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# Social behavior and welfare in horses (*Equus caballus*)

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## PREFACE

I have been fascinated by horses for as long as I can remember. I can recall being this little girl daydreaming about galloping across prairies and mountains. I've never lost this passion for horses when growing up, and I've had the chance to live a life filled with horse adventures. From the years trail riding in the south of France, to the months observing semi-wild horses in the Greek mountains and all the incredible experiences in between, I've gotten to know horses in their purest form. My eyes have seen foals being born, herds peacefully grazing, youngsters playing, wild stallions confronting each other and close friendships being formed, but I have also encountered the harsh reality of the equine industry. Horses weaving lifelessly in their stalls, subordinates crawling into the corners of – much too small – group-paddocks in an attempt to escape aggressions, horses being treated as a 'thing to ride on' rather than a living being. After having cried my heart out numerous times, I decided that I was going to do something about it and make it my mission to speak for those who are not heard. I could say "for those who cannot speak", but that would be a false supposition since animals communicate plenty, we often just don't take the time to listen, or make the effort to understand their messages. So, on the one hand I am deepening myself into horsemanship, to hopefully one day be able to offer horses a training that they can understand and accept as a partnership. And on the other hand I would like to take part in behavioral research, in the hope that someday it can make a difference for captive and domestic horses by helping people truly understand horses and their needs.

The inspiration behind this thesis subject and behind the research questions comes from all of my previous horse encounters. But it is my love for horses as well as my wonderment regarding their behavior that have been my driving force during this project.

Of course, I could not have done any of this without the help of my entourage. So I want to thank my parents Tabitha and Jonathan, for their undying support and patience. My sister Nagaïa and my friends, for sharing and entertaining my study breaks. My grandmother Hélène, for offering me a quiet place to work. And not to forget, all the wonderful animals who have fueled my motivation along the way.

I especially want to thank my professor and thesis supervisor Dr. Hilde Vervaecke for the great teachings and insights she has passed along during my time as her student, for her precious advice and support during the writing process of this thesis, and mostly, for inspiring me to one day become an animal scientist.

## ABSTRACT

Nowadays, most domestic horses are kept either in individual housing-systems or as managed groups in paddocks and loose stalls. Unfortunately, these husbandry practices present various threats to equine health and welfare. On the one hand, isolation goes against natural horse behavior, triggering abnormal behaviors, peaking stress-levels and health issues. On the other hand, grouping under suboptimal conditions (regarding food- and space availability, group stability and composition) can provoke higher aggression- and injury rates, which lead to serious psychological and physiological welfare concerns. Although there is an increasing interest in animal welfare over the last decade, scientific studies concerning social isolation, or the management of group-kept horses are still scarce. In this study we have thus decided to research several aspects of equine social behavior, in order to comprehend the functioning of horse societies. This knowledge will also help us understand the effects of social isolation and of high-density grouping, as well as possibly lead us to solutions that will deliver a better outcome for managed horse populations. Our research included a herd of Akhal-Teke horses (n=14) located in Estonia and a herd of Icelandic horses (n=9) in Belgium. Both groups were the subject of behavioral observations where agonistic- and affiliative behavior was recorded ad libitum and where several social and spatial parameters were documented during focal scans. The Icelandic horses were also exposed to an isolation test during which each individual was physically and visually separated from their conspecifics for five minutes, each performed stress behavior was then recorded ad libitum. The hierarchy was linear in both groups and rank was significantly related to age and residency time, but not to height or body condition. Agonistic behavior consisted mostly of threats and neutral approaches and contact-aggression was higher (15% vs. 5%) in the group with the smallest space availability. Horses who showed many agonistic acts received less aggression in return, but they also received less affiliative acts. In each group, three dyads formed strong affiliative bonds and further analysis revealed that these friendships occurred solely between horses of similar rank order. All-round sociability however was not related to rank nor age, meaning that horses of all age- and rank categories have a strong behavioral need to participate in affiliative interactions. Besides, our isolation test revealed that horses who exhibited a lot of affiliative acts also showed the most stress signals when separated from their herd. Furthermore, each horse had an acute reaction to the isolation test, some horses exhibited more than six stress indicators per minute, which revealed high anxiety levels amongst the test animals. Finally, subordinates from the Akhal-Teke herd were more likely to be found in periphery of the herd, while the dominants occupied the center. The distance to the closest neighbor was however not influenced by rank in either of the research populations.

We conclude that social isolation – even for short periods of time – has tremendous effects on the horse and therefore we strongly discourage owners of keeping their horses in housing systems that deprive them of physical contact with conspecifics. Moreover, we suggest that aggression- and injury rates in grouped horses are directly related to human management practices. The concern of increased injury risks in grouped horses is thus not a valid enough motive to keep a horse separated from conspecifics, since correct management (and thus low aggression rates) is entirely in our hands. To improve management practices, and ultimately horse welfare, we recommend that horses be kept in stable groups on big living spaces that allow the horses to retreat when necessary. We also propose that the horses should be offered constant roughage (hay) availability (or grazing possibilities) and that the food should be scattered around the living area to reduce food-related aggression or monopolization of resources.

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## INTRODUCTION

The horse (*Equus caballus*) is a highly social species that has a natural urge to associate with conspecifics (Waring, 2003). And although husbandry conditions have improved over the last few years, the major part of the domestic horses are still kept in individual housing-systems that allow no contact with others (Hartmann et al., 2012). Isolation is thought to be one of the most powerful stressors known for horses (Luescher et al., 1991). It deprives the horse of the possibility to express their intrinsically motivated natural social behavior and strips the individual of the comfort and benefits of group life. These deprivations have severe consequences for the horse's psychological and physiological wellbeing (Alexander et al., 1988; Van Dierendonck & Spruijt, 2012; Visser et al., 2008). Side effects of isolation can include – but are not limited to – the development of stereotypies (Visser et al., 2008; McBride, 2009), elevated levels of stress hormones (Mal et al., 1991) which have an immunosuppressive effect on the body (Roggen et al., 2014; Dhabhar, 2002), digestive problems such as gastric ulcers (Vervuert & Coenen, 2002) and problems during training (Cloux, 2017; Hausberger et al., 2008). Nevertheless, horse owners keep choosing for housing in single boxes and individual paddocks because of the widespread and unfounded belief that keeping horses in groups will automatically increase injuries inflicted by others (Jørgensen et al., 2015). Some horse owners do attempt to adopt a more natural approach by keeping their horses in groups, which tremendously increases the welfare of these individuals (Van Dierendonck & Spruijt, 2012). In some of these groups however higher aggression- and injury rates are observed, most often this is caused by the suboptimal management practices (such as limited space- (Knubben et al., 2008) and food availability (Burla et al., 2016) or constant changes in group composition (Christensen et al., 2011)) laid upon these groups rather than by grouping itself (as believed by most horse keepers). This is supported by the fact that aggression rates are higher in domesticated horses than in their feral conspecifics (Hartmann et al., 2017; Grogan & McDonnell, 2005). With this information, we can conclude that domestic horses face constant challenges related to their captive lives (Christensen et al., 2011) and that in order to better understand and possibly solve these welfare issues, a deeper empirical knowledge is required concerning equine social behavior in general. Therefore, in this paper we will look at different aspects of social behavior, including isolation. We will start by studying the natural history of the horse and we will learn about how horses function in the wild. Secondly, we will address the subject of dominance and hierarchy to discover how horses structure their societies. After that, we will get deeper into the matter of sociability and positive interactions. We will then combine the information gathered on these different subjects to analyze how the modern husbandry practices affect social welfare in horses. In a last theoretical part we will confront social and spatial aspects of horse behavior with each other to uncover any links between them. Furthermore we will talk about the goals of this study and look at the specific research questions, followed by a detailed description of how the study was set up and how the data was collected. Finally, we will describe the results and discuss our findings in the light of their implications for equine welfare.



# 1 NATURAL HISTORY OF THE HORSE

## 1.1 Habitat, home range and distribution

Captive horses are present in every part of the world except for Antarctica, this vast distribution is due to domestication and the wide range of human uses of horses (Bradford, 2015; Beever, 2013). In the wild, horses have been known to prefer roaming on open grasslands, but they can also inhabit deserts, semi – desert plains, subalpine regions, forests, coastal areas, wetlands and scrublands as well as tropical savannah grasslands. In other words, the horse can adapt to a wide range of habitats and environmental conditions (GISD, 2017).

Feral, free roaming horses can still be found in several parts of the world as on the mainland of Africa, Asia, Europe, Australia (Zabek et al. 2016), South America, North America (Turner Jr, 2015) as well as on islands as the Galapagos, Hawaii and other oceanic islands (Grubb, 2005). Populations of semi-feral horses also occur in some parts of the world. These herds are made up of privately owned horses that roam free across the land. Feral horses (*Equus caballus*) are listed as an invasive species (Beever, 2013).

In natural conditions, horses walk considerable distances each day to access vital resources such as water. A study on Australian feral horses found that the horses walked 8 – 28 km each day. It also occurred that the horses distanced themselves up to 55km from their closest water source, which they had to get back to through a 12 hour walk (Hampson et al., 2010). In parallel, the size of a herd's home range varies upon several factors, the most important being resource availability (Back & Clayton, 2013). Studies have also shown that home range sizes vary accordingly to herd sizes, with larger herds tending to occupy larger home ranges than smaller herds (Clement, 2015).

According to a study by Miller (1983) horses have seasonal movement patterns relative to the available water sources. In this study home range sizes were recorded between 73 and 303km<sup>2</sup>. Back & Clayton (2013) however reported home ranges varying between 0.9 and 48km<sup>2</sup>, but they also reported that this is dependent on study site and, as mentioned before, the availability of vital resources. The resource factor could also be explanatory for the fact that winter home ranges are on average bigger than summer ranges (Clement, 2015), as in winter bigger territories are needed to collect the same amount of resources than in summer.

Overall, we can conclude that horses are locomotive animals (Back & Clayton, 2013) and that *E. caballus* has adapted to a wide range of habitats, both in feral and domestic form.

## 1.2 Food habits

Horses are grazing herbivores, which means they feed mostly on grasses. Although they might also forage on foliage, trees, shrubs and fruits, their diet is primarily fiber-based (van den Berg, s.a.). In contrast to ruminants, the horse does not digest fibrous plant material in their stomach. Cellulose is digested in the intestinal tract (*caecum* and *colon*) through the help of different microorganisms. Because cellulose digestibility is not as efficient as in ruminants (45% efficiency), horses must take in large quantities of forage to fulfill their dietary needs (Whitaker & Hamilton, 1998). Thus, horses spend 16-20 hours per day moving around foraging (Fry, 2007; Henderson, 2007).

## 1.3 Lifespan and reproduction

Horses can live into their twenties and forties, on average horses will live 25 to 30 years. This is however strongly dependent on environmental factors, breed, physical activity, nutrition and all-round health (Clement, 2015; Kilby, 2007; McGowan, 2011). The longest living domestic horse has

been recorded at 61 years of age while the oldest recorded wild (Przewalski) horse died at age 36 (Willoughby, 1974).

Horses have a polygynous mating system, which means one stallion mates with several mares (Clement, 2015). Mares are sexually mature at about 18 months of age, which means they go into heat (*oestrus*) and can start breeding. Breeding season is usually in spring and gestation lasts for about 11 months. Small breeds carry their foals slightly longer (340 – 342 days) than heavier breeds (330-340 days) (Bukowski & Aiello, 2016). Although stallions reach their full reproductive capacity around age three, they already begin producing sperm at 12 – 14 months of age which makes them able to procreate (EquiMed Staff, 2015). In contrast to humans, the horse is a precocial species, the foals are standing and walking within a few hours after birth (Garwicz et al., 2009; McKinnon et al., 2011). The first years of a horse's life is one of rapid growth and weight gain. Some foals will reach 90% of their height and 75% of their adult weight at 12 months of age, others will attain this size later, at 24 months. After this fast-growing stage, horses will keep growing but at a slower pace. It will take five to seven years until the horse is fully grown and has attained his adult and final form (Sellnow, 2013).

## 2 SOCIAL STRUCTURE AND HIERARCHY IN THE HERD

### 2.1 IN THE WILD

*Equus caballus* is a social species that forms herds. A herd is generally made up of 2 to 21 individuals, comprising one (or several) stallion(s), a group of mares and their offspring. Typically, a herd can be compared to a harem, a male and his group of females with a polygynous mating system (Landsberg, s.a.; Clement, 2015). The dominant stallion (if more than one) has priority to breed any of the mares in the group. He also has the role of protecting the herd against threats and other males. The dominant stallion will remain dominant until defeated by another (stronger) stallion. If this occurs, he will be expelled, and the new stallion will take over his harem. A stallion stays dominant for two years on average, but it has been recorded that stallions keep their position up to a decade (Overall, s.a.; Williams, 2004). Next to the dominant stallion, the herd also has an 'alpha female', also called the 'lead mare'. The lead mare does not gain her position solely by dominance but rather by age and experience. The herd relies on her to guide them through the land, find the water supplies, avoid dangers etc. (Williams, 2004).

Offspring tend to leave the herd, either because they are expelled by the dominant stallion, which is the case for colts gaining maturity, either because fillies (young mares) disperse to avoid incest. When fillies do stay in the herd they tend to have less offspring (Feh, s.a.).

In the wild, horses form complex social structures with a linear hierarchy of dominant, subdominant and subordinate individuals (Heitor et al., 2006a; Landsberg, s.a.). According to Fureix et al. (2012), once this hierarchy is established in a group of adult horses, the rank order remains relatively stable, with few aggressive confrontations between individuals. In natural circumstances, dominance is recorded to be translated through subtle signals and communications between ranks rather than constant aggressive interactions.

### 2.2 DOMINANCE AND HIERARCHY

Dominance, hierarchy or rank are terms to describe the social position of an individual within a group (Klimov, 1988). Dominance has evolved as a response to the competition there is in the wild for essential resources. And rank differences between individuals are made possible by the cost – benefit balance, which states that – for an individual to remain in a group – the cost of being a subordinate must be lower than the cost associated with dispersing or living solitarily (higher predation risk for example) (Vehrencamp, 1983 ; Estevez et al., 2007). This social organization gives high ranking animals the benefit of priority upon resources which has a favorable impact on their weight and body condition and consequently also on their fitness. Low-ranking animals in their turn adapt to this social structure which causes them to generally be less fat and heavy than the higher-ranking horses (Giles et al. 2015; Vehrencamp, 1983).

#### 2.2.1 Factors affecting dominance rank

In this section a review will be given upon the possible factors affecting dominance rank. It is important to mention that a fair amount of research has been done on this subject, but that there is, however, a large controversy across studies. This is presumably due to the heterogeneity of the research methods, animal group compositions and management practices used in the different studies. Moreover, some of these factors have been studied in addition to the main subject of a study (as a confounder) rather than being the subject of research itself.

### **Age**

Most of the studies conducted on hierarchy have analyzed the factor age as a variable in rank attribution. As a result, a wide range of studies have confirmed a correlation between age and hierarchical position (Giles et al., 2015; Wells & von Goldschmidt-Rothschild, 1979; Tyler, 1972), where older horses seem to be dominant over younger horses (Rutberg & Greenberg, 1990). This correlation has been found in feral horses (Keiper & Sembraus, 1986; Rutberg & Greenberg, 1990) as well as in domesticated herds (Van Dierendonck et al., 1994; Ellard & Crowell-Davis, 1989; Komárková et al., 2014). Although most studies point in the same direction, there have been early research results which did not support a correlation between age and dominance (Haupt et al., 1978).

### **Body condition and weight**

According to a study done by Giles et al. (2015) on outdoor-living domestic horses, dominance rank would be correlated with body condition. Their results showed that – when age and height were controlled for – high ranking individuals generally had higher body condition scores. Similar results were found in an earlier study on a group of Icelandic mares by Vervaecke et al. (2007). Weight also seems to be a factor affecting rank in the hierarchy as found by Tyler (1972), Haupt et al. (1978) and this was confirmed a decade later by Ellard & Crowell-Davis (1989).

Several studies have suggested that these correlations could be explained by the previously stated fact that being a high-ranking animal procures priority access to food resources, which obviously influences weight and overall condition. In this case body condition and weight would be merely a consequence of rank, and not a cause (Vehrencamp, 1983; Ingólfssdóttir & Sigurjónsdóttir, 2008).

### **Height**

Ellard & Crowell-Davis (1989) found a correlation between dominance and height in a study on twelve draft mares, their findings were however contradicted by Van Dierendonck et al. in 1994. Although a real comparative study has not been conducted regarding the effects of height on hierarchy rank, diversity in findings can be explained by the fact that a lot of studies are conducted on herds of the same breed, which often show little differences in height between individuals.

### **Kinship**

The effect of kinship on dominance rank is to this day still a double-edged subject as studies contradict each other:

Haupt et al. (1978) found that the daughters of dominant domestic mares were dominant in their own separate herd, Haupt & Wolski (1980) found similar results in a later study. This however only affected the offspring of dominant mares, there was no correlation found in middle and lower ranking horses.

In a study on naturally kept feral horses, Keiper & Sembraus (1986) did not find any correlation between rank and kinship; nor the adult offspring nor the juveniles had a similar rank to that of their mothers. This was supported by Komárková et al. (2014) in a study performed on a large population of domestic mare-foal pairs.

### **Time in the group**

Residence time in the herd has been shown to have an effect on the rank position of an individual, as found by Van Dierendonck et al. (1994). Studies suggest that the longer an individual has been in the

herd, the higher it will stand in the hierarchy (Komárková et al., 2014). This translates that newcomers are at a disadvantage regarding to dominance rank and that they usually enter a group at the lowest rank position in the hierarchy (Keiper & Sambras, 1986).

## 2.3 ASSESSING HIERARCHY

Animals living in social organizations need to know what their position, role or place is in the group in order to gain control and predictability over their environment. Therefore, they need to gather information regarding other individuals in the herd. This information can be obtained by confronting or challenging the other animal(s) either by real aggressive encounters or by threats that do not escalate (Krueger & Heinze, 2008). Dominance relations are symbolized by agonistic – submissive interactions (Van Dierendonck et al., 1994).

### 2.3.1 Agonistic behavior

Agonistic behavior can come in different forms: ritualized behavior, low-intensity aggressions known as threats (Keiper & Receveur, 1992) and real contact aggression such as bites and kicks. Ritualized behavior can range from neutral approaches to pinning ears and aggressive head tosses (McGreevy, 2012) while threats or low-intensity aggressions are more confrontational, for example bite threats, kick threat or short chasing another individual (Haupt et al., 1978).

Studies have found that dominance and rank in horses is directly related to aggressiveness, this would entail that high-ranking individuals display more aggressive behaviors than low-ranking animals (Vervaecke et al., 2007; Heitor et al., 2006a). Other findings however suggest that once an individual has attained a high-ranking position, displays of aggression start to decrease (Rutberg & Greenberg, 1990). And that maintaining that position is done by expressing ritualized behaviors and low-intensity aggressions (threats) towards the lower rank members (Fureix et al. 2012). More aggressive individuals would then be the animals who are still trying to establish their position and/or trying to climb the hierarchical ladder, hence the use of more confrontations (Fureix et al. 2012). Although dominance is commonly seen as agonistic behavior, in general researchers do agree that once a hierarchy has been attained within a herd, aggressive encounters decrease, and the hierarchy remains stable over time (Craig, 1986; Briefer Freymond et al., 2013; McDonnell, 2003). This stability is necessary in order for individuals to be able to predict contest outcomes, which in turn might demotivate aggressive encounters and minimize injuries. Most frequently, horses will show the minimum amount of aggressiveness needed in a situation (Briefer Freymond et al., 2013; Hartmann et al., 2017).

### 2.3.2 Submissive behavior

If aggressiveness is not the only determining factor in rank assessment, then perhaps submissive behavior also plays a key role. The response given by the receiver of an aggressive display might even say more about the rank position of the actor than the mere frequency of his aggressive displays. In this light, the ultimate form of dominance is when the subordinate submits to the actor while it did not show any aggressive behavior. Van Dierendonck et al. (1994) have found that, in well-established herds, an animal's status can be recognized by this effortless and/or spontaneous avoidance shown by subordinates. A common example is when a high-ranking individual neutrally makes his way through the herd and that other horses yield to him and step away (Van Dierendonck et al., 1994). Most often however, submission is not entirely effortless and requires some sort of threat or

aggression (depending on the level of subordination) to extract a submissive response (see earlier 2.3.1) (McDonnel, 2003).

