S13	2	un
ga	Gamla	S115	1	F
vi	Vinda	-	2	F
le	Leira	-	1	C
gr	Grána	-	1	-
mo	Molda	-	1	un
fi	Fifill	-	5	-
su	Stubbur	-	5	-
mi	Mosi	-	5	-
st	Stjarna	-	4	-
da	Daufablesa	-	4	-
lj	Ljót	S81	1	un
ll	Litlaljót	S52	1	C
gl	Glóa	141	2	un
sn	Snoppa	S36	1	-
sb	Skakkablesa	25	3	un
la	Lala	18	3	un
dr	Dökkrauðka	95		un
so	Sóta	S99	1	un
po	Pó	S6		C
di	Dipsý	S86	1	F
lr	Litarauð	-	4	-
ro	Rökkva	142	2	C
ti	Tinna	S90	1	un
	Brussa	S91	1	un
dm	Dimma	S83	1	un
no	Nótt	S82	1	un
sk	Söðulbaka	S105	1	-
x4	**Blesi (the stallion)**		**1**	

Total number of horses: 30

Sex distribution (females/males): 87% / 13%

Age distribution

Age group 1 (born 1997 and before): 16

Agegroup 2 (1998-2000): 4

Agegroup 3 (2001-2004): 2

Agegroup 4 (2005): 3

Agegroup 5 (2006): 3

H5**

Code	Name	Age	Foal born in the year
g	Gydja	15	C
m	Muska	11	F
o	Drottning	6	-
u	Reisn	3	-
h	Hera	9	F
c	Gæfa	8	Un
i	Víma	13	F
t	Pila	23	-
j	Jodis	11	C
b	Aría	11	F
s	Vordis	8	C
f	Fasta	8	F
r	Rispa	4	F
n	Nepja	8	Un
q	Líf S	6	-
9	Gná S	17	C
8	Fjodur	13	F
k	Kyrja	5	-
p	Ponta	9	C
y	Hylling	11	F
e	Kedja	18	C
w	Dama	12	-
d	Dilja	20	C
a	Harpa	7	-
v	Vakning	19	F
l	Líf E	9	F
z	Gná 2	11	-
2	Gjöf	13	Un
3	Þruma	15	C
5	Kylja	13	Un
6	Snekkja	14	Un
7	Eik	21	un
x	**Adam (the stallion)**	**13**	

Total number of horses: 33
Average age 11,64

H6**

Code	Name	Age	Foal born in the year*
m	Mjöll	7	-
y	Freyja	14	Un
1	Þruma	6	-
k	Katla	9	Un
o	Molda	20	Un
d	Efri-dís	5	-
l	Fluga	24	Un
a	Kolga	15	Un
i	Kolfinna	13	Un
v	Vordís	17	Un
n	Elín	15	Un
w	Vaka	15	Un
b	Þöll	11	Un
e	Svana	6	-
r	Þrinna	9	Un
h	Hekla	11	-
j	Atorka	11	Un
t	Lyfting	5	-
s	Sprengja	15	Un
u	Hnota	10	Un
2	Eik	11	Un
3	Dimma	14	-
g	Góða nótt	11	Un
q	Mánadís	10	Un
z	Sif	14	Un
c	Slaufa	18	Un
p	Prúð	9	Un
x	**Númi (the stallion)**	**11**	

Total number of horses: 28
Average age 12