Submissive behavior can be demonstrated through many different forms, the most common being avoidance and retreat. Retreat can be defined as the stepping/jumping away of a subordinate in reaction to the approach of a dominant individual. Avoidance on the other hand is shown when a subordinate changes its itinerary in order to avoid a dominant individual, avoidance can also be seen when a low-ranking animal waits until the dominant leaves before approaching a limited resource (Mills & McDonnel, 2005). Retreat is a very important submissive behavior that has the role of avoiding aggression and possible injuries, it can however only be expressed when there is enough space available to move away from the dominant individual, which is not always the case. On the assumption that retreat is not spatially possible, the horse will still be able to show submission to the dominant by means of its body language. When cornered and wanting to submit, a horse will either tuck its tail and crouch its hindquarters which gives a tightened appearance to the horse (most often when the aggressor is behind) or it will toss its head and neck upwards, also possibly to the side to avoid the aggressor who is in front (Waring, 2003). It has been recorded that just moving the head away from the aggressor is sometimes a sufficient and acceptable sign of submission towards the dominant, in this case displacement of the receiver's whole body is not necessary (McGreevy, 2012). In younger horses and juveniles, submission can be shown through "snapping". This behavior can be recognized by the up- and down movement of the lower jaw in a chewing-like motion (McDonnel, 2003). This is performed repeatedly with the neck extended towards the dominant individuals. Youngsters will exhibit snapping when approached by an adult individual or when they approach an individual themselves and want to show submission in order to avoid other (possibly agonistic) interactions. This behavior tends to fade when the horses mature (Waring, 2003).

## 2.4 FACTORS INCREASING AGGRESSION

As discussed above, naturally, a herd hierarchy is relatively stable with few and mild aggressive encounters, however, captive environments can increase aggression level and intensity between group members (Fureix et al., 2012). The frequency of agonistic (aggressive) interactions strongly depends upon the management practices used by humans. Living space and the distribution of resources are one of the most important factors impacting on aggressiveness in horses (Hartmann et al., 2017).

### 2.4.1 Space

According to Klimov (1988), rank determines the spatial structure of a group, and the distribution of individuals over their living space. With subordinates tending to stay on the outer layer (i.e. in periphery) of the herd (Ingólfssdóttir & Sigurjónsdóttir, 2008). Heitor et al. (2006a) found that horses displayed more aggression in aim to control their space rather than to access limited resources, which translates that personal space and inter-individual distance is an important aspect in a horse's living environment. Consequently, studies have found that living space and aggression are strongly correlated in the way that, when space decreases aggressive interactions increase (Jørgensen et al., 2009; Hogan et al., 1988) and when space increases aggression decreases (Flauger & Krueger, 2013). Groups living under suboptimal management conditions – such as limited space – will show a higher rate of aggression, of which subordinates will mostly pay the costs, as they cannot disperse or retreat to their peripheral positions to avoid agonistic interactions (Estevez et al., 2007; Van Dierendonck & Spruijt, 2012). As described earlier, horses tend to strive for social homeostasis in the group to create an environment with few aggressions and risks of injury. Several studies have found that

aggression levels and injury rates are much higher in horses kept under domestic conditions in comparison to feral or semi-feral horse groups (Hartmann et al., 2017; Grogan & McDonnell, 2005). It has been suggested that high aggression rates in (stable groups) are directly related to management practices (Fureix et al., 2012; Hartmann et al., 2017). In this light, it is important to give group kept animals sufficient space in order to avoid injuries or stress related to aggression (Knubben et al., 2008). According to Flauger & Krueger (2013) a minimum of 331 m<sup>2</sup> per horse is required to obtain a low aggression rate between group members.

#### **2.4.2 Resource availability**

Space is, however, not the only factor that affects aggressive behavior. The access to (limited) resources such as food and water also has an effect on competition, and consequently on agonistic interactions.

In the wild horses spend 60% - 70% of their time foraging (Boyd, 1991), domestic horses on the other hand are usually fed two-three times a day. This limited feeding-time creates horses to compete for their food through increased agonistic interactions (threats or contact-aggression) (Burla et al., 2016). A reduction of aggressive behavior can be obtained through feeding management practices (Haupt & Wolski, 1980), like providing constant hay and other roughage. Burla et al. (2016) have found that increasing the duration of hay availability significantly reduces agonistic interactions.

#### **2.4.3 Social factors**

Moreover, the social management of a herd has an impact on the amount and severity of agonistic interactions. Group size for example is a factor affecting the frequency of aggression and threats, Burla et al. (2016) found that aggressive interactions increased with the number of mares in the group. Furthermore, group stability is also something to consider when managing a herd, it has been found that regrouping (i.e. often adding or taking away an individual) had an amplifying effect on aggressive encounters (Christensen et al., 2011).

Nowadays, horse owners tend to group horses by gender thinking this will reduce aggressiveness and the risk for serious injuries. However, in a study on the correlation between gender composition and aggression, Jørgensen et al. (2009) found that grouping horses by gender did not affect aggression rates.

As a conclusion, management is a key factor in maintaining a healthy social environment for domestic horse groups and in improving their overall welfare. To summarize, the preferred management goes towards stable group compositions, a feeding strategy containing constant roughage availability and last but not least, a living space that allows each horse to choose its inter-individual distance and that permits retreat from aggression.

## 3 SOCIABILITY IN HORSES

### 3.1 WHAT IS SOCIABILITY?

Sociability can be described as an individual's tendency to seek out close contact with conspecifics (Gibbons et al., 2010; Sibbald et al., 2005).

Affiliative relationships are a very important component of the social structure of social species such as the horse (Sankey et al., 2010). They do not only help stabilize group dynamics through the buffering of agonistic interactions and reconciliations after fights (Cozzi et al., 2010). But affiliative interactions also have benefits on an individual level, such as long-term alliances and cooperation's (Feh, 1999), increased reproductive success (i.e. fitness) (Cameron et al., 2009) and more immediate benefits such as reduced heart rates as a result of grooming activities (Feh & de Mazières, 1993).

Social interactions such as grooming, or play are usually limited to two individuals, but partners can vary across time. It is however also often observed that horses form long lasting dyads, these relationships or friendships can be recognized by the frequent close proximity of two individuals, between which there are no more limits of personal space. Each individual of the dyad can come and go into the personal zone of the other without being the target of any agonistic behavior (Budiansky, 1997).

Relevant to mention is that, in order for social relationships (agonistic and affiliative) to exist it is necessary that individuals possess the ability to recognize others on a personal level, as well as have the capacity of recalling previous (positive or negative) interactions in order to predict the outcome of a future encounter and to know how to act towards group members (Sankey et al., 2010). Proops et al. (2009) researched this social aspect in horses and found that they can indeed recognize each other, and that this ability is not just based on visual signals but on acoustic and olfactory signals as well.

#### 3.1.1 Factors linked to sociability

Here we will discuss which variables might have an impact on a horse's social relationships and the formation of bonds.

##### **Age**

Because it has been reported in humans that social relationships decrease with age (Marcum, 2013), Heitor & Vicente (2010) tested the hypothesis that older horses had less affiliative interactions. They did however not find any consistent evidence to support this hypothesis. The same question has been tested on non-human primates, with the same outcome: there is no significant correlation between age and affiliative relationships (McDonald Pavelka, 1991). Lansade et al. (2008) however did a study on gregariousness in horses and found that the temperament trait decreased with age. Older animals are known to be more knowledgeable in regard to finding resources and avoiding predators and dangers. In this light it would be expected that older horses have more social interactions and are more attractive social partners given the fact that they have more life experience and often a longer residency in the herd (Heitor & Vicente, 2010). In counterpart it is also said that older horses have less diversity in social partners than younger horses, as individual preferences occur with time and familiarity with the other herd members (Sigurjónsdóttir et al., 2003). Overall, not many studies have been conducted on the matter, thus no consistent evidence has yet been found to validate any of these hypotheses. Further research is needed to gain deeper insight on the impact of age on social interactions in horses.



### Reproductive state

It has been found that affiliative interactions have a positive influence on reproduction in mares. In mixed- and free-ranging herds, male harassment is frequent. Which has a reducing effect on the reproductive success of the mares, as they are exposed to aggressions and are in consequence prone to experiencing a lot of physiological stress. It is believed that social interactions and the strong bonds between mares decrease the level of harassment by males, which has a beneficial impact on the mares' success to reproduce (Linklater et al., 1999). To summarize, being integrated in (a) social relationship(s) has strong fitness benefits for mares (Cameron et al., 2009). In parallel, Heitor & Vicente (2010) found that mares spatially organized in relation to their reproductive states, i.e. they stayed in close proximity to mares in the same state.

The impact of affiliative interactions on fitness is clear, however it is not pronounced if reproductive state itself has an increasing impact on affiliative interactions (other than spatial organization) such as grooming and other affiliative contact.

### Rank

Sigurjónsdóttir et al. (2002) found that dominance rank was an important factor impacting affiliative interactions, both regarding spatial proximity and frequency of positive interactions. Earlier studies by Van Dierendonck et al. (1994) on Icelandic horses and by Kimura (1998) on Japanese free-ranging horses found that individuals of similar rank stayed spatially close to each other. This was supported later by a study on a group of Sorraia mares: the findings showed that the mares spent more time in close proximity to near-ranking individuals and lower-ranking females. However, mares who had strong social bonds did not show less aggressiveness towards each other (Heitor et al., 2006b). Alongside the other researchers, Sigurjónsdóttir et al. (2002; 2003) also found that horses tended to bond with individuals close in rank and that they also remained in close proximity to those individuals. They suggested that the correlation between rank and affiliative bonds could be explained by the fact that dominants have an advantage in bond formation- and maintenance as they can choose with whom to interact and subordinates cannot, as usually it is the high-ranking animal that initiates an affiliative interaction.

### Kinship

Multiple studies have shown that kinship also has an effect on social interactions and the formation of bonds. Sigurjónsdóttir et al. (2002) observed that the horses in their herd had a preference to bond and associate with individuals to which they were related. Heitor et al. (2006b) found similar results in their study on a group of Sorraia mares where bonds were stronger between mares with a higher kinship coefficient. However, in a next study Heitor & Vicente (2010) did not find any significant correlation between kinship and sociability.

In 1988, Keiper observed a herd of Przewalskii horses (*Equus przewalskii*) in the Munich Zoo and found that grooming occurred more often between related animals.

This behavior was also confirmed in free-ranging horses by Sigurjónsdóttir et al. (2003) who found a positive correlation between kinship, allogrooming, play and also proximity (standing close to each other) in a group of Icelandic horses.

We can conclude that kinship can be (but is not always) a factor affecting affiliative interactions and the formation of bonds between horses.

## 3.2 ASSESSING SOCIABILITY

As mentioned earlier sociability can be described as an individual's tendency to seek out close contact with conspecifics (Gibbons et al., 2010; Sibbald et al., 2005). This close contact can appear

under different forms, such as spatial proximity, grooming, play and other positive interactions between group members (Van Dierendonck, 2006). In this section we will discuss what has already been found regarding these characteristics of social behavior and explore how they can help us assess the relative sociability of an individual.

### 3.2.1 Positive interactions

#### Grooming

Grooming or allogrooming (mutual grooming) occurs when horses use their teeth and lips to scratch and rub some part of another individual's body (Kimura, 1998).

(Allo)grooming behavior originated from the need to remove parasites in places the individuals could not access themselves (such as the neck, back, manes and tail). Over time it has however also evolved to become a way of strengthening social bonds. This ritualized behavior has been known to be an effective buffer for social tensions and to help maintain the stability of the herd (Budiansky, 1997; Feh & De Mazières, 1993). Grooming also shows physiological benefits for the horse, studies have proved that scratching the withers slows the horse's heart rate. Thus, grooming has a calming effect on the horse's nervous system, anatomically this can be explained by the fact that the grooming site (withers) lies close to a ganglion of the autonomic nervous system (Normando et al., 2003; Feh & De Mazière, 1993).

Kimura (1998) observed a group of free-ranging mares over a period of two years and found that allogrooming behavior was strongly dependent on seasonal changes, the frequency of grooming was highest in summer and lowest in winter. In a study on Haflinger ponies, Lamoot & Hoffmann (2004) also found a seasonal difference in grooming behavior, however in their study the grooming frequency was highest in spring, allegedly due to the shedding season.

Kimura (1998) also uncovered that low-ranking horses had more grooming partners in summer, but that the frequency of grooming itself was not correlated with dominance rank.

#### Play

Throughout the years, animal play has been the subject of many discussions, the proximate mechanisms and the ultimate functions behind play are – up to today – still not fully understood (Held & Spinka, 2011; Hausberger et al., 2012). Nevertheless, we will give a review of the explanatory theories that have been proposed and of the research that has been conducted in relation to play in horses:

Spinka et al. (2001) suggest that play is an evolutionary way of preparing animals for future encounters with environmental control-loss. In other words, play teaches horses the physical and emotional responses needed during unexpected events such as the confrontation with a predator or a competitor. It is believed that through play animals create unexpected and "handicapping" situations in order to learn to enhance their agility and to teach themselves how to cope with emotionally stressful situations. Budiansky (1997) states that for horses, play mostly emphasizes on escape maneuvers, sham fighting and mating behavior such as mounting, which clearly prepares foals for their future social- and prey life. In an early study by Fagen & George (1977) it was uncovered that play is the main component of a young horse's exercise routine. Although play frequency is relatively the same for both sexes, types of play differ between colts and fillies. With colts engaging more often and longer in interactive- and fight play, which can be explained by the social structure of adult horses in natural conditions, where males have to compete against each other for females (Crowell-Davis et al., 1987; Rho et al., 2007).

Play can be recognized under different forms and can be categorized under 1) playing at an adult such as mounting, biting, kicking and pushing; 2) locomotor play such as running and bucking alone

or in group; 3) interactive play in the form of contact play or fight-play and 4) play with an object (Crowell-Davis et al., 1987).

Crowell-Davis et al. (1987) have found that play decreases with age, Budiansky (1997) even states that play ends abruptly at adulthood. Indeed, in natural living conditions adult horses rarely engage in play behavior. It has however been reported that play occurs more frequently in captive horses (Hausberger et al., 2012). Because play seems to be unnatural in adult horses, the hypothesis of a correlation between adult play and welfare issues in captivity has been tested in 2012 by Hausberger et al. The results have shown that 'playful' horses had more stress indicators than 'non-playful' horses, which means that play in captive adult horses may be an indicator of stress and bottled-up frustrations (linked to social, spatial and feeding restrictions). Held & Spinka (2011) also looked at play in relation to welfare, on one hand they stated that play may be a good indicator of welfare as it reflects a 'happy' state. On the other hand, they discussed the paradox of play increasing in stressful situations, and how therefor it does not necessarily reflect on good welfare or acceptable living conditions.

Overall, we can conclude that play is necessary for the healthy development of young horses as it prepares them for their social life and their life as a prey animal. Adult play remains a controversial subject and more research is needed to understand its function, occurrence and its implications for welfare.

### **Other affiliative interactions**

Other positive interactions between horses can include but are not limited to: approaching one-another across one (or less than one) body-length distance, huddling (standing less than 0.5 meter apart in an antiparallel position), following each other, and a series of friendly contacts that are not grooming or play. These affiliative contacts can be recognized by the positioning of the ears, the ears are put forward or laterally when the encounter/contact between two individuals is not agonistic (Heitor & Vicente, 2010; Briard et al., 2015).

### **3.2.2 Inter-individual distance and nearest neighbors**

Positive interactions (or "active interactions") are not the only indicators of sociability. In fact, Wells & von Goldschmidt-Rothschild (1979) found that the relationships in a group of Camargue mares were characterized mainly by their close proximity rather than by friendly contact (i.e. allogrooming, play, and other positive interactions). Thus, one other component in assessing the level of sociability of an individual is to look at the relative distance it keeps towards his closest neighbor. To determine to which individual it prefers to affiliate, it is also important to record the identity of this nearest neighbor (Sibbald et al., 2005).

Sigurjónsdóttir et al. (2002) found that there was also a positive correlation between affiliative relationships and the parameter 'standing close' to one another. Kimura (1998) and Van Dierendonck et al. (1994) found that this proximity occurred most often between horses of similar rank. It has also been found that middle-ranking horses spend more time in close proximity to others than low- or high-ranking individuals (Van Dierendonck et al., 1994).

Gibbons et al. (2010) state that when individuals are identified as nearest neighbor more often than expected by chance, these animals have associated as a dyad. When this occurs, the horses can be identified as 'friends', and more often than not there will be no more mention of "personal space" between those individuals (Budiansky, 1997).

### 3.3 GROUPING AND SPATIAL POSITION IN THE HERD

#### 3.3.1 The evolution of grouping

Survival and reproduction are the single most important things in an animal's life (Budiansky, 1997). For most living beings, life consists of finding a balance between foraging to obtain sufficient energy and nutrient intake for maintenance, growth, and reproduction and avoiding predators (Kie, 1999). In other words, animals face a trade-off between satisfying their elementary needs and reducing predation risk (Herberholz & Marquart, 2012).

Evolution has made sure that only individuals who adopted the right adaptive strategy would survive and bring their genes into the next generation: only the most efficient behaviors regarding cost-benefit options will assure the survival and fitness of the individual (Herberholz & Marquart, 2012). How animals behave regarding these trade-offs is mainly dictated by the environment they live in, and more precisely by the availability of resources: when food sources are stable and defendable it is most advantageous for the animals to be solitary and territorial. However, when resources are scarce and scattered across the territory it is most advantageous to be social and non-territorial (Budiansky, 1997; Keeling, 2001). But why is it advantageous to be social in this case? When food sources are unstable, individuals have to migrate across the land in order to find food, and when resources are scattered they cannot be protected. Which means territoriality is not an option and males cannot count on any territory to attract and seduce females. As we said earlier, reproduction is one of the key goals in an individual's life, thus animals have found a way to survive on the resources as they are distributed by nature and find a system where they can mate easily: keep everyone together in a group (Budiansky, 1997). For horses this group is qualified as a harem (as seen earlier 2.1)(Clement, 2015).

It is well known that animals need to gain fitness advantages from living in groups that are higher than those gained from solitary life in order for social structures to exist (Keeling, 2001). Now that we have explained how resource availability and mating systems play a role in the formation of social structures we have to address the main fitness advantages of grouping: predation avoidance and foraging efficiency (Rubenstein, 1978).

Prey animals form groups to decrease predation risks (Mooring & Hart, 1992; Morrell et al., 2011; Heard, 1992). Living in groups makes it possible to detect predators more effectively as more animals are alert and will potentially see/hear the attacker, this has been defined as the 'many eyes hypothesis' by Pulliam (1973). The time spent scanning the environment per individual diminishes, which frees up time for other activities such as foraging. In turn, a higher foraging efficiency will increase fitness (Herberholz & Marquart, 2012; Keeling, 2001). Furthermore, in groups there is a dilution effect (Hamilton, 1971) where the chances of being killed will decrease with increasing group size. Because, as a solitary animal the chances that a predator attacks you in particular is 100%, if you form a duo the chances become 50% - 50% and when you live in a herd or group the chances of being eaten diminish by each added group member. Additionally, when – during an attack – group-members collect together into an aggregation it is much more difficult for predators to single out one individual, which increases the safety of the herd (Kie, 1999; Keeling, 2001). Finally, grouping gives the opportunity for defense cooperation, which has already been seen in many ungulate species (Berger, 1979 in pronghorn antelopes; Estes, 1991 and Wasser, 2012 in African elephants ('sub-ungulates'); Novaro et al., 2009 in guanacos)), by standing united against the attacker, herds can thereby protect their young by making a barrier around them (the famous "circle defense" in muskoxen (NPS, 2015); also observed by Bertolino (2003) in Alpine chamois), or protect each other by counter attacking the predator (as seen in Bighorn Sheep rams (Shank, 1977)). This anti-predator

defense behavior does principally occur in large body sized species whereas small sized species mostly rely on predator detection and dilution effect to reduce predation risks (Novaro et al., 2009)

### 3.3.2 Spatial position in the herd

Because in group settings there is competition for essential resources and other fitness increasing benefits (shade, predator-safe positions...) evolution has found a way to structure social organizations by putting up a dominance hierarchy (Cozzi et al., 2010). This rank system has permitted to stabilize groups and to minimize tensions and aggression related to competition (Fureix et al., 2012). It is clear that in these dominance structures not all individuals achieve the same fitness benefits. High ranking animals have priority to resources and to other benefits whereas low-ranking animals are left with secondary access to the resources and less fitness benefits. So, for subordinates there is a real trade-off to be made, to see if the costs of dominance lie up against the benefits of group life. Up to now this seems to be the case, otherwise group life in horses would not be observed (Estevez, 2007; Keeling, 2001; Vehrencamp, 1983). Moreover, group life is beneficial for everyone and therefore dominants will establish a balance to not lose any (subordinate) group-members by dispersal. This is why the cost-benefit options outside the group (the fitness benefits or costs if an individual disperses) dictate how much pressure the dominants can put on subordinates (Vehrencamp, 1983).

We have seen that grouping is a major benefit when it comes to avoiding predators, however this benefit is not equally distributed over the individuals as they occupy different spatial positions in the herd. The selfish herd hypothesis (Hamilton, 1971) illustrates how occupying certain positions in the herd can reduce predation risks. Overall, animals staying on the outer layer of the herd (i.e. in periphery) will encounter greater predation risks than animals remaining in the center of the herd (i.e. centrally) (Morrell, et al., 2011). In horses this spatial distribution is mostly dictated by the dominance hierarchy within the herd (Ingólfssdóttir & Sigurjónsdóttir, 2008; Klimov, 1988). As mentioned above, high-ranking animals have access to more fitness benefits than subordinates (Keeling, 2001) and this also applies to the access of favorable spatial positions. Many studies have proven the prevalence of dominant animals having a central position within the herd (Barta et al., 1997 and Hemelrijk, 2000 in theoretical studies; King et al., 2012 in sheep; Janson, 1990 in capuchin monkeys), Ingólfssdóttir & Sigurjónsdóttir (2008) found similar results in horses, where low-ranking individuals were more systematically found in periphery of the herd than dominant horses. Overall researchers agree that the spatial position is correlated with dominance, but this is not only to be explained by the 'predator avoidance factor'. Hemelrijk (2000) found that centrality of dominant individuals is stronger in herds where the dominance is steep and based on high aggression. This can be explained by the fact that: the more two opponents differ in rank, the higher the chances that the subordinate is prone to retreat from the encounter and move away from the dominant individual. We can thus speculate that this can give rise to a general tendency where subordinates stay at a certain distance of the dominants, which explains the peripheral position of subordinates (Christman & Lewis, 2005).

## 3.4 SOCIAL ISOLATION

As seen earlier (3.3), horses have evolved into highly social species and have a natural urge to associate with conspecifics (Waring, 2003). Domesticated horses however do not have the luxury to decide over their social life, and today most modern husbandry practices result in the social isolation of horses. The reasons behind this isolation are multiple but the most persistent is that of owners trying to limit injury risk caused by other horses (Van Dierendonck & Spruijt, 2012). These unnatural

conditions forced upon the horses conflict with their natural adaptive behavior and may severely affect their wellbeing (Goodwin, 2007; Henderson, 2007).

Social contact is one of the most important parts of a horse's life, as evolutionarily their existence, survival and herd functioning depends on it (Budiansky, 1997). Social interactions also seem to have an enhancing effect on welfare, grooming for example has a calming effect on the horse as it reduces its heart rate (Normando et al., 2002; Feh & De Mazière, 1993). Consequently, when social contact is prevented horses can start developing a number of welfare issues. These issues can show through emotional, ethological and physiological stress. When horses are isolated from their conspecifics physiological changes occur such as an increase in the production of stress hormones (such as cortisol, AVP, ACTH, adrenaline and noradrenaline (Ayala et al., 2012)) (Mal et al., 1991). The production of stress hormones translates a disturbance in the horse's life (environment, health issue, etc.). Thus when horses experience stress, various endocrine responses are set in motion by the body to improve the individual's fitness during this disturbance (Möstl & Palme, 2002). And although stress hormones have an immune boosting and fitness increasing function during acute stress situations, chronic stress (i.e. long term stress) can cause substantial damage to the horse, as long term emissions of stress hormones in the blood stream have an immunosuppressive effect on the body. This means that the organism has a decreased capacity of neutralizing external organisms and pathogens which in its turn results in more severe, prolonged and repeated infections (Roggen et al., 2014; Dhabhar, 2002). These findings show that social isolation does not only have an emotional welfare reducing effect, but that it is directly related to the horse's health.

Luckily for the horse owners, stress signals do not only show through physiological changes but can also be detected through the animal's behavior (i.e. 'ethological stress' (Van Dierendonck & Spruijt, 2012)). When horses are isolated they can display behavioral stress signals such as excessive sweating, hyperventilation and abnormal excitement (freezing and thoroughly scanning the environment) (Alexander et al., 1988; Harewood & McGowan, 2005) this excitement can also be shown through nervous walking ('pacing'), defecating (McCall et al., 2006) and repeated vocalizations (Lansade et al., 2008). Moreover, long term social isolation and the impossibility to fulfill the need for social interactions may result in the development of stereotypic behavior (see further 4.1.1). (Keiper, 1986; McAfee, 2002). Weaving for example – stereotypic behavior where the horse performs a repetitive lateral swaying of the head, neck, forequarters and sometimes hindquarters – has been associated with social isolation in several studies (Mills & Davenport, 2002; McAfee et al, 2002).

Social isolation does not only affect horse's welfare but has also been found to have an effect on the horse – human relationship. Hausberger et al. (2008) observed that young horses who were raised without social contact were prone to search more contact with humans, but that this contact was negative rather than positive. These horses would show increased aggressive behavior towards humans and would be extensively harder to train. Horseman Antoine Cloux (2017), has acknowledged this first hand and states that orphaned foals as well as young horses who were raised in isolation represent a greater challenge during training. According to him, for some horses irreparable behavioral disturbances could arise from this isolation period.

In this light we can conclude that it is extremely important for both health, emotional well-being, manageability and the general welfare of horses to come into regular contact (preferably on a daily basis) with conspecifics and to have the chance to experience herd behavior and dynamics.

## 4 SOCIAL WELFARE AND THE MODERN KEEPING OF HORSES

### 4.1 SOCIAL WELFARE ISSUES

The issues related to isolation itself are described in the previous section (*3.4 Social isolation*)

#### 4.1.1 Isolation and the (in)expression of natural behavior

In the wild horses live in stable social groups and forage for 16 – 20 hours per day moving around big territories. Today most horses are stalled individually in a tiny space (related to their body size), feed only for a couple of hours each day and do not get the same locomotory exercise. Through domestication horses have not differentiated much from their feral conspecifics, and the need for an outlet of natural behaviors is still strongly present in the domesticated horse (Budiansky, 1997). Being faced with the inability to perform intrinsically motivated behaviors such as movement, foraging or social contact can create serious welfare issues and frustrations, which are expressed by the horse through the development of coping-behaviors, called stereotypic behavior (Visser et al., 2008; McBride, 2009; Henderson, 2007). Stereotypic behavior is described as an invariant repetitive behavior that has no apparent goal or function (Waters et al., 2010). Stereotypies can be categorized into locomotor movements, oral stereotypies and other abnormal behaviors that do not occur in the wild (Mason & Rushen, 2006). A study by Henderson (2007) suggests that stereotypic behavior is a good indicator of welfare issues in horses. Cooper & McGreevy (2007) also found that stereotypic behavior is a symptom of bad welfare, furthermore they discovered that these abnormal behavioral patterns could arise from boredom, frustration and an aversion of human environments such as the stalls horses are kept in.

Stereotypies appear to develop as a way of coping with the suboptimal environment that the modern horse is confronted with (McBride & Cuddeford, 2001). Studies have shown a correlation between stereotypic behaviors and the secretion of opioids such as endorphins, which means that by performing these behaviors animals stimulate the release of stress reducing hormones (Zanella et al., 1996; Cronin et al., 1986; Mason, 1991a; ). Stereotypies are thus encouraged by this endocrinal reward mechanism which causes the behaviors to become 'addicting' (and thus more and more repetitive) to the horse (Rendon et al., 2001). Although these abnormal behaviors are physiologically rewarding to the individual performing them, it is of utter importance to prevent them from developing as they are a sign of poor welfare and unnatural living conditions (Mason, 1991b). Another issue regarding stereotypies is that horse owners see them as 'stable-vices' that have to be interrupted or regulated (Sarrafchi & Blokhuis, 2013), and for this, many methods are used: crib-biting horses for example may be put through surgery to render the behavior physically impossible to perform (Turner et al., 1984), others may get a crib-strap around their neck. Weaving horses are restrained by an anti-weaving bar (McBride & Cuddeford, 2001), pharmaceuticals might also be used to reduce the display of stereotypic behaviors (McGreevy & Nicol, 1998). Several studies have shown that preventing an animal to display these coping behaviors may put additional stress on them and further decrease their welfare. As seen earlier, performing stereotypies rewards the horse with stress-reducing opioids in order for him to be able to cope with its environment, so prohibiting these behaviors dismantles the hormonal feedback mechanisms and increases the individual's distress (Cooper & McGreevy, 2007). Researchers state that it is thus very important not to treat the symptoms of stereotypic behavior but to resolve and remove the causes (see earlier) instead (Broom & Zanella, 2004; Nicol, 1999; Sarrafchi & Blokhuis, 2013).

Furthermore, Hausberger et al. (2007) performed a groundbreaking study searching for a correlation between stereotypies and learning abilities in horses. They found that horses that displayed stereotypic behavior needed extensively more time resolving a task (opening a chest by using their nose) than non-stereotypic horses. Additionally, they uncovered that stereotypic horses spend less time sleeping and lying down. These findings are important for the horse industry, as both learning abilities and sleeping patterns of the horse seem to be affected by the development of stereotypical behavior on top of the already known welfare issues.

#### **4.1.2 Group living under suboptimal conditions**

As seen earlier in 3.4 & 4.1.1, social isolation is a major welfare concern in horses. However, not only isolation can form a threat to social welfare, suboptimal grouping conditions can also affect the horse's well-being (Van Dierendonck & Spruijt, 2012). Studies have found that injury rates and aggressions seem to be higher in domesticated horses than in their feral conspecifics, and that this is often due to suboptimal husbandry practices (Hartmann et al., 2017; Grogan & McDonnell, 2005). This has already extensively been discussed in the section "2.4 Factors increasing aggression" but we will briefly give an overview of the issues related to suboptimal management in this section as well:

##### **a Living space**

The size of the group's living space may well be the most important factor affecting the horse's social welfare as studies have shown that living space is correlated with aggression rates. When the space decreases the aggression increases (Jørgensen et al., 2009; Hogan et al., 1988). This aggression does not only affect the horse's health (through possible injury) but it can also considerably elevate physiological and mental stress levels (Grandin et al., 1999). For a horse to obtain positive welfare it is thus necessary that each individual have the required space to be able to retreat from aggression when needed and to be able to preserve the desired inter-individual distance with dominant or aggressive group members (Van Dierendonck & Spruijt, 2012; Heitor et al., 2006a).

##### **b Group composition**

Horse owners who do acknowledge that their horses need social interactions might insert them into a herd, which is a great intention, but often results in stress for the horse as the herd members and the size of the herd has been chosen by man and can lead to interactions that would not occur in natural conditions (Van Dierendonck & Spruijt, 2012). Herd size is important mostly in relation to the available living space, studies have shown that these parameters are strongly correlated, the more horses on the less space, the higher the aggression in the group (Burla et al., 2016; Jørgensen et al., 2009). Furthermore, we have seen that horses form relatively stable herds with little dispersal or addition of new members (except for dispersal of offspring (Feh, s.a.)). In captivity however, group compositions are frequently altered which may increase aggression rates. Adding a horse may heighten the attacks on the newcomer whereas exporting a herd member may disrupt the group balance as hierarchical power positions have to be reevaluated, this comes with additional aggression and agonistic behavior. Needless to say that this increasing social stress and injury risks takes its toll on the herd members (Christensen et al., 2011).

##### **c Resource availability**

Herd animals are prone to experience intra-group competition due to limitation of essential resources. The conflicts that arise from this competition can escalate into highly aggressive interactions (Cozzi et al., 2010; Hartmann et al., 2017). In domestic conditions, horses are usually fed two or three times a day at specific hours. On the one hand, this increases the competition because



there are moments in the day that there is no more food left, and on the other hand, aggressions may arise around feeding times. It has been found that food-related aggression could be reduced by increasing the hay availability (Burla et al., 2016; Benhajali et al., 2009) and improving the husbandry conditions (Haupt & Wolski, 1980))

After reviewing these husbandry practices we can conclude that the way a herd is managed will be conclusive over the health and welfare of the horses that are a part of it. The literature has shown that there is to be given priority to stable groups kept in large living spaces with a constant availability of roughage.

## **5 RELATION BETWEEN DIFFERENT SOCIAL AND SPATIAL ASPECTS**

### **5.1 SOCIABILITY AND DOMINANCE**

Van Dierendonck et al. (2004) did a study on Icelandic mares and found that there was no correlation between rank and other social preferences such as affiliative interactions. So according to this study, it is not because a horse is high- or low-ranking that it has more/less affiliative interactions with group members. Similarly, Kimura (1998) did not find any significant relationship between rank and the frequency of allogrooming. However, he did find a correlation between rank and the variety of grooming partners with high ranking individuals having more partners in winter and low-ranking more in summer. This was however not supported by Sigurjónsdóttir et al. (2003) who did not observe any differences in the number of allogrooming partners in relation to dominance rank but found a positive relationship between rank and allogrooming frequency. This however did not mean that high- or low ranking horses would allogroom more/less but rather that individuals close in rank would groom more with each other rather than with individuals of different rank categories. This last finding was supported by Heitor et al. (2006b) as they found that close-ranking individuals spent more time in proximity to each other, but this was not specified for allogrooming in particular. It seems more studies need to be conducted on the matter as results are controversial, variety in results may appear due to the different research methods and study animals.

A recent study by Pierard et al. (2018) has looked at the relationship between received/given affiliative acts and received/given agonistic acts. Their results suggest that horses receiving more agonistic acts give less affiliative acts and that individuals receiving more affiliative acts give higher rates of agonistic acts. In other words, this would mean that when a horse is aggressed a lot it will display less affiliative interactions towards its group mates, but also that a horse receiving a lot of positive interactions will also shows a lot of aggressiveness. Because this has not been researched before they state that further studies are necessary.

### **5.2 SOCIABILITY, DOMINANCE AND SPATIAL DISTRIBUTION**

Barta et al. (1997) and Hemelrijk (2000) have done some theoretical research regarding spatial structure and dominance in group-living animals, both concluded that high-ranking individuals had a preference and tendency of staying in a central position within the herd. Nevertheless, only a few studies on this matter have been conducted regarding horses in particular. Ingólfssdóttir & Sigurjónsdóttir (2008) observed five groups of Icelandic horses to see if there was a relation between dominance and the access to food and shelter in winter, in addition they found that spatial structure was also influenced by rank. They observed that the low-ranking horses were more likely to be found in periphery of the herd than the dominant horses. These findings were not supported by Krueger et al. (2014) who found no significant correlation between spatial structure and rank, meaning that all horses were equally likely to be found in a central or peripheral position. Because the study results are contradictory, more research needs to be done to clarify the relation between dominance and spatial distribution.

No studies have yet been conducted on a relation between sociability, affiliative interactions and spatial distribution. However, we can speculate that – as subordinates tend to spend a bigger proportion of their time in a peripheral position – they may also have less affiliative interactions,

solely by the fact that being central means being closer to other individuals and increasing the chances of social contact. Nonetheless, further research needs to be done to clarify this question.

### **5.3 SOCIABILITY, DOMINANCE AND SOCIAL ISOLATION**

The literature study on this matter has given poor results and scarce clarifications, confirming the statement by Søndergaard et al. (2011) that still relatively little is known about social isolation in horses.

The only information that could be found is that of horse trainer McAllister (2008) who published an article in *The Horse Magazine* where she elucidated the relationship between rank and social isolation anxiety. She based her article on quotes by researcher Konstanze Krueger. It is however unclear if these statements came out of a personal interview or out of unpublished work by Krueger, as no publications regarding this matter could be found in the literature. The magazine material will be presented below because no other studies have been found regarding a correlation between isolation stress and rank, but it needs to be read with reservations.

As reported by McAllister (2008), dominant horses would be more sensitive to social isolation than subordinates and would show more distress when separated from their herd. According to Krueger (in the article) this could be explained by the fact that dominant horses have an accepted (privileged) position within the group which they don't want to abdicate from. Social isolation might cause more stress for a high-ranking horse because in the wild leaving a group means having to join another one (or suffering the fitness-cons of solitary life) where the chances of acquiring the same privileged rank in the new herd are very slim. Low-ranking horses on the other hand can easily join other herds as subordinates, without losing anything. McAllister (2008) added another statement by Krueger explaining that horse personality plays even a bigger role on the reaction to isolation than rank. Meaning by this that dominant horses are not necessarily the ones who are self-confident and that low-ranking animals are not always anxious, but rather that this depends on the horse's personality. A very confident horse can be low-ranking, just by the fact that it tries to avoid confrontation and thus doesn't try to climb the hierarchical ladder. As said earlier these statements have not been confirmed by published data and are to be taken with a grain of salt until further research has been conducted on the matter.

Similarly to the dominance question, information on sociability and isolation was hard to come upon, no scientific studies have been found in the literature to clarify whether there is a possible correlation or not. We do not know if horses that are more involved with affiliative interactions or that are more often in proximity to others would show more stress in isolation or not. The scarcity of data demonstrates the need for research on these subjects. More knowledge is needed on the causes and factors playing a role in social isolation anxiety, as this can be an important welfare factor for the horse.

## 6 GOALS

It is suggested that – contrarily to other species – horses have not differentiated much from their feral relatives through domestication, and therefore it is believed that horses show the same ethological needs as their wild conspecifics. A wide range of studies have already been conducted on *Equus caballus* and a broad range of data is available for horse owners to browse through. However, there remains a tremendous gap of information concerning certain aspects of the horse's social behavior and consequently on the horse's welfare. Nowadays, numerous domestic horses live in suboptimal conditions and show signs of bad welfare which are often found to be related to management practices that go against natural social structures. This occurs not because of bad will from the owners but mostly because of a lack of information and reliable knowledge on the horse in its whole. So, in order to improve husbandry practices, meet the ethological needs of our domesticated horses and improve their welfare we are in need of more knowledge and of a broader understanding of how horses function in groups and how the absence or abundance of conspecifics might affect this species.

Therefore, the aim of this paper is to gain insight into the social behavior of horses and into its involvement in the horse's wellbeing. Within the broad understanding of social behavior we will specifically focus on the themes of hierarchy, affiliative interactions, social isolation and spatial positions within the herd. These topics will be discussed singly as well as in relation to each other (see below) and the results will mostly be examined in the light of their implications for horse welfare.

The data for this study was collected in two separate herds and geographical locations: one part of the observations was done in Vorumaa, Estonia and the other in Antwerp, Belgium. Data was collected through the period of February – May 2018.

The ultimate goal of this study is a positive outcome for the equine species. Hopefully, a greater sense will arise of what is essential to the well-being of horses and hopefully – based on this knowledge – changes will be made to increase the welfare of managed horse populations.

### 6.1 MAIN STUDY QUESTIONS

In order to achieve the research goals stated above we have put up a list of research questions, answers to these questions will be given in the Discussion section (9) below.

#### 6.1.1 Sociability, dominance and spatial distribution

In this section we will review the questions regarding the links between sociability, dominance (rank as well as aggression) and spatial distribution.

- ✚ First, we will research whether sociability is related to social status by evaluating the question: is there a correlation between a horses' degree of sociability and its rank order within the herd?

*H<sub>1</sub>: there is a no correlation between rank and sociability: a high ranking horse does not necessarily have more affiliative interactions than a subordinate.*

- ✚ We also wish to evaluate if there is some sort of balance system between agonistic interactions and affiliative interactions i.e. do horses that give/receive a lot of agonistic acts receive/give less/more affiliative interactions?

*H<sub>2</sub>: horses receiving a lot of agonistic acts will give less affiliative acts and individuals receiving more affiliative acts give more agonistic acts.*

- ✚ As friendships are an important role in the horse society we wish to gain a better understand of its structure and functioning and we will thus evaluate: is there a correlation between the formation of strong affiliative bonds and the proximity in rank of the individuals part of this bond? Here we will only look at the strongest of reciprocal affiliative bonds (i.e. with the most total affiliative acts) in each herd.  
*H<sub>3</sub>: horses form strong affiliative bonds with horses close in rank.*
- ✚ Additionally we want to see if strong bonds who are solely based on spatial proximity ('standing close and nearest neighbor parameters) are influenced by the rank distance between herd members. I.e. do horses who are closer/further in rank spend more/less time in proximity to each other?  
*H<sub>4</sub>: the closer in rank two horses are, the more time they will spend in close proximity to each other.*
- ✚ In order to evaluate if rank can predict the spatial distribution of horses in the herd we will analyze the question: is a horses' dominance rank related to its spatial distribution in the group?  
*H<sub>5</sub>: the higher a horse stands in the hierarchy, the more central its spatial position in the group i.e. subordinates stay in periphery of the group and dominants in the center.*
- ✚ Furthermore we will look at whether this spatial position is in any way correlated to the amount of positive interactions an individual is part of: is the spatial distribution (central/peripheral) of a horse linked to its degree of sociability (total of affiliative acts)?  
*H<sub>6</sub>: a horse that gives/receives less affiliative acts will stand in periphery of the herd more often than in the center.*

### 6.1.2 Relationship between the different social and spatial aspects and social isolation

Here we will state the questions regarding the correlations of social isolation with sociability, dominance and spatial distribution.

- ✚ Is there a relationship between the sociability of a horse and its reaction to social isolation?  
*H<sub>7</sub>: the more affiliative interactions (given/received) a horse is part of, the more anxiety it will express when separated from the herd.*
- ✚ We want to know if a dominant horse is more prone to be at ease when separated from its herd, or if it will, to the contrary, be more anxious than low ranking animals. Therefore we question: Does dominance rank influence the reaction to social isolation? And we suggest that:  
*H<sub>8</sub>: a dominant horse shows more distress in isolation than low ranking horses.*
- ✚ Does the spatial position of a horse within its herd have an effect on its reaction to social isolation?  
*H<sub>9</sub>: a horse that often stands in periphery of the herd will show less anxiety when separated from its group and put into isolation.*

## 6.2 SECONDARY RESEARCH QUESTIONS

Next to the main questions we will also evaluate other correlations and subjects that will give us a better understanding of herd dynamics and social behavior:

### 6.2.1 Dominance

- ✚ We wish to research whether variables such as age, body condition, height and residency time affect the rank order a horse gets within the hierarchy:
  - ✚ Is age correlated with rank order?  
*H<sub>10</sub>: older horses are more dominant than younger horses.*
  - ✚ Is there a relationship between dominance and body condition?  
*H<sub>11</sub>: individuals with higher body condition scores stand higher in the dominance rank.*
  - ✚ Is there a relationship between dominance and height?  
*H<sub>12</sub>: taller individuals are more dominant*
  - ✚ Does residency time affect a horse's rank position?  
*H<sub>13</sub>: the longer a horse has been in the herd the higher it stands in the hierarchy.*
  
- ✚ We want to know if horses that spend more time next to each other are more indulgent towards each other when in confrontation. Is there a correlation between the nearest neighbor parameter and the total of submissive acts after aggression ?  
*H<sub>14</sub>: individuals who spend a lot of time being nearest neighbor to each other show more submission after aggression towards each other.*
  
- ✚ Because horses have a well-defined personal space but let some individuals come into their space, we wish to research if this distance an individual keeps towards its nearest neighbor could be related to rank order. Is there a correlation between the mean distance to nearest neighbor and the rank order of an individual ?  
*H<sub>15</sub>: the higher in rank, the bigger the mean distance to closest neighbor.*
  
- ✚ Furthermore we will take a look at if there is a relationship between the given and received aggressive acts: are giving and receiving aggressive acts related to each other ?  
*H<sub>16</sub>: the more aggressive acts an individual gives, the less aggressive acts it will receive from other herd members.*
  
- ✚ In order to shine light on the intensity of aggressive encounters in group-held horses we will evaluate the percentage of high-intensity agonistic acts within the herds.  
*H<sub>17</sub>: most aggressive encounters are low-intensity interactions (not contact-aggression).*
  
- ✚ Finally we will look at parameters such as the different forms of aggressive acts, the rate of ignored aggressions and the context of aggressive interactions to give us more insight into how and in which situations horses are aggressive as well as how well the hierarchy in place is accepted or challenged (ignored aggressions) within each herd.

### 6.2.2 Sociability

- ✚ Regarding sociability we want to uncover whether there is a balance system that rewards strongly affiliative horses with the return of positive interactions or whether the reception of affiliative acts is completely random. In other words: is there a correlation between given and received affiliative acts ?  
*H<sub>19</sub>: the more affiliative acts that are given by one individual, the more are also received by this individual.*

- ✚ Furthermore we want to research if personal variables such as age can affect the positive social behavior of a horse: does age affect the amount of given/received affiliative acts? We will not research the effects of reproductive state or kinship.

*H<sub>20</sub>: older horses are part of less affiliative interactions than younger horses.*

- ✚ Finally we will take a look at friendships and search for empirical evidence of their existence in horse communities. Do horses have preferred partners within the herd (towards whom they show more affiliative acts) ?

*H<sub>21</sub>: horses have individuals in the herd to which they prefer to affiliate and create strong bonds that could be seen as friendships.*

## 7 MATERIALS AND METHODS

### 7.1 STUDY ANIMALS

#### 7.1.1 Group 1: Akhal - Teke's

The first part of the study was conducted on fourteen mares (n=14) which included thirteen purebred Akhal-Teke horses and one Estonian cross-bred mare. However a fully homogenous group would have been preferable for clarity regarding social behavior variances between breeds, it was not possible to separate this individual from the herd for the purpose of this study. The mares were between 3 and 22 years old when the research was conducted. Ten out of fourteen were born at the Akhal-Teke EST Stud, three were imported from Russian studs and the cross-bred came from within Estonia. Most mares (except the cross-bred) were related to another mare in the herd, either directly (mother – daughter bond) or by half-kinship on the paternal side. Half-sisters from the mother's side also occurred but this regarded only two mares. Five mares were pregnant during the observation period, foals from the previous year had been weaned two months before the observations started.

The herd was fed with big round hay bales every couple of days. As hay was only recharged when the previous was finished, there was always a transition day where the food was less abundant (although sufficient) which might have caused some competition (and thus agonistic interactions) between herd individuals. Once a day the mares also received a small portion of oats mixed up with vitamins, minerals and canola seed oil.

*Table 1: Akhal-Teke age sheet*

Name	Year of birth	Age
Akargul	2015	3
Akkol	1996	22
Ayra	2010	8
Belentgyz	2008	10
Feriya	2012	6
Fliki	2013	5
Fragariia	2004	14
Gul-Oyluk	2013	5
Kichitorgai	1999	19
Okgunly	2015	3
Okra	1998	20
Ozariya	2009	9
Sara	2010	8
Saryyagyz	2008	10

#### 7.1.2 Group 2: Icelandic Horses

The second study group comprised of nine (n=9) purebred Icelandic Horses. This group contained seven mares and two geldings, ranging from 4 to 23 years old at the time of data collection. Except



the youngest mare, all horses were at adult age and above nine years old.

All horses were in some way related to (an)other member(s) of the herd, most of the relationships being those of (half)sister/brother. In contrast to group 1, there were no mother/daughter relationships within the herd. There were no pregnant mares at the time of the observations.

Contrarily to the Akhal-Teke mares, the Icelandic horses were ridden weekly and were used to being separated from their fellow herd mates to go on trail rides.

The herd was fed silage as well as dry hay multiple times a day, and they would have constant access to the pile of older hay in the paddock. Some horses would get grain supplement but only when ridden.

*Table 2: : Icelandic's age sheet*

Name	Year of birth	Age
Assa	2003	15
Drynja	1996	22
Hannah	2004	14
Landi	2005	13
Loa	1995	23
Saga	2014	4
Sura	2003	15
Tenor	2003	15
Vekka	2004	14

## 7.2 STUDY AREAS

### 7.2.1 Group 1: Akhal – Teke's

The research took place at the Akhal-Teke EST Stud in the region of Vorumaa, Estonia. The herd of mares was kept on a 40-ha pasture which was about 2.5 – 3km wide. However, they only used a small portion of this available land because the observations took place in winter and the snow prevented the animals from grazing. Most of the time the mares would remain around the feeding spot, where 5 – 6 round hay bales were put down for foraging.

When extreme weather (rain or strong winds) hit the stud, the mares were turned in: they were put into a smaller paddock containing a shelter where they could seek refuge, this shelter was closed on three sides and big enough to accommodate all fourteen mares at once. Data was however solely recorded when the mares were out on the big pasture.

### 7.2.2 Group 2: Icelandic Horses

The second part of the research took place at the Schütterbach Icelandic Horse Stud located in the province of Antwerp, Belgium. The herd was kept on a big paddock with a large walk-in stable that could house all nine horses at once. The stable was closed-off by walls on two sides and by a barrier on the third side, the fourth side remaining open towards the paddock. The stall floor was covered by a thick layer of straw to which new straw bales were added to keep it fresh and dry. In the back of the stall the hay was available through vertical metal bars (as seen in cattle housing), the hay was situated on the outside of the paddock/stall and the horses had to put their head through the bars to

access it. The feeding system was L-shaped, and all horses could feed at once. The paddock outside of the stable was configured as a wide corridor, leading up to a wide paddock in the back. In this wider part, there was also a pile of older hay where the horses liked to feed. Starting May, the horses would have access to a big field to graze, this was however not the case during the observations as they took part earlier in April. The horses spent the most time around the wide area and in/around the stable.

## 7.3 RESEARCH METHODS

### 7.3.1 General

The research sessions comprised of focal scans and *ad libitum* observations. Sociability and hierarchy were assessed by doing fifteen-minute focals of each animal during which the interactions (affiliative and agonistic) of the focal were recorded *ad libitum* as well as the interactions between other group members. These group observations were put into place in order to obtain more data, as some focals could very well show no interaction for fifteen minutes and leave us dataless for that particular session.

During each focal session we also recorded information regarding the spatial position and the activity budget of the focal animal, this was done by using *instantaneous scan sampling* every five minutes. Every session thus comprised of four scans of the focal animal, one at minute 0; 5; 10 and 15. The time was managed using a smartphone stopwatch, which was put into vibrate mode, thus avoiding that the horses would be influenced by the ringtone (and for example show the behavior 'Human awareness' or 'Standing attentive' mentioned in Table 5).

Group 1: The research consisted of 17.5 hours of observations (70 sessions x 15 minutes). Each mare was observed 5 times as a focal during the whole research period, which started on February 9<sup>th</sup>, 2018 and ended on February 21<sup>st</sup>, 2018.

Group 2: The research consisted of 22.5 hours of observations (90 sessions x 15 minutes) and each horse was observed 10 times as a focal. The data collection occurred from April 17<sup>th</sup> to April 27<sup>th</sup>, 2018.

The observation order of the horses was randomized using Excel. However, observations did not occur at the same time each day, thus randomization did not have an eliminative effect on the confounder "time of day" but it did prevent the observer from starting with the same animal every time or from picking an animal solely on its "interesting" behavior at the start of a session. All the individuals were observed once before a focal was observed a second time (etc.), this prevented that some horses had all their focals in one day. This excluded daily confounders.

Research methods for the social isolation test are described below (7.3.4).

For each mare we also listed variables of age, height, kinship, time in the group, body condition and reproductive status. Since the literature revealed this to correlate to some extent with hierarchy and sociability.

### 7.3.2 Sociability

To assess sociability in horses we recorded affiliative interactions, spatial positions and inter-individual distances of the mares.

### a Affiliative interactions

Positive interactions (see ethogram) between two individuals were recorded using *ad libitum sampling*. Each mare was observed during fifteen minutes as a focal animal to make sure every mare was observed as meticulously as the others (eliminating subconscious favoritism by the observer). As described above, during these focals any affiliative interaction between horses other than the focal animal were also recorded.

Positive and affiliative behaviors used to translate sociability are listed in Table 3.

Table 3: Ethogram affiliative interactions between horses

(based on: McDonnell, 2003; Ransom&Cade, 2009 and personal observations)

Category	Subcategory	Behavior	Code	Observation
Affiliative and positive behavior	Play	Locomotor/ Movement play	LP	Bucking, jumping around, running with another individual
		Fight-play	FP	Repeated non-intense biting, pushing, striking, kicking, the ears are not laid back in the neck
	Grooming	Allogroom	AG	Two individuals grooming each other by nibbling, nuzzling or rubbing along the back, withers, shoulders, chest, tail or mane standing head-to-shoulder or head-to-tail
	Other	Groom	GR	Grooming another individual by nibbling, nuzzling or rubbing along the back, withers, shoulders, chest, tail or mane
		Approach	AP	Approach another individual with less than one body length distance without any threat- or aggressive behavior display, approaching in regard to food is not taken into account
		Follow	FO	Walking, trotting or galloping one after the other without threat or aggression
		Huddling	HU	Resting with other individual in a head-to-tail orientation
		Affiliative contact other than grooming	CO	Physical contact with ears forward or slightly to the side
		Resting close	SC	Standing in a resting posture one body length or closer to

				another individual, the other individual is either eating, resting or lying down
		Sniffing	SN	Individuals smell/sniff each other either nose to nose or nose to flank

## b Spatial position and activity budget

During each fifteen-minute focal scan (see above) the mares were also screened every five minutes using *instantaneous scan sampling* to record the following:

### Number of sides which the focal is surrounded from

In other words, this records on how many sides the horse has a neighbor. The data was recorded as followed:

Table 4: Data collection method for number of sides with a neighbor

Number of sides with a neighbor	Description
4	the focal was surrounded on four sides
3	one side without a neighbor
2	neighbors on two sides, two sides without any other individual present
1	three sides without neighbor
0	the focal is standing out of the group. The focal stood out of the group when their position to the closest neighbor was twice the distance that other group members had towards each other (on average).

This variable is important to estimate the focal's sociability as it shines light not only on the position a horse has in the herd but also how it manages its space regarding to other horses.

### Identity of the closest neighbor

The individual standing/lying the closest to the focal animal was written down on minute 0; 5; 10 and 15. After data analysis this will unveil which are the tightest relationships between mares, and which are the mares' favorite (spatial) companions in the group.

### Inter-individual distance

The distance to the closest neighbor was measured in body length's. When inferior to 1, the following notations were also used: 0.25 and 0.5.

The measurement "0.25" was used when horses stood very close to each other for example during foraging. The orientation of the horse relative to another (head to tail, head to head...) was not accounted for.

### Position relative to the group

Standing *central* or *peripheral* to the group was an important criterion in the assessment of sociability. 'Peripheral' meant as well standing out of the group (when "0" for the first criteria) as

standing on the outer layer of the group. Although, a horse did not necessarily have to stand alone to stand in periphery, if, for example a tight group stood on one side of the feeding spot and the focal with one/two other individuals stood a couple of body lengths further, this would qualify as 'in periphery' regarding to the mayor part of the group.

#### General activity

The activity budget of each focal was brought to light by scan sampling the exact general behavior of the individual every five minutes. The ethogram used to record these activities can be found in Table 5. Including the activity budget in the research is relevant as it reveals what the horses do the most of their time. In relation to the other factors it can reveal the social preferences of a certain activity, for example some horses (of a certain rank) may want to spend their resting time (activity) out of the group (number of neighbors).

*Table 5: Ethogram of general behavior in horses*

*(based on: McDonnell, 2003; Ransom&Cade, 2009 and personal observations)*

Category	Subcategory	Behavior	Code	Observation
<b>All-round behavior</b>	<b>Locomotion /movement</b>	Walking	WA	Forward movement at a small pace without grazing activity
		Trotting	TR	Running in a three-beat medium speed gait
		Galloping	GA	Running fast in a four-beat gait (one leg touches the ground at each moment)
		Trek	TR	Two or more animals moving together over a certain distance, typically following in line, one after the other
	<b>Ingestive behavior</b>	Eating	EA	Ingesting food sources through the mouth (hay, grain, shrubs...)
		Drinking		Ingesting water through the mouth by pursing the lips and aspirating the liquid
		Paw	PA	Scratching on the ground (dirt, hay, snow) with one of the forelimbs
		Mouth	MO	Manipulate with mouth, as if to gain taste or touch
	<b>Elimination behavior</b>	Defecating	DE	Expelling of feces through the anus with the tail raised
		Urinating	UR	Male: expelling of urine by keeping forelegs slightly extended forward and hind legs extended backwards and slightly spread, the penis is fully or partially relaxed from the prepuce Female: hind legs are extended backwards, tail lifted and back arched, urine is expelled through the vulva

	<b>Self-care</b>	Rolling	RO	Rolling on the ground consecutively on each side of the body
		Auto grooming	AG	Nibbling, biting, licking or rubbing a part of own body
		Scratching	SC	Scratching part of the body with own hoof or against external object
	<b>Environment interaction behavior</b>	Weather shielding	WS	During snow, wind or rain standing inactive in group or alone, most frequently with the hind in the direction of the wind, the head is horizontal or slightly lowered
		Standing attentive	SA	Ears pointed toward external stimulus, rigid body posture and focused eyes
		Human awareness	HA	Horse pauses in its activity to stand attentive to a nearby human
	<b>Resting behavior</b>	Standing	STA	Standing up without performing any other significant activity, head is horizontal or lowered, eyes partly or entirely closed and one of the hind legs is slightly elevated
		Lying down	LD	Rest or sleep while lying on the ground with the head up (sternal recumbency) or head outstretched on the ground (lateral recumbency)

### 7.3.3 Group ranking

To assess hierarchy in the herd we scanned agonistic and submissive interactions between horses (see table 6). There was a difference made between actual aggressive encounters (with contact), chasing, and agonistic threats which did not result in any possible injury for the receiver. It was important to make a difference between contact and non-contact aggressions as this is relevant to make predictions regarding management of horse groups and resource spreading in captivity. The violence of the agonistic interactions may also be determining for the hierarchy assessment.

A behavior was considered as significantly submissive from the moment the receiver would move its feet (or one foot) away from the actor, even the slightest step. Head avoidance (moving the head away from the actor) was not listed as a submissive behavior as this did not seem pronounced enough to base the rank analysis on.

Table 6: Agonistic and submissive behavior in horses  
(based on: McDonnell, 2003; Ransom&Cade, 2009 and personal observations)

Category	Subcategory	Behavior	Code	Observation
<b>Agonistic and submissive behavior</b>	<b>Agonistic Threats</b>	Pinning ears	PE	Ears laid back in the neck, no other threat or agonistic behavior visible
		Head-Threat	HT	Ears laid back; wrinkled, pinched nostrils; the head is turned in direction of the receiver and protruded in its direction, sometimes accompanied with a head toss
		Threat approach	TA	Approaching the receiver with ears pinned back (not in the neck), pinched nostrils
		Kick-threat	KT	Ears pinned back, the rear end is turned towards the receiver, one of the hind legs is lifted of the ground possibly aiming for the receiver
		Bite threat	BT	Ears are pinned back, head is thrown in direction of receiver with bare teeth or a bite movement without contact
		Striking	ST	Extension and downward motion of one or both front feet, behavior sometimes accompanied by scream
	<b>Contact aggression</b>	Pushing	PU	Physically pushing the receiver with the head, neck or shoulder
		Bite	BI	Threat-bite with contact, hair, skin or flesh is nipped
		Kick	KI	Kick-threat with contact, one or both hind legs are kicked towards the receiver with contact
		Fighting	FI	Repetitively kicking, biting and possibly rearing and kicking with front legs
	<b>Chasing</b>	Short Chase	SC	Ears pinned back, bite threat and kick-threat but action is more energetic, neck is more protruded, and the actor moves more than two strides in the direction of the receiver
		Long Chase	LC	Following and chasing other individual, often in gallop, with ears pinned back. A longer distance is covered, and it is less explosive than an attack
	<b>Submissive behavior</b>	Step away	SA	Receiver steps away after approach, threat or aggression of other

				individual
		Jump away	JA	Receiver jumps away after approach, threat or aggression of other individual
		Submissive smacking	SS	Individual smacks with its mouth at other individual, ears are pinned forward, not necessarily after threat/aggression, possibly also when going up to another horse to show submissiveness (ritualized behavior)
	<b>Other behavior</b>	Neutral approach	NA	Individual moves in the herd, towards other food spot etc. without any agonistic expressions or threats
		Ignoring aggression/threat	IG	Receiver does not modify its activity/behavior after approach, threat or aggression of other individual

### 7.3.4 Social isolation test

In order to gain insight into the stress associated with social isolation field observations were not suitable, thus an experiment was conducted. This isolation test was only possible on the Icelandic horse herd.

#### a Observation area

The isolation test took place in the main stall at the Schütterback Stud. The stall was about 25m<sup>2</sup> and located in a separate building about 50m from the paddock. There was no visual contact possible with the herd. The stall was closed on three sides, with one open side, the size of a door. A small window was present on one of the closed sides through which the horses could put their head to look outside. Normally the stall was used as housing for the stud's stallion, which was removed for the purpose of the test. Smells could however still have been present (possible confounder for stress). The floor was covered with straw and water was available for the horse to drink from. Most of the horses had been in the stall before during illnesses etc. They were however not used to being isolated and confined. The possibility that the horses expressed stress signals solely due to confinement was buffered through the relatively big size of the stall; they could easily walk around and even trot a few strides.

#### b Behaviors related to social isolation

During this isolation test, stress related behaviors such as vocalization (ex. neighing), anxious locomotion (ex. pacing), pawing, defecation and freezing were recorded. The frequency that these behaviors were displayed will give us an idea of the anxiety level a horse goes through when it is separated from its herd.

*Table 7: Ethogram of stress behavior in horses (based on Lansade et al., 2008 and McDonnell, 2003)*

Category	Behavior	Observation
Stress behavior	Vocalization	Neighing, snorting or any other distress sounds



	Locomotion	Pacing, trotting or gallop with tense body and attentive eye
	Freezing	Stopping (if walking), ears forward, attentive eye and tense body position
	Defecating	Expelling of feces through the anus with the tail raised
	Pawing	Hitting the ground with one hoof in an anxious manner
	Nervous head tossing	Tossing the head sideways or to the front with wide eyes and a tense body

### c Experimental method

Each horse was brought into the stall alone, there were no other horses around at the time of observation and no visual contact could be made with the herd. Once the horse was let loose and the stall door was shut, the timer started rolling. The observer stood outside of the stall for data collection, thereby avoiding any physical contact with the research animal. However, the horse had visual contact with the observer. The test horse was observed during 5 minutes, and the frequency of each stress behavior was measured *ad libitum*. Stress behaviors expressed from the paddock to the stall were also recorded which gave us not only an indication of the isolation anxiety itself but also of anxiety created by the action of getting separated from the herd/leaving the herd. Other behaviors expressed from the stall back to the herd were also recorded (trotting, pulling on the lead...), as this could show the motivation to rejoin the group. After consideration, only the results from the 5 minute focal were taken into account in the study.

## 7.4 DATA ANALYSIS

### 7.4.1 Statistical analysis of rank order

For rank-order analysis, all possible agonistic behaviors followed by a submissive behavior were used, i.e. all behaviors eliciting either yield, retreat or flee as reactions. The dominance matrix was analyzed with SocProg to find an order most consistent with a linear hierarchy according to the I&SI method, which minimizes the number of inconsistencies (I) and the strength of inconsistencies (SI) (De Vries, 1998). Dyads, which thereafter still showed a direction of interactions that did not fit the linear order, were “inconsistent dyads”.

The index of linearity  $h$  was calculated and tested for significance by means of a randomization test in SocProg (Whitehead, 2009). The steepness of the hierarchy was calculated by using  $D_{ij}$  allowing for the comparison of matrices containing different interaction frequencies (De Vries et al., 2005).

After analyzing the linear rank order of the horses in a group containing  $n$  individuals, the top individual was assigned rank one and the lowest ranking individual was assigned rank  $n$ .

### 7.4.2 Statistical Analysis

Kolmogorov-Smirnov tests were applied to evaluate normality or non-normality of the data prior to applying the appropriate statistical tests, performed with SPSS software. P values for significance were set at 0.05. All tests were two-tailed except when indicated differently.

#### Correlations:

Correlations were analyzed using a Spearman's rank correlation in SPSS. The different variables were put against each other and analyzed by the software to seek for a possible relationship. The SPSS data was interpreted as followed: the closer the Spearman's correlation coefficient ( $r_s$ ) was to 1 (for a positive correlation) and -1 (for a negative correlation), the stronger the relation between the variables. When the coefficient reached towards 0 there was no relationship between the two variables.

#### Matrix correlations:

We used the Kendall's form of rowwise matrix correlations in order to correlate two matrixes using the program SocProg (Whitehead, 2009). This method takes dyadic variation into account and controls for differences in the row totals.

#### Statistical significance:

Significance of the test results was set at  $p < 0.05$ .

In case  $0.1 < p < 0.05$ , the result was considered to show a trend to statistical significance.

### 7.4.3 Sociogram

The herd sociograms were made using the online application LeaderboardX:

<http://leaderboardx.herokuapp.com/#/graph-editor>. Each actor/receiver interaction was accounted for and different colors were used to show the intensity of each interaction.

### 7.4.4 Other analyses, tables and figures

All non-statistical data analyses were done using Excell 2016. Tables and figures were afterwards imported into Word.

## 8 RESULTS

### 8.1 DOMINANCE

#### 8.1.1 Dominance interactions

Table 8: Matrix of the dominance interactions in group 1: Akhal-Teke's

Actor / Receiver	Aka	Akk	Ayr	Bel	Fer	Fli	Fra	Gul	Kic	Okg	Okr	Oza	Sar	Sry	Total
Aka	0	10	4	7	25	2	3	6	1	14	6	1	5	0	84
Akk	0	0	0	0	0	0	0	0	0	0	3	0	0	0	3
Ayr	0	5	0	8	1	0	3	0	1	0	7	0	9	0	34
Bel	0	1	0	0	0	0	4	0	6	0	4	0	0	0	15
Fer	0	5	14	12	0	0	8	0	0	0	5	0	11	0	55
Fli	0	5	5	4	7	0	13	9	0	0	9	0	12	0	64
Fra	0	2	0	0	0	0	0	0	0	0	3	0	0	0	5
Gul	0	21	7	3	18	0	4	0	6	0	7	3	10	0	79
Kic	3	2	10	1	17	11	13	0	0	10	3	0	1	0	71
Okg	0	6	4	15	14	8	10	6	1	0	6	1	5	0	76
Okr	1	1	0	0	0	0	0	0	0	0	0	0	0	0	2
Oza	0	9	3	6	7	11	4	0	5	0	5	0	1	0	51
Sar	1	7	0	15	0	0	7	0	7	0	7	0	0	0	44
Sry	2	0	8	4	8	11	2	3	4	6	0	3	5	0	56
<b>Total</b>	<b>7</b>	<b>74</b>	<b>55</b>	<b>75</b>	<b>97</b>	<b>43</b>	<b>71</b>	<b>24</b>	<b>31</b>	<b>30</b>	<b>65</b>	<b>8</b>	<b>59</b>	<b>0</b>	

This matrix shows the dominance interactions between herd members as well as the rate of initiating dominance or receiving dominance per individual. Interesting to notice is that Saryyagyz did not display any dominance acts towards any of her fellow herd mates, she however received aggression from all the horses, except Akkol and Okra (the two highest in rank, see further Table 10). Both Ozariya and Akargul displayed very little dominance towards other individuals and had only four opponents, Akargul however received the most aggression of all individuals and this from everybody in the herd except Saryyagyz. Okra (2), Akkol (3) and Fragariia (5) received almost no dominance acts. Okra received one of her two aggressions from Akkol, Akkol received all her aggressions from Okra and Fragariia received her five aggressions from both Okra and Akkol. Belentgyz received very little aggressions as well (15), and this by the three stated above as well as Kichitorgai.

Between duo's, the most frequent aggressions were displayed between Feriya and Akargul, with Feriya being the one displaying the aggression. Furthermore, Akkol and Feriya both showed high aggression rates towards Gul-Oyluk.

Table 9: Matrix of the dominance interactions in group 2: Icelandic horses

Receiver / Actor	Ass	Dry	Han	Lan	Loa	Sag	Sur	Ten	Vek	Tot.
Ass	0	5	8	8	6	6	3	11	0	<b>47</b>
Dry	1	0	3	8	0	9	9	11	10	<b>51</b>
Han	0	0	0	0	0	7	4	1	0	<b>12</b>
Lan	1	1	6	0	1	1	0	0	0	<b>10</b>
Loa	3	12	6	10	0	10	10	14	24	<b>89</b>
Sag	0	0	3	6	0	0	1	3	0	<b>13</b>
Sur	2	1	4	6	2	11	0	17	2	<b>45</b>
Ten	2	0	14	4	0	10	1	0	0	<b>31</b>
Vek	9	0	5	15	1	13	4	17	0	<b>64</b>
Tot.	18	19	49	57	10	67	32	74	36	

Contrarily to group 1, in the Icelandic herd all horses displaced another at least once. Nevertheless, the displacement rates varied considerably between individuals, with Landi, Hannah and Saga showing the less aggressions (or at least effective aggressions). Loa showed the most aggression with 89 displacements. Drynja, Assa and Sura showed similar rates of displacement whereas Vekka positioned herself between them and Loa. Tenor received the most aggressions and by consequence showed the most submissions. He is followed by Saga and Landi who received a lot of aggression as well. Loa received the least aggression of the whole group followed by Assa and Drynja who also showed considerably less displacements than the rest of the group. The most agonistic interactions happened between Loa and Vekka, with Loa displaying the aggression. Tenor received a high rate of agonistic behavior from Vekka and Sura.

### 8.1.2 Analysis of the hierarchy

Table 10: The rank order measured by the 'I&amp;SI'-method (de Vries 1998)

Rank order	Group 1: Akhal Teke's	Rank order	Group 2: Icelandic Horses
1	Okra	1	Assa
2	Akkol	2	Loa
3	Fragariia	3	Drynja
4	Belentgyz	4	Vekka
5	Sara	5	Sura
6	Ayra	6	Tenor
7	Feriya	7	Hannah
8	Fliki	8	Saga
9	Kichitorgai	9	Landi
10	Ozariya		

11	Gul-Oyluk
12	Okgunly
13	Akargul
14	Saryyagyz

According to the I&SI method (de Vries, 1998), Okra and Akkol are the highest-ranking individuals in group 1 and Assa and Loa in group 2. Lowest ranking individuals are Saryyagyz and Akargul for group 1 and Landi and Saga for group 2.

#### Linearity of the hierarchy

In group 1 the hierarchy was significantly linear:  $h' = 0.760$  (landau's index of linearity).

In group 2 the hierarchy was also significantly linear:  $h' = 0.858$  (landau's index of linearity).

#### Steepness of the hierarchy

For group 1 the steepness of the hierarchy was:  $-0.751$ .

For group 2 the steepness of the hierarchy was:  $-0.713$ .

### **8.1.3 Relationship between received and given dominance acts**

We correlated the sums of given and received agonistic behaviors (followed by submission) per horse. In both group 1 and group 2 we found a significant negative correlation between given and received aggressions, and it showed that the more dominance acts were given, the less dominance acts were received (group 1:  $r_s = -0.688$ ,  $p < 0.007$ ,  $n = 14$  and group 2:  $r_s = -0.733$ ,  $p < 0.025$ ,  $n = 9$ ). In other words, the more a horse would display agonistic behavior (dominance acts), the less aggressions it would receive.

### **8.1.4 Relationship between dominance and age**

To see how age affects social status we correlated the dominance rank of each individual with its age. Group 1: the Akhal Teke's showed a significant positive correlation ( $r_s = -0.636$ ,  $p < 0.015$ ,  $n = 14$ ) which means older horses were consistently found higher in the rank order.

The Icelandic horses of group 2 presented similar results ( $r_s = -0.792$ ,  $p < 0.011$ ,  $n = 9$ ). The data was significant and there was a positive correlation between age and dominance.

### **8.1.5 Relationship between dominance, height and body condition**

In order to test our hypothesis that taller and fleshier horses are more dominant, we correlated these two variables with the rank position of each horse. In the Akhal-Teke herd there were height-measurements only for 8 out of 14 individuals.

Height: the results showed no significant correlation between height and dominance, nor in group 1 ( $r_s = -0.457$ ,  $p < 0.255$ ,  $n = 8$ ) nor in group 2 ( $r_s = -0.168$ ,  $p < 0.666$ ,  $n = 9$ ).

Body condition: for both groups there was no significant correlation found between body condition and rank (group 1:  $r_s = -0.114$ ,  $p < 0.6997$ ,  $n = 14$ ; group 2:  $r_s = -0.308$ ,  $p < 0.420$ ,  $n = 9$ ).

### 8.1.6 Relationship between dominance and length of stay in the group

We tested the hypothesis that length of stay would influence the rank order of the horses. To do this we correlated the rank order with the order of arrival in the herd. For group 1 this correlation could not be analyzed as data on length of stay in the group was missing.

However, in group 2 a significant correlation was found: the higher the rank order (so the lower the rank number) the longer the length of stay ( $r_s = 0.850$ ,  $p < 0.004$ ,  $n = 9$ ). These results suggest that the longer a horse has been in the herd, the higher it stands in the hierarchy, and correspondingly, that a new horse scores low in the dominance rank.

### 8.1.7 Forms of agonistic interactions

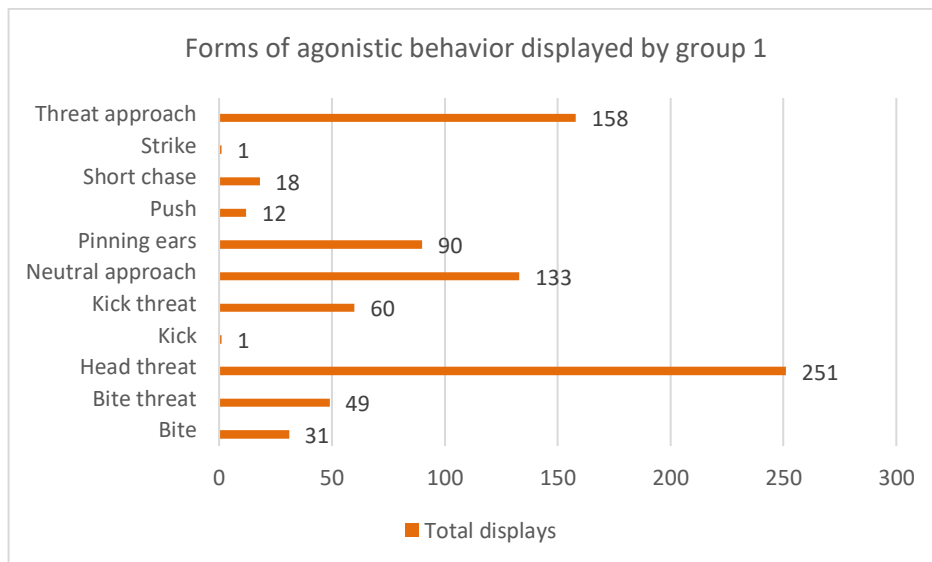


Figure 1: Different forms of aggressive behavior displayed by group 1

In group 1, the most frequently performed aggressive behaviors are the head threat, the threat approach and the neutral approach.

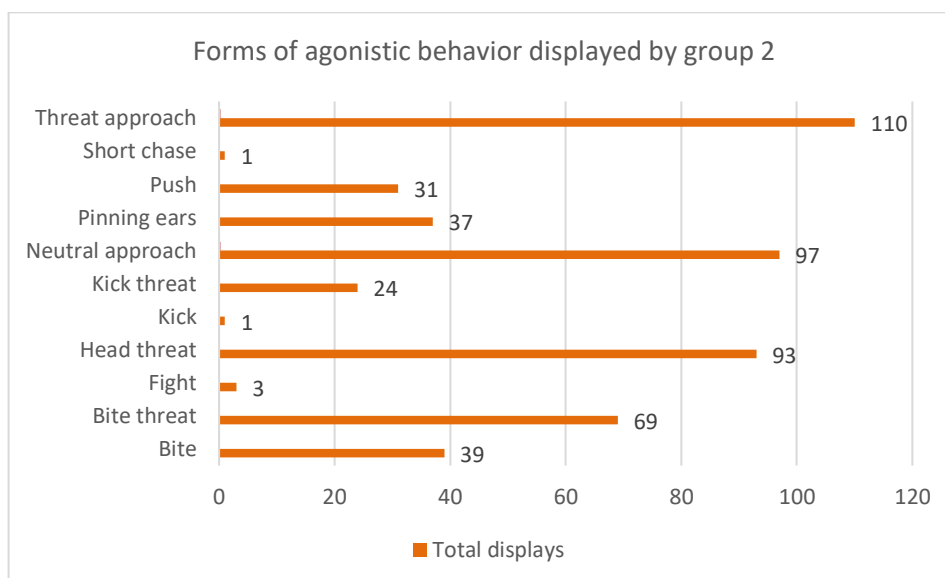


Figure 2: Different forms of aggressive behavior displayed by group 2

In group 2, the threat approach is the preferred agonistic behavior shown, followed closely by the neutral approach and the head threat.

In both groups these are the three leading behaviors.

### 8.1.8 Contact-aggression vs. mild aggression

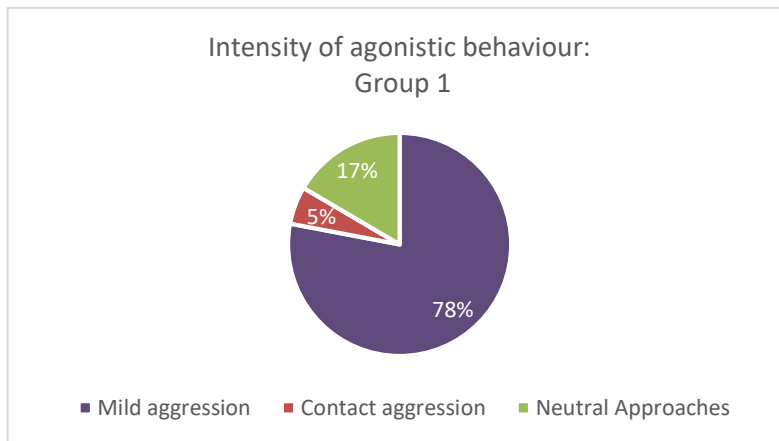


Figure 3: Types of agonistic behavior displayed by group 1

In group 1, contact aggression was rarely shown (5%) whereas mild aggression occurred the most frequently (78%). Neutral approaches also played a relatively important role in the dominance between horses with 17% of the displacement acts being non-aggressive.

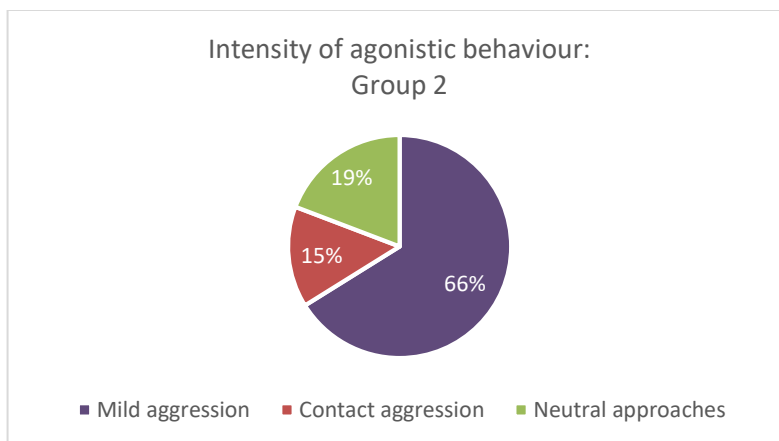


Figure 4: Types of agonistic behavior displayed by group 1

In group 2, contact aggression was three times higher than in group 1 (15% vs. 5%). However, also neutral approaches were slightly more important (19%). Similarly to group 1, mild aggression (threats) was also the dominant type of behavior in group 2 (66%).

### 8.1.9 Ignored aggressions

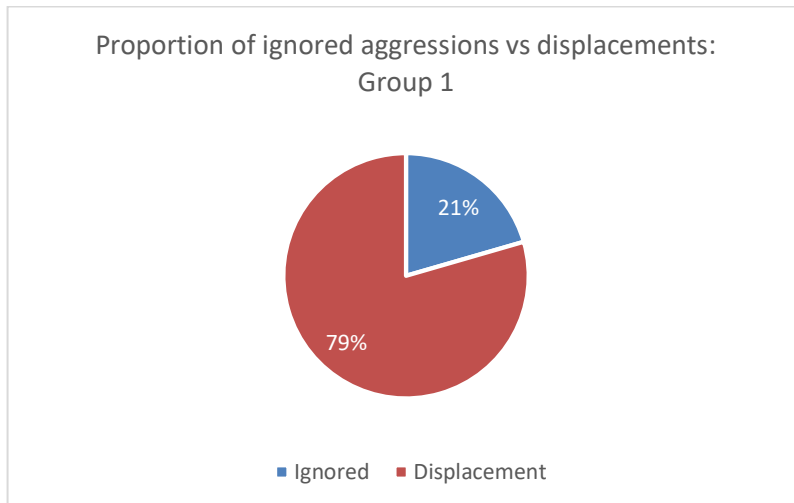


Figure 5: Group 1 reaction to aggression: displacement and ignoring

In 21% of the interactions between members of group 1, the aggressive behaviors were ignored. The major part (79%) of the agonistic interactions however resulted in displacement of the receiver.

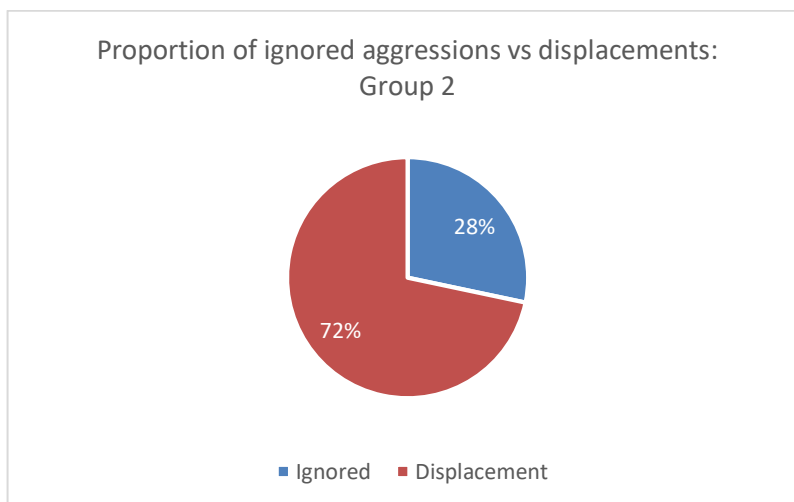


Figure 6: Group 2 reaction to aggression: displacement and ignoring

The aggression-receivers in group 2 ignored the behavior in 28% of the confrontations. In parallel, they retreated from the threats/aggressions in 72% of the time.



### 8.1.10 Context of aggression

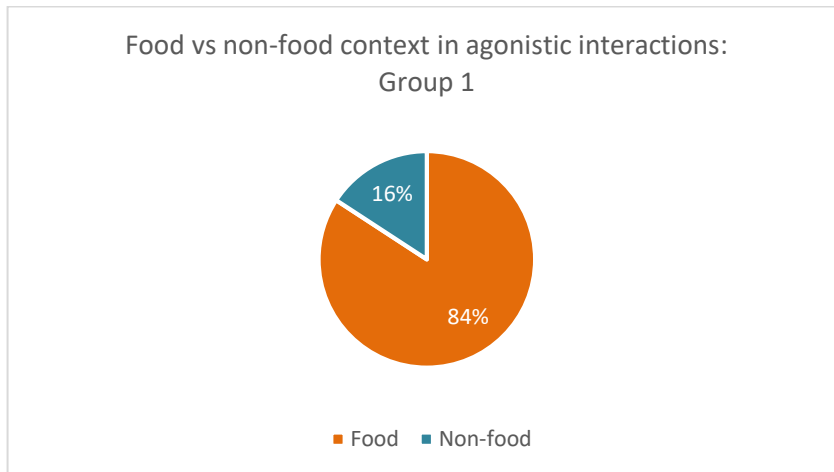


Figure 7: Group 1 context of aggression: food or non-food

Group 1 showed aggression most often in relation to food (84% of the cases) and a small amount in relation to non-food (16%).

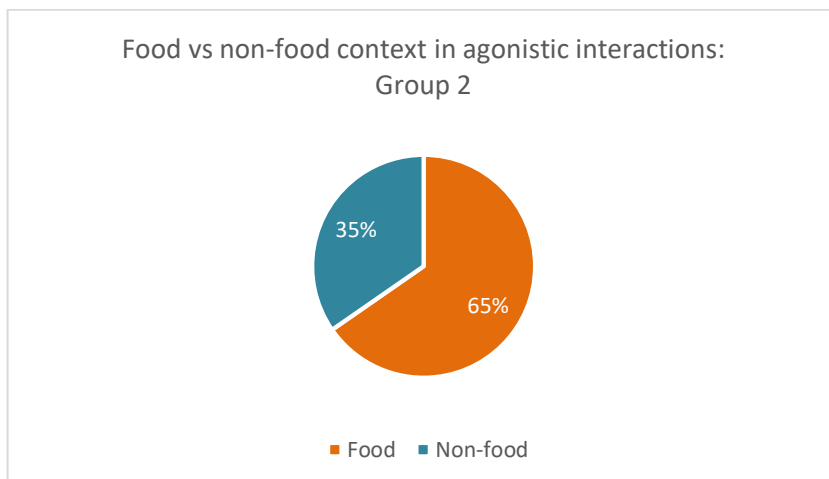


Figure 8: Group 2 context of aggression: food or non-food

Group 2 displayed more aggression in non-food contexts than group 1: 35% of all agonistic interactions was not related to food. However, the main context of aggression remains food with 65% of all interactions.

## 8.2 SOCIABILITY

### 8.2.1 Forms of positive social behavior

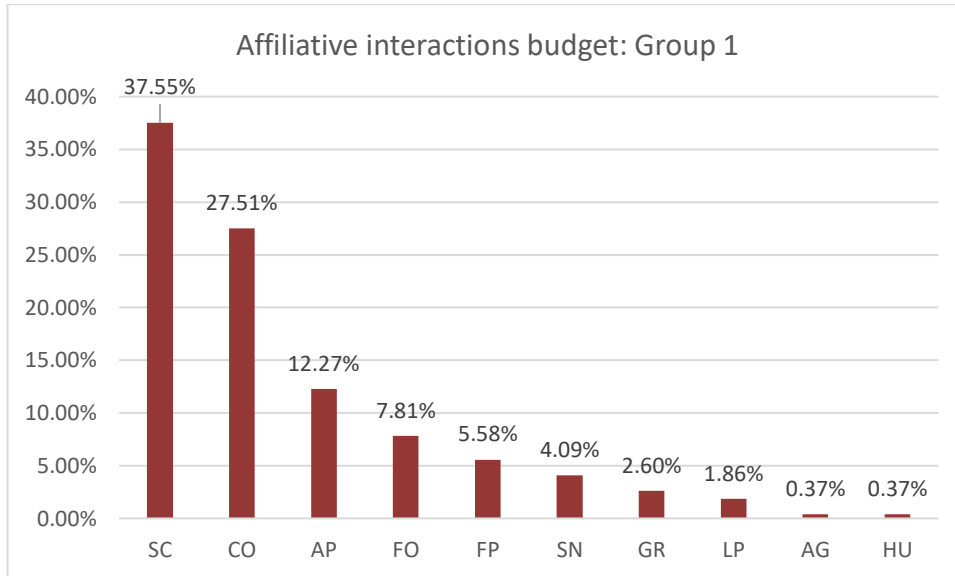


Figure 9: Proportion of different affiliative interactions expressed by group 1

This graph shows that the most performed positive interactions between the Akhal-Teke mares were standing close (37.55%) and making contact (27.51%). And although standing close was the main affiliative behavior, standing head-to-tail (huddling) did almost not occur (0.37%) in the herd. The horses approached another individual 12.27% of all focal scans and followed each other for 7.81%. Playing represented about seven percent of all affiliative interactions, with fight play (5.58%) being the favored choice in contrast to locomotor play (1.86%). Grooming occurred for less than three percent of all observations and allogrooming was nearly inexistent (0.37%) between the Akhal-Teke mares.

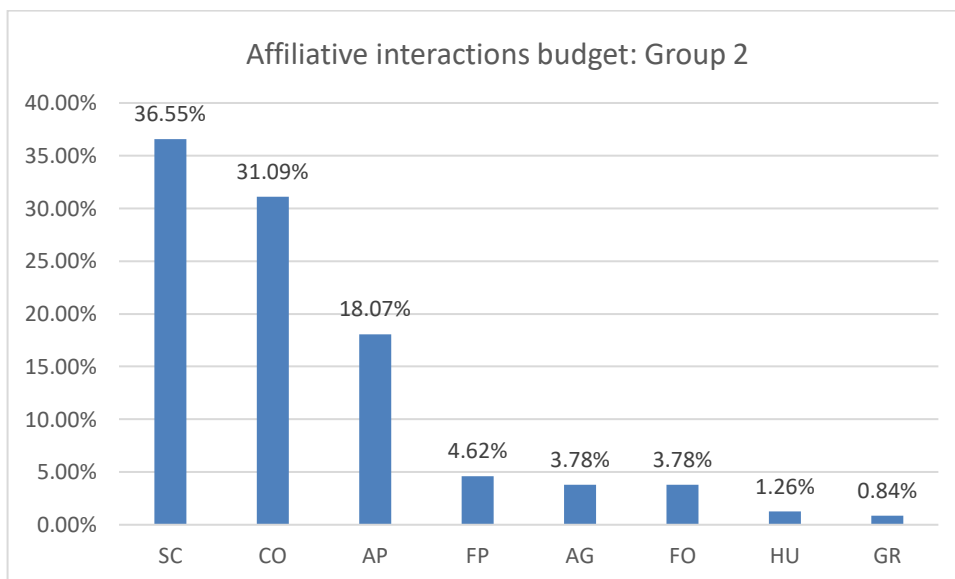


Figure 10: Proportion of different affiliative interactions expressed by group 2

Uniformly with group 1, the Icelandic horses showed their affiliation most of the time by standing close to each other (36.55%) and by making contact (31.09%). Horses huddled more often than in group 1, nonetheless it represented still a small proportion of the interactions (1.26%). Both contact- and approaching behavior (18.07%) occurred more often than in group 1. Yet, following behavior was half as important (3.78% vs 7.81% in group 1). Unidirectional grooming was performed less than one percent of the time whereas allogrooming was shown considerably more often than in group 1 and for almost four percent of all interactions. Play was also a big part (4.62%) of the positive social interactions in the group, this was in the form of fight play only.

### 8.2.2 Relationship between received and given affiliative acts

For each horse, we correlated the sums of affiliative acts given and received. This relationship was significantly correlated in group 1 ( $r_s = 0.628$ ,  $p < 0.016$ ,  $n = 14$ ) and it showed that the more affiliation was given, the more affiliation was also received.

This correlation was not found in the Icelandic herd (group 2).

### 8.2.3 Relationship between sociability and age

We correlated age with different sociability parameters (affiliative acts given, affiliative acts received, sum of given/received) in order to test any influence of age on affiliative social interactions in horses. In both groups there were no significant correlations found for either one of the sociability parameters:

- age and affiliative acts given: group 1:  $r_s = -0.235$ ,  $p < 0.419$ ,  $n = 14$  ; group 2:  $r_s = 0.517$ ,  $p < 0.154$ ,  $n = 9$ ,
- age and affiliative acts received: group 1:  $r_s = -0.055$ ,  $p < 0.851$ ,  $n = 14$  ; group 2:  $r_s = 0.604$ ,  $p < 0.085$ ,  $n = 9$ ,
- age and sum of acts given/received: group 1:  $r_s = -0.154$ ,  $p < 0.600$ ,  $n = 14$  ; group 2:  $r_s = 0.506$ ,  $p < 1.64$ ,  $n = 9$ .

### 8.2.4 Affiliation matrix

Table 11: Matrix of affiliative interactions in group 1: Akhal-Teke's

Receiver/Actor	Aka	Ako	Ayr	Bel	Fer	Fli	Fra	Gul	Kic	Okg	Okr	Oza	Sra	Sry	Tot.
Aka	0	1	0	1	3	0	0	1	4	24	1	2	0	2	39
Ako	0	0	0	0	0	0	0	1	0	0	12	0	0	0	13
Ayr	0	0	0	0	1	0	1	0	0	0	1	1	0	1	5
Bel	0	1	1	0	1	0	6	0	0	1	0	0	2	0	12
Fer	3	1	1	0	0	4	2	3	2	8	1	0	1	3	29
Fli	0	0	1	3	3	0	0	0	1	2	3	0	2	0	15
Fra	0	0	1	11	5	0	0	0	0	2	0	0	0	0	19
Gul	0	2	0	0	0	0	0	0	1	1	0	2	1	0	7
Kic	0	1	0	1	0	0	4	0	0	0	1	7	4	1	19
Okg	31	0	1	5	5	2	0	0	3	0	2	4	2	0	55
Okr	2	13	0	0	0	1	0	1	0	0	0	0	1	1	19

<b>Oza</b>	4	0	0	0	0	0	0	5	2	3	0	0	3	2	<b>19</b>
<b>Sra</b>	0	2	2	2	1	0	0	1	2	1	1	0	0	0	<b>12</b>
<b>Sry</b>	0	0	0	0	1	0	1	0	1	0	0	1	2	0	<b>6</b>
<b>Tot.</b>	40	21	7	23	20	7	14	12	16	42	22	17	18	10	

Table 11 presents the affiliative interactions between individuals with special emphasis on the actor and receiver of the act, which gives us an idea of who initiates the interaction. The results reveal that Ayra, Saryyagyz and Gul-Oyluk initiated the least affiliations. On the opposite side, Okgunly and Akargul originated the most positive interactions, they also received the most affiliations in the group. But these interactions were mainly with each other and less with other horses. Ayra, Fliki and Saryyagyz received the less affiliations from their group members.

The most horses show a lot of diversity in partners but do have one preferred individual (i.e. an individual they initiate most with). Pairs interacting mostly with each other rather than with other individuals were: Okgunly – Akargul, Akkol – Okra and Fragariia – Belentgyz.

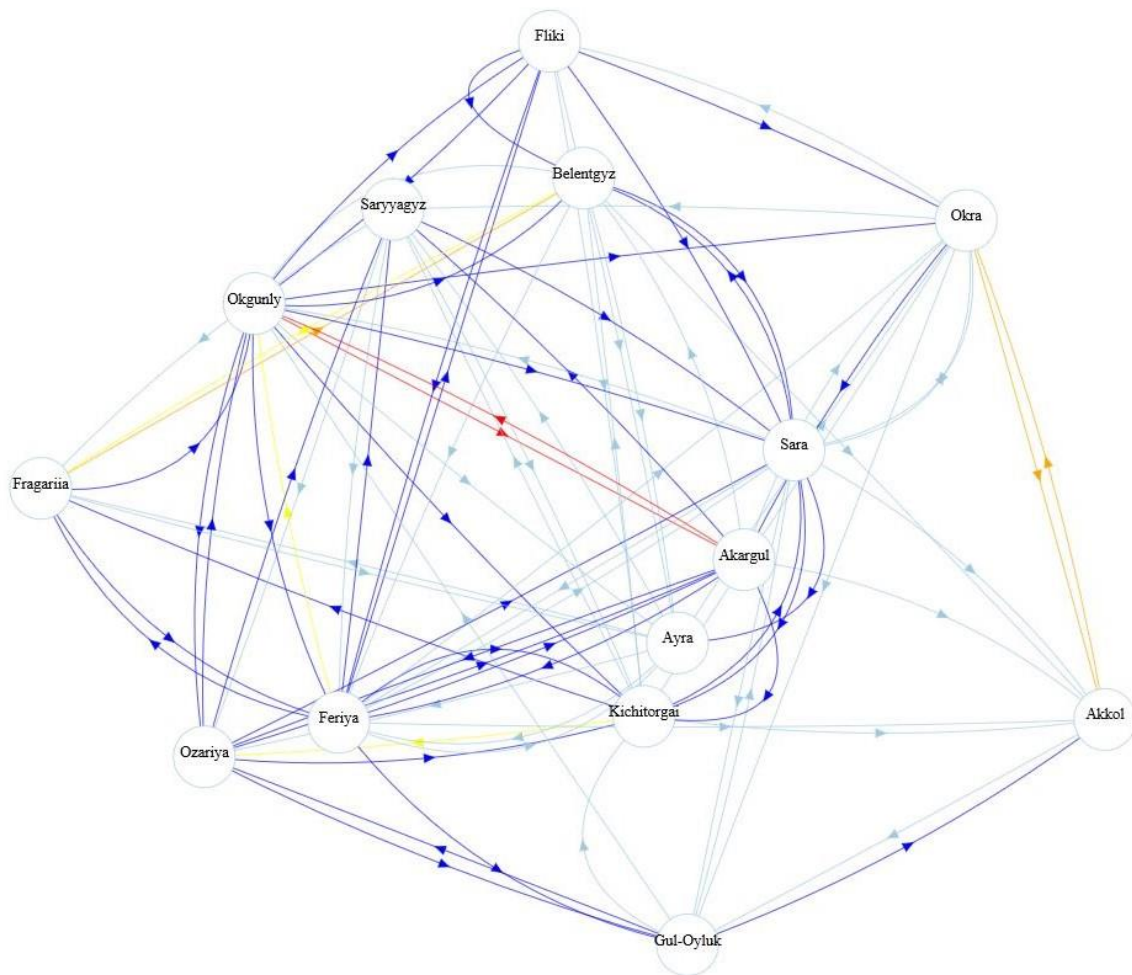
Table 12: Matrix of affiliative interactions in group 2: Icelandic's

Receiver/ Actor	Assa	Drynja	Hannah	Landi	Loa	Saga	Sura	Tenor	Vekka	Total
<b>Assa</b>	0	7	2	4	9	3	3	1	0	<b>29</b>
<b>Drynja</b>	1	0	0	4	1	2	4	0	4	<b>16</b>
<b>Hannah</b>	0	4	0	2	3	1	11	1	0	<b>22</b>
<b>Landi</b>	4	11	5	0	4	1	5	0	0	<b>30</b>
<b>Loa</b>	10	0	1	1	0	0	4	1	3	<b>20</b>
<b>Saga</b>	4	7	1	7	2	0	7	6	0	<b>34</b>
<b>Sura</b>	1	1	1	1	16	4	0	6	1	<b>31</b>
<b>Tenor</b>	5	3	0	3	8	7	15	0	1	<b>42</b>
<b>Vekka</b>	3	3	0	0	3	2	3	0	0	<b>14</b>
<b>Total</b>	28	36	10	22	46	20	52	15	9	

Firstly, the data shows that all the horses initiated affiliations at least fourteen times. Vekka and Drynja initiated the least (<20x) and Tenor the most (>40x). Secondly, it appears that Vekka and Hannah received the less affiliations. Sura and Loa were the two individuals whom other animals initiated the most with, i.e. they received the most positive acts. All the horses had a great diversity of partners and associated with at least five different individuals. Sura initiated a lot with Loa, and Tenor a lot with Sura.

Similarly to group 1 but less significantly, this herd also revealed pairs who associated more with each other than with other group members: Assa – Loa, Drynja – Landi and Vekka – Drynja.

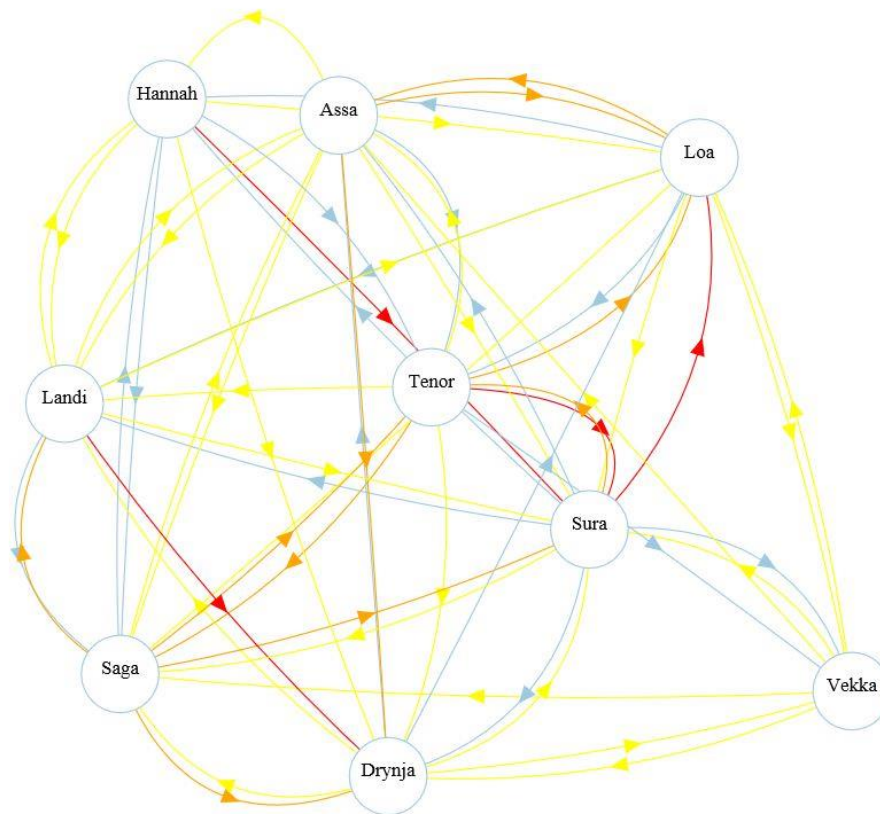
### 8.2.5 Sociogram



Interaction rates: *blue*: 1, *dark blue* 2 – 5, *yellow*: 6 – 10, *orange*: 11 – 20, *red*: 21 – 31

Figure 11: Sociogram of the Akhal-Teke herd

The sociogram illustrates the interactions between herd members of group 1 along with the rates at which horses interacted. We can see that most of the interactions occurred only 5 or less times between two individuals. Part of this, one-time interactions were also appearing a great deal in the sociogram. Only two couples made strong and similar advances to each other: Okgunly and Akargul both initiated an interaction with the other at a rate of 21 to 31 times whereas Okra and Akkol did the same but at a smaller rate of 11 to 20 times. Fragariia and Belentgyz also appear to have a strong affiliative bond but Fragariia initiated more (11 to 20 times) than Belentgyz (6 to 10 times). Furthermore we can see two 6 to 10 times interactions, but these were unidirectional: Kichitorgai interacted with Ozariya and Feriya with Okgunly. Furthermore, a lot of the 2 – 5 interactions were reciprocated at the same initiation rate, but some were only reciprocated once or not at all. We can see for example that Akkol received a lot of 1 time interactions but gave affiliative acts only to Okra and Gul-Oyluk, all the others remained unreciprocated.



Interaction rates: *blue*: 1, *yellow*: 2 – 5, *orange*: 6 – 10, *red*: 11 – 16

Figure 12: Sociogram of the Icelandic herd

Similarly to group 1, most of the interactions between the same two individuals occurred at a rate of 5 or less. Again one-time interactions are also part of the sociogram, and this time they seem to balance each other out with the 2 to 5 rates. Also in this herd a lot of acts that were given 2 to 5 times were also reciprocated 2 to 5 times. However, not all affiliations were mutual, for example Hannah initiated a high rate of acts (11 to 16) towards Sura, but Sura initiated only once. In parallel Sura initiated to a great extent (11 to 16 times) with Loa who did not initiate with her at all. Landi also interacted 11 to 16 times with Drynja, who only interacted 2 to 5 times with him. Contrarily to group 2, no couples initiated reciprocally more than 11 times with each other. Saga and Tenor as well as Loa and Assa appear to have a balanced relationship as both couples initiated 6 to 10 times with one another. Tenor and Sura also seem to have a good relationship as Tenor interacted 11 – 16 times with Sura and Sura 6 – 10 with Tenor. Moreover, Saga interacted 6 to 10 times with Drynja and Drynja gave her affiliative acts only 2 to 5 times during the whole observation period. Saga also liked to interact with Landi, but he only took the initiative once to interact with her. The same occurred with Tenor and Loa.

### 8.2.6 Nearest neighbor matrix

Table 13: Matrix of the nearest neighbor affiliations in group 1: Akhal-Teke's

NN/ Focal	Aka	Ako	Ayr	Bel	Fer	Fli	Fra	Gul	Kic	Okg	Okr	Oza	Sra	Sry
Aka	0	1	2	1	3	1	0	6	4	1	0	0	1	0
Ako	0	0	1	0	0	0	1	2	0	0	13	2	1	0
Ayr	2	4	0	0	0	0	1	0	4	0	1	3	1	4
Bel	1	0	0	0	0	4	5	1	0	1	1	1	3	3
Fer	2	4	0	0	0	3	1	2	1	6	0	0	1	0
Fli	0	0	1	2	1	0	0	1	2	2	4	5	0	1
Fra	0	0	2	10	0	1	0	0	3	1	0	2	0	1
Gul	0	4	0	2	2	0	2	0	1	0	6	0	0	3
Kic	2	1	3	2	3	2	0	1	0	1	2	1	2	0
Okg	6	0	0	2	4	1	0	0	0	0	2	0	3	2
Okr	0	14	1	0	1	0	1	2	1	0	0	0	0	0
Oza	2	0	0	1	1	2	0	5	2	1	0	0	0	6
Sra	1	1	1	4	2	1	3	0	1	1	1	0	0	4
Sry	1	1	1	0	0	2	0	4	7	1	1	0	2	0
Total	17	30	12	24	17	17	14	24	26	15	31	14	14	24

This matrix shows that during her focal scans, Okra stood most often next to Akkol and that this was reciprocal. The same case occurred with Fragaria and Belentgыз as well as with Kichitorgai and Ayra. The data reveals that Akkol and Okra are the most attractive neighbors as they appear the most frequently as nearest neighbor. In this light, Ayra seems to be the least attractive neighbor.

Table 14: Matrix of the nearest neighbor affiliations in group 2: Icelandic's

NN/ Focal	Assa	Drynja	Hannah	Landi	Loa	Saga	Sura	Tenor	Vekka
Assa	0	3	5	4	5	2	6	1	7
Drynja	3	0	3	8	2	5	7	5	7
Hannah	1	4	0	7	0	1	6	6	11
Landi	4	8	1	0	1	13	8	0	3
Loa	3	3	3	7	0	3	10	6	4
Saga	6	1	3	1	5	0	9	4	8
Sura	5	0	9	5	7	6	0	3	3
Tenor	3	8	2	3	5	13	4	0	2
Vekka	9	7	2	6	0	3	5	6	0
Total	34	34	28	41	25	46	55	31	45

The results in this matrix show that during her focal scans Vekka stood next to Assa more often than next to other individuals, this was reciprocal and thus Assa stood most often next to Vekka during her own focal scans. In this group this only occurred in this 'pair'. Landi associated a lot with Saga, as well did Tenor; Loa and Saga associated most often to Sura and Vekka was found surrounded by Assa and Hannah on many occasions. The total displays that Sura is the most attractive neighbor followed by Saga, Vekka and Landi.

### 8.2.7 Distance to closest neighbor

Table 15: Mean distance to the closest neighbor of each individual in group 1

	Mean distance to closest neighbor (in body lengths)
Kichitorgai	0.56
Akkol	0.59
Feriya	0.60
Okra	0.60
Fragariia	0.68
Gul-Oyluk	0.74
Okgunly	1.00
Saryyagyz	1.04
Belentgyz	1.08
Akargul	1.10
Ayra	1.23
Ozariya	1.51
Fliki	1.53
Sara	1.59

This table represents the mean distance to the closest neighbor of each individual in the group, expressed in body lengths. For group 1, this mean varied between 0.56 and its triple: 1.59 body



lengths. With most horses (8 out of 14) keeping on average at least 1 body length from their closest neighbor.

Table 16: Mean distance to the closest neighbor of each individual in group 2

	Mean distance to closest neighbor (in body lengths)
Sura	0.65
Loa	0.74
Vekka	1.01
Tenor	1.04
Landi	1.07
Saga	1.17
Drynja	1.31
Assa	1.36
Hannah	1.65

In group 2, the mean distance varied between 0.65 body lengths and 1.65 bl. As in group 1, most of the horses (7 out of 9) kept on average more than 1 body length distance to their closest neighbor.

### 8.2.8 Spatial distribution

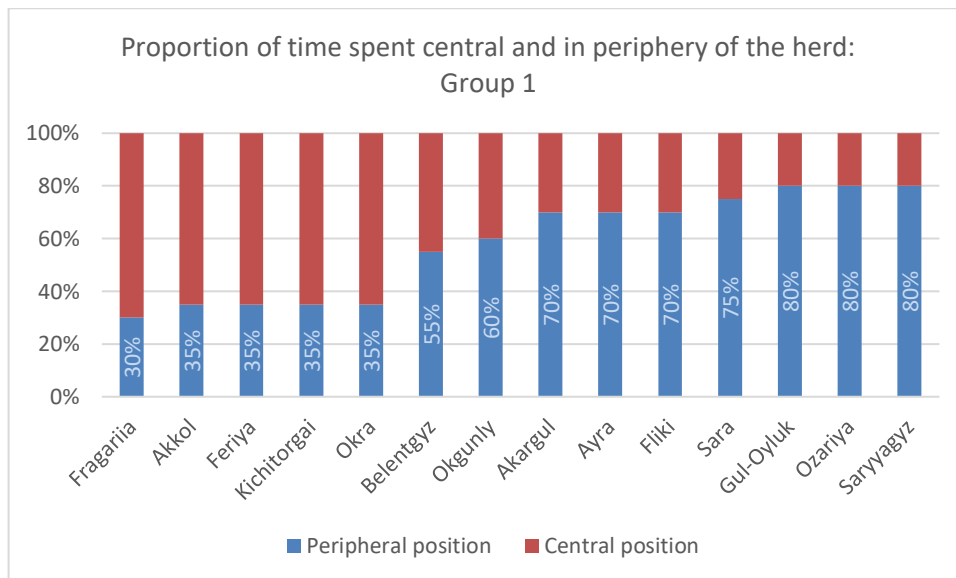


Figure 13: Group 1: percentage of time spent per individual in central and peripheral position

This graph shows that Fragaria spent the most time in central position of the herd (70% of the time), followed closely by Akkol, Feriya, Kichitorgai and Okra (65% of their time). The largest part of the herd (9 out of 14 individuals) however spent more than 50% of their time in periphery of the group.

With at the extremity: Gul – Oyluk, Ozariya and Saryyagyz spending 80% of their time in a peripheral position.

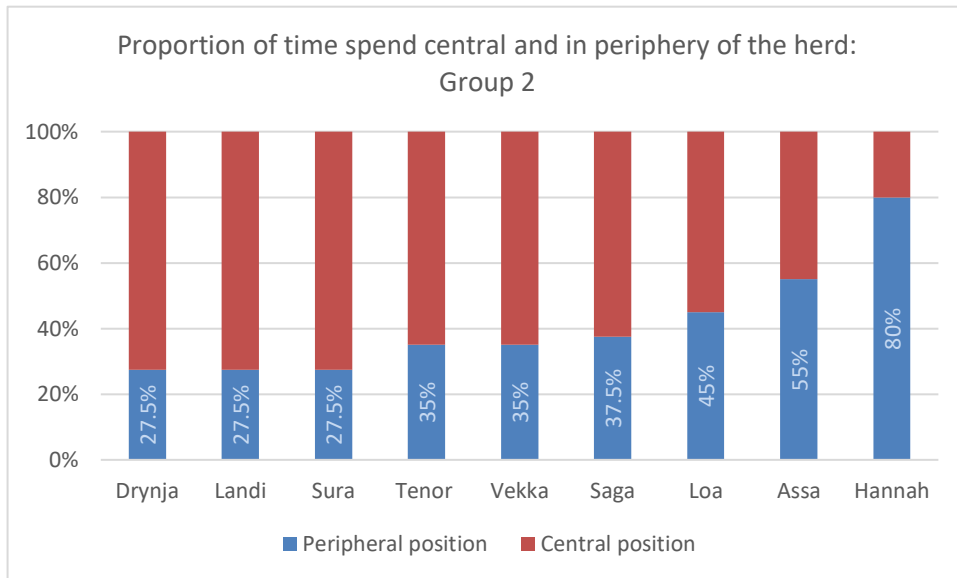


Figure 14: Group 2: percentage of time spend per individual in central and peripheral position

Figure 14 demonstrates that Drynja, Landi and Sura were the individuals spending the most time in a central position (72,50% of their time), followed by Tenor, Vekka and Saga (65%). In contrast to group 1, the minority (and not the majority) of individuals spend more than 50% of their time in periphery (2 out of 9), these horses were: Assa and Hannah, with Hannah spending 80% of her time in periphery.

### 8.3 ACTIVITY BUDGET

#### 8.3.1 Main activity budget

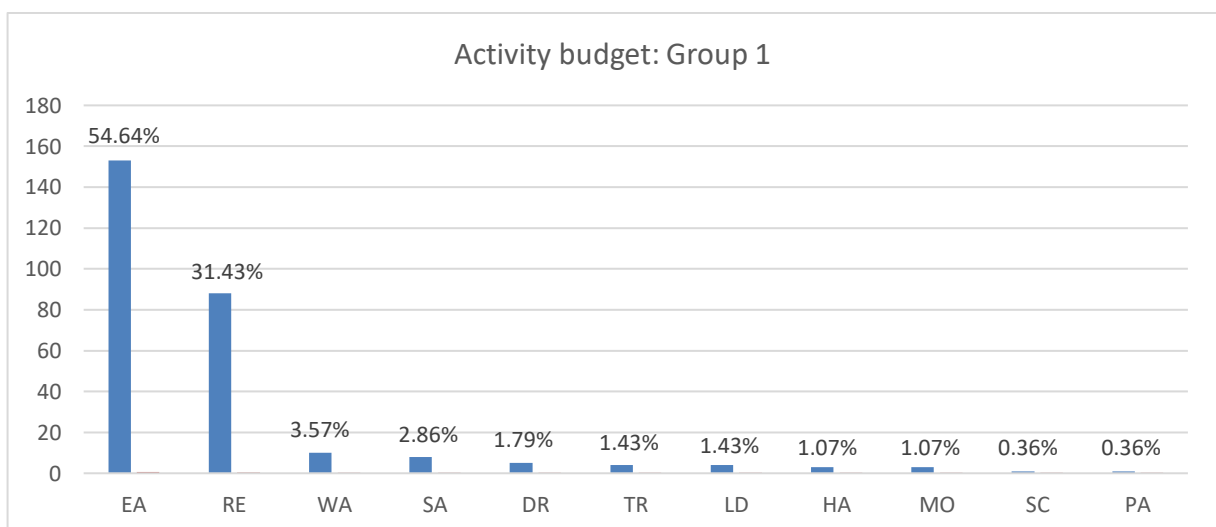


Figure 15: Activity budget for group 1

The main activity of group 1 was eating (54.65%), which they did more than half of the time they were observed. Followed by resting which they did during 31.43% of their time. Other activities occurred much less, walking was performed less than four percent of the time and standing attentive less than three. Drinking, trotting, lying down, human awareness and mouthing occurred at a scale between one and two percent whereas scratching and pawing occurred only 0.36% of the time.

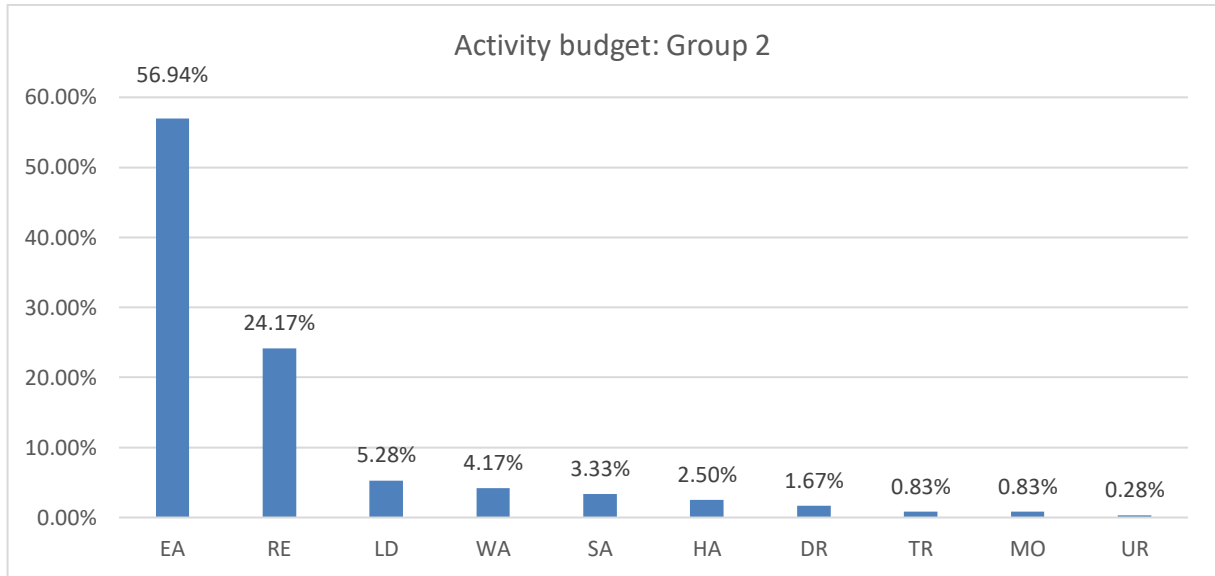


Figure 16: Activity budget for group 2

Similarly to the Akhal Teke's, the herd of Icelandic horses spent more than half of their time eating (56,94%). They had a slightly smaller proportion of resting activity with 24.17%, this was however made up for in lying down behavior which was higher than in group 1 (5.28% vs 1.43%). There was also more walking and standing attentive (resp. 4.17% and 3.33%). There was more than double as much human awareness in the Icelandic herd but drinking activities were similar in both groups. Trotting, mouthing and urinating represented less than one percent of the total activity budget.

### 8.3.2 Activity budget per horse

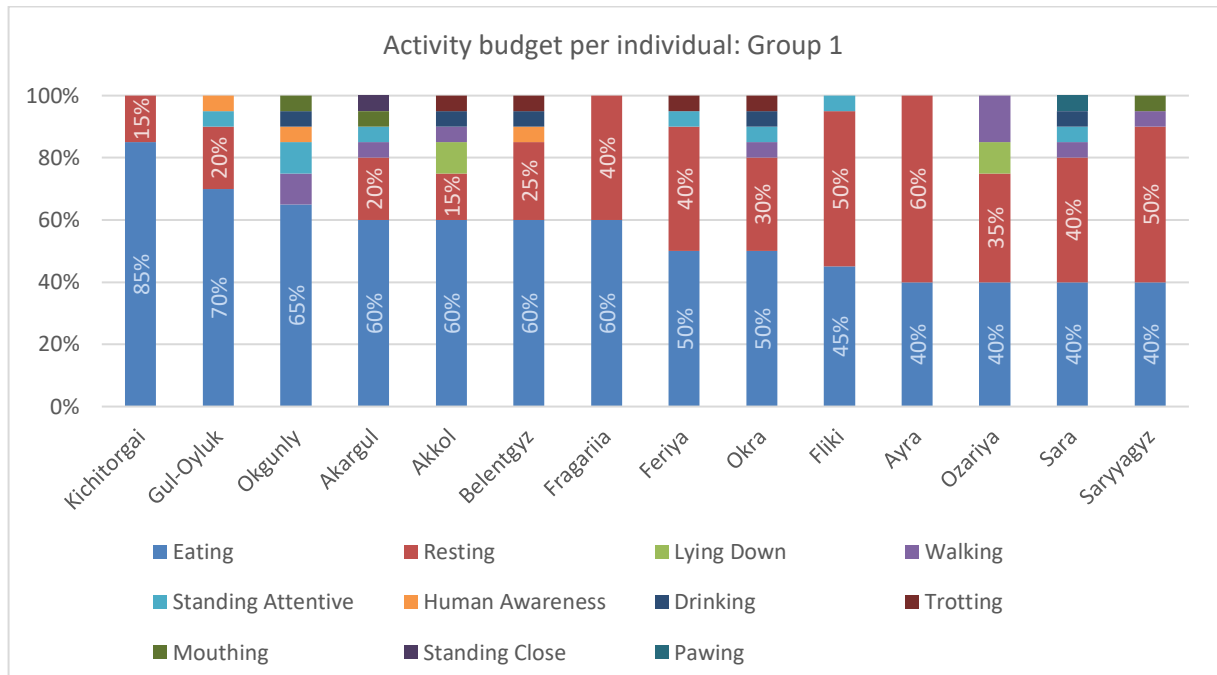


Figure 17: Activity budget per horse in group 1

The majority of horses (9/14) spend more than 50% of their time feeding. Kichitorgai for example only performed two activities during the observations which were eating (85%) for the most part and resting (15%) for the minor part. Gul-Oyluk rested for 20% of her observations and ate during 70% of them, the ten remaining percent she spent aware of her environment (human awareness and standing attentive). Okgunly did not rest during the research sessions (0%), eating was her main activity (65%), the last 35% of her activity budget she spent on walking, environmental awareness, human awareness, drinking and mouthing.

Akargul, Akkol, Belentgyz and Fragariia all spent 60% of their time eating and 15% - 25% resting except for Fragariia who rested for 40%. Feriya and Okra were feeding for half of the focal scans and rested for 30% and 40% respectively. Only three horses out of fourteen had resting as their main activity: Fliki (50%), Ayra (60%) and Saryyagyz (50%). Ozariya and Akkol were the only two horses lying down during the focal scans. And Ozariya was the horse which was recorded to walk the most frequently.

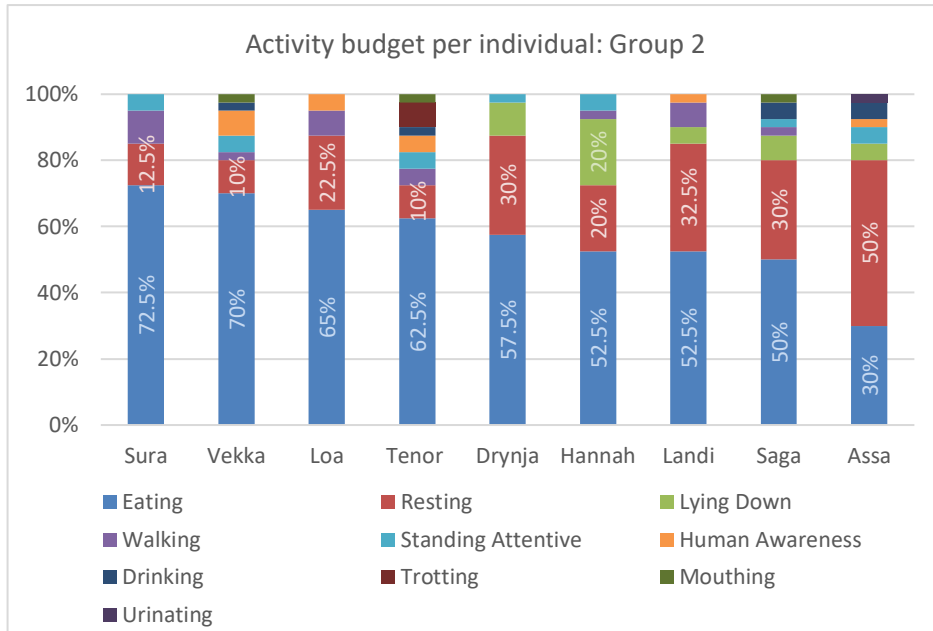


Figure 18: Activity budget per horse in group 2

Eight out of nine horses spent at least 50% of their time eating. Only Assa spend 50% resting and only 30% feeding. Sura ate for 72.5% of the observations and rested only 12.5%, the remaining percent she spent on walking and standing attentive. Vekka, Loa and Tenor fed during 62% - 70% of the observations whereas Drynja, Hannah, Landi and Saga fed during 50% - 58% of the time. Resting was recorded around 30% of the scans for Landi, Saga and Drynja. For Sura, Vekka, Loa, Tenor and Hannah resting represented only 10% to 23% of their activity budget. However, Hannah spend as much time resting (20%) as lying down (20%) which makes her all-round resting percentage considerable (40%) and second highest next to Assa. In contrast to group 1, horses performed many different behaviors and all the individuals did more than solely eat and rest. However two horses out of nine horses did rest for only 10% of the time, any absence of resting behavior was not found (as seen in group 1).

## 8.4 SOCIAL ISOLATION

### 8.4.1 Occurrence of different reactions to social isolation

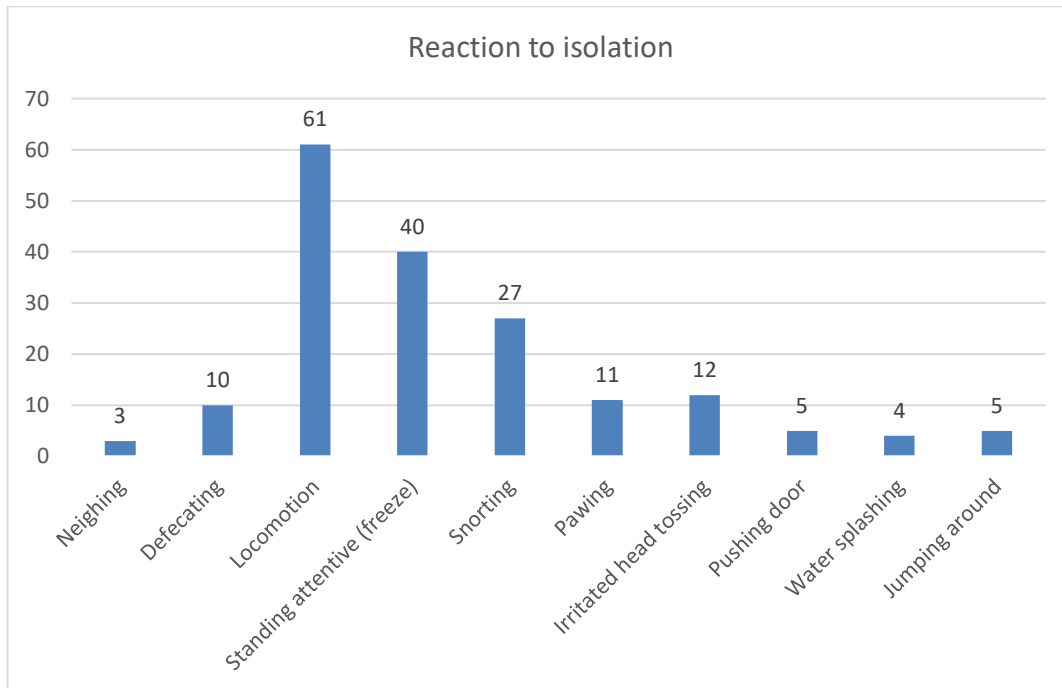


Figure 19: Different reactions to the isolation test in group 2: Icelandic horses

During the isolation test, the Icelandic horses displayed a number of different stress-related behaviors. Locomotion and 'freezing' were the two most performed behaviors, followed by snorting. Behaviors such as irritated head tossing, pawing and defecating were also displayed often during the isolation. Finally some behaviors occurred less often but still a few times considering the group size ( $n=9-1$ ), jumping around occurred as frequently as pushing against the door (5 times in 8 sessions) and water splashing occurred only four times. Neighing was only performed three times across all the sessions.

### 8.4.2 Frequency of performing stress-related behavior per individual

Table 17: Per individual frequency of each reaction to the isolation test in group 2: Icelandic horses

Horse	Neighing	Defecating	Locomotion	Standing attentive (freeze)	Snorting	Pawing	Irritated head tossing	Pushing door	Water splashing	Jumping around	Total
Tenor	0	1	5	5	11	0	0	3	0	0	25
Loa	0	1	2	3	0	4	3	0	0	0	13
Vekka	0	2	11	5	0	2	0	0	0	0	20
Hannah	0	2	8	6	1	5	0	2	0	0	24
Sura	0	1	9	6	14	0	0	0	1	0	31

Drynja	0	0	7	4	0	0	0	0	1	0	12
Saga	0	1	10	3	1	0	9	0	2	5	31
Landi	3	2	9	8	0	0	0	0	0	0	22
Assa*	/	/	/	/	/	/	/	/	/	/	0
<b>Total</b>	<b>3</b>	<b>10</b>	<b>61</b>	<b>40</b>	<b>27</b>	<b>11</b>	<b>12</b>	<b>5</b>	<b>4</b>	<b>5</b>	

\*the individual refused to enter the isolation area, therefore we have no useable data.

This table shows that locomotion and ‘freezing’ was performed by all the horses, and that except Drynja, all the focals defecated at least once during the test. Half of the individuals snorted and only a minority pawed, splashed water, pushed against the door or tossed their heads. Jumping around was performed only by Saga but at a rate of one jump a minute, Landi was the only individual who neighed at their conspecifics and he did this three times during the test.

The behavior with the highest occurrence rate was snorting and it was performed by Sura (14x) and Tenor (11x). Vekka and Saga locomoted the most but were followed shortly by Sura and Landi. Loa locomoted the least (2x).

Overall, Loa and Drynja were the two horses who showed the less anxiety signals during the isolation test with half as many signals as the major rest of the group. Saga and Sura took first place in the anxiety rank with more than six signals per minute (31/5min).

## 8.5 CORRELATIONS

### 8.5.1 Relationship between dominance and affiliation

We tested the hypothesis that animals would interact more/less with each other according to their rank order. Hereto we correlated the matrix with agonistic interactions row by row with the matrix of affiliative interactions. In group 1 there was no significant correlation between the two matrices (Kr-test,  $p=0.73$ ), neither was there in group 2 (Kr-test,  $p=0.58$ ).

Since there were many zeros in the affiliation matrix, meaning that some animals had no affiliative contact whatsoever, we decided to look if there was a relationship between the giving of aggressive acts and the receiving of affiliative acts and vice-versa. Therefore we correlated the total sums of aggressive acts given and received (followed by submission) and affiliative acts given and received per horse.

The relationships were significantly correlated in group 2 only:

- The more aggressive acts were given (followed by submission), the less affiliation was received ( $r_s=-0.733$ ,  $p<0.025$ ,  $n=9$ ).
- The more aggressive acts that were received, the more affiliative acts that were given ( $r_s=-0.617$ ,  $p<0.077$ ,  $n=9$ , statistical trend where  $0.05<p<0.1$ ).

So firstly, this data suggests that the more aggressive behavior an individual shows, the less positive interactions it will receive from its fellow herd mates. And secondly that the more an individual will receive aggressive acts, the more it will show affiliative behavior towards its herd mates.

### 8.5.2 Relationship between nearest neighbor and dominance acts

We tested the hypothesis of whether horses that stand close (or far) in proximity would show less (or more) agonistic acts towards each other. To do so we correlated the ‘nearest neighbor matrix’ and the matrix of ‘submissions after aggression’. In both herds we did not find any significant correlation

(group 1: rowwise Kr-test  $p < 0.598$ ; group 2: rowwise Kr-test  $p < 0.986$ ).

These results suggest that individuals who tend to spend more (or less) time as nearest neighbors do not necessarily show more (or less) submissive acts to these individuals.

### 8.5.3 Relationship between rank order and distance to nearest neighbor

We tested for a relationship between dominance rank and the tendency to stand closer to (or further from) other individuals ('distance to closest neighbor' parameter). No such relation was found, nor in group 1 (Akhal Teke's:  $r_s = 0.249$ ,  $p < 0.391$ ,  $n = 14$ ) nor in group 2 (Icelandic horses:  $r_s = 0.083$ ,  $p < 0.831$ ,  $n = 9$ ). Meaning that a high (or low) ranking horse does not show higher prevalence of standing closer to (or further from) another herd member.

### 8.5.4 Relationship between dominance and spatial distribution

The hypothesis of spatial distribution according to rank order has been evaluated. In group 1 there was a significant correlation between rank and spatial position in the group ( $r_s = 0.641$ ,  $p < 0.013$ ,  $n = 14$ ) with subordinates having peripheral positions and dominants central positions within the herd. These results suggest that the higher an individual stands in the hierarchy the more centrally it will be located in the group and vice versa.

In group 2 (Icelandic horses) no significant correlation was found ( $r_s = -0.085$ ,  $p < 0.828$ ,  $n = 9$ ).

### 8.5.5 Relationship between sociability and spatial distribution

We analyzed the possibility of a correlation between positive social interactions and the spatial position of an individual within its herd. Nor in group 1 nor in group 2 was there any such correlation.

- Spatial position and given affiliative act: group 1:  $r_s = (-)0.438$ ,  $p < 0.117$ ,  $n = 14$ ; group 2:  $r_s = (-)0.085$ ,  $p < 0.828$ ,  $n = 9$ .
- Spatial position and received affiliative acts: group 1:  $r_s = (-)0.326$ ,  $p < 0.256$ ,  $n = 14$ ; group 2:  $r_s = (-)0.323$ ,  $p < 0.396$ ,  $n = 9$ .

The data shows that there is no relationship between the given/received affiliative acts and a peripheral/central distribution

### 8.5.6 Rank and proximity (standing close and nearest neighbor)

In order to evaluate a relationship between rank distances and spatial proximity we associated two matrixes. The matrix of rank distance (with each possible dyad given a number based on the subtraction of their rank orders to measure the scale of their hierarchical differences) and the matrix representing the sum of times one individual was nearest neighbor and 'standing close' to different herd members. In both groups no significant correlation was found between these factors (group 1: Kr-test:  $p < 0.71$ ; group 2: Kr-test:  $p < 0.898$ ). These results imply that – based on proximity alone – horses do not associate more/less with horses closer/farther in rank.

### 8.5.7 Dyad formation and rank (i.e. social bonds within same rank level)

We researched whether two members of a strong dyadic relationship are of similar rank order or whether these relationships are totally unrelated to hierarchical positions. Using the sociograms (see 8.2.5) we only accounted balanced relationships where both partners initiated at similar rates and



relationships where mutual rates were under 6 – 10 times.

The sociograms showed that in both group 1 and group 2 there were three strong dyadic bonds:

Table 18: Hierarchical rank order and dyadic bonds between horses (bonds highlighted in the same color)

Rank order	Group 1: Akhal Teke's	Rank order	Group 2: Icelandic Horses
1	Okra	1	Assa
2	Akkol	2	Loa
3	Fragariia	3	Drynja
4	Belentgyz	4	Vekka
5	Sara	5	Sura
6	Ayra	6	Tenor
7	Feriya	7	Hannah
8	Fliki	8	Saga
9	Kichitorgai	9	Landi
10	Ozariya		
11	Gul-Oyluk		
12	Okgunly		
13	Akargul		
14	Saryyagyz		

Table 18 shows that that five out of six dyads are bonds between individuals of similar rank with no other individual between them on the hierarchical ladder.

The sixth pair, Tenor and Saga show a small hierarchical distance but are still of close rank (see Table 18). Overall, we can conclude that horses form close dyadic bonds with individuals of similar rank and thus that rank does affect the formation of strong relationships in horses.

### 8.5.8 Social isolation and dominance rank

We tested the hypothesis that dominance rank affects the horse's reaction to social isolation in group 2. This was not supported by the recorded data, as no significant correlation was found ( $r_s$ : 0.661,  $p < 0.108$ ,  $n=8$ ). This means that the total stress indicators shown by the isolated individuals did not depend on the horse's social status in the group, dominant horses did not show more/less anxiety in isolation than subordinate horses.

No data regarding isolation was recorded for group 1.

### 8.5.9 Social isolation and sociability

After analyzing the corresponding data we found a significant positive correlation between given affiliative acts and the total stress reactions shown by the isolated individuals ( $r_s$ : 0.826,  $p < 0.011$ ,

n=8). However, a correlation with received affiliative acts was not found ( $r_s: -0.024, p < 0.955, n=8$ ). The results suggest that, the more affiliative interactions an individual initiates the more distress it will experience during isolation.

#### **8.5.10 Social isolation and spatial distribution**

Finally, we looked for a connection between the reactivity to social isolation and the spatial position of each individual within the group. Our data revealed no significant relationship between these two variables ( $r_s=0.062, p < 0.885, n=8$ ). In other words, it does not mean that centrally positioned individuals show more anxiety when separated from their conspecifics, and vice-versa.

## 9 DISCUSSION

The purpose of this study was to gain a broader understanding of social behavior in horses with the hope that this knowledge could improve the welfare of captive equines. Because the subject of social behavior is large we have tried to cover as many aspects as possible and therefore we will discuss a broad range of research questions in this section.

### 9.1.1 Dominance

In our study we found that in both herds the hierarchy was significantly linear. This means that each individual in the rank order is dominant towards individuals lower on the social ladder and is subordinate to those who are ranked higher (contrarily to circular hierarchies where for example A dominates B and B dominates C but C dominates A (Mascaro & Csibra, 2014)) this supports the previous findings by Heitor et al. (2006a) in a herd of Sorraia mares. Moreover, the significance of the data proves the validity and usability of the rank order represented in Table 10 as data for the further correlation analyses regarding rank in horses.

Furthermore, in both groups, the steepness of the hierarchy approached -1 (group 1: -0.751 and group 2: -0.713) which – according to De Vries et al. (2006) – shows that these horses live in a despotic rather than egalitarian system where resources are unevenly distributed between the subordinated and dominants.

But what is it that makes one individual dominant and the other one subordinate? Surely there are factors increasing one's chance to become a high ranking individual? Based on the results from earlier studies we searched for relationships between hierarchy and different individual parameters such as age, height, body condition and length of stay in the group:

Contrarily to what had been found by Ellard and Crowell-Davis (1989) in a group of draft mares, we did not find any correlation between rank and height. The results for group 1 are however not entirely objective as the dataset for height measurements was incomplete in this herd, only eight out of fourteen horses were tested. Nevertheless, the data from our Icelandic herd supports the early findings by Van Dierendonck et al. (1994) on a group of Icelandic horses in captivity. Our similar research results out of corresponding observational settings (captivity, breed) strengthens the validity of these findings. Whether this data can be generalized to all groups of horses, is another question as the horses from each herd in these studies belonged to the same breed (except Okra in group 1), which ensures that height differences were minimal between individuals. The assumption that height is not a factor in rank achievement can therefore not be extrapolated to groups composed of different breeds.

According to a wide range of studies, body condition is correlated to rank and dominant horses are heavier, fleshier than low-ranking horses (Tyler, 1972; Houpt et al., 1978; Ellard & Crowell-Davis, 1989; Giles et al., 2015). Despite the fact that these results have also been found in Icelandic horses by Vervaecke et al. (2007), our data does not support the earlier findings and thereby also rejects our hypothesis that horses who have a better condition score are higher ranked. The fact that our data is not common could be explained by different factors. First, the data collection was based on a body condition score sheet and as a non-expert student in body condition assessment, it is possible that judgement errors occurred regarding classification. More so that some mares in the Akhal-Teke herd were pregnant at the time of evaluation and this variable was not controlled for in the score. Secondly, it has been suggested by Vehrencamp (1983) and Ingólfssdóttir & Sigurjónsdóttir (2008) that this correlation does not necessarily mean body condition is at the origin of a certain rank achievement, but that body condition might, to the contrary, be an effect (and not a cause) of dominance and priority access to resources linked to this status. Because horses in this study were

fed hay ad libitum and the feed was spread over the territory in such way that all horses could access it, it could be possible that low-ranking horses also accessed sufficient food.

We did find a significant link between age and rank order which supported our initial hypothesis that older horses achieve a higher position on the social ladder and younger horses usually score lower in the hierarchy. This statement was already widely accepted within the literature as many studies have acclaimed similar results (Giles et al., 2015; Wells & von Goldschmidt-Rothschild, 1979; Tyler, 1972; Rutberg & Greenberg, 1990), whether in domesticated captive horses (Van Dierendonck et al., 1994; Ellard & Crowell-Davis, 1989; Komárková et al., 2014) or in feral populations (Keiper & Sambras, 1986; Rutberg & Greenberg, 1990). As seen in the literature review, one large study on 11 herds contradicts the findings of the other studies, Houpt et al. (1978) found no significant evidence of a relationship between age and dominance, however they did establish that juveniles were subordinate to adults. These contradicting results are valuable as their research population was vast, but the conflicting results could be explained by the fact that different research methods were used to assess hierarchy. Paired-feeding tests were employed to establish dominance hierarchies rather than direct herd observations. Absence of the whole group may have affected power dynamics between certain individuals during the observations. To summarize: because of the large number of studies conducted on the matter we can generally accept that age is linked to dominance rank.

Similarly to age, residence time was also a factor affecting rank achievement in our Icelandic herd. Unfortunately, this correlation could not be analyzed for the Akhal-Teke herd as corresponding data was not available. In their study on captive Icelandic horses, Van Dierendonck et al. (1994) also found that high-ranking individuals were more ancient within the group, this was also found earlier by Keiper & Sambras (1986) and supported later by Komárková et al. (2014) but remains an aspect of dominance that has not been studied a lot. Further empirical evidence is important as these findings could have an important value for horse welfare: the present results suggest that when new members are introduced into a herd, they immediately receive the lowest place in the rank order. So they are possibly exposed to higher aggression rates, especially when the management practices are suboptimal regarding living space (Estevez et al., 2007; Van Dierendonck & Spruijt, 2012; Jørgensen et al., 2009; Hogan et al., 1988). In this light it is thus extremely important to have enough roaming space when newcomers are introduced, they need to be able to retreat from dominants to show them that they accept their subordinate position and more importantly to be able to escape aggressions and avoid possible injury (Knubben et al., 2008).

Nowadays most horses, and particularly sport horses live in suboptimal conditions where they have no physical contact with other horses. These isolating management practices are the consequence of different reasons but mostly of the common belief that group-housed horses show high injury rates resulting out of confrontations with conspecifics. Horse owners thus limit social interactions to reduce injury risks, however negatively this may affect the psychological wellbeing of the horses (Van Dierendonck & Spruijt, 2012). But is this common belief even substantiated by empirical evidence? It is obvious that a member of a herd will be more exposed to social aggression than a horse that never encounters another individual, however, are injury rates really high among grouped horses? In the wild, horses live in stable groups where aggression rates have been found to be very low, and injuries from aggression rare. According to a wide range of studies, confrontations consist mostly of threats and low-intensity aggressions where only the minimum amount of aggressiveness is used and escalations into fights are limited (Fureix et al., 2012; Craig, 1986; Briefer Freymond et al., 2013; McDonnell, 2003; Hartmann et al., 2017). Our findings support these claims as Figure 1 and Figure 2 (8.1.7) show that in both herds the most frequent forms of agonistic behavior used are head threats, threat approaches and neutral approaches. None of those behaviors could result into injuries as by definition (see Materials and Methods, chapter 7) no contact is made with the receiver of the aggression. According to Figure 3 and Figure 4 (8.1.8) neutral approaches – where the receiver

obtains displacement without any threat signal of the actor – represented almost 1/5<sup>th</sup> of the total amount of agonistic interactions in both herds (17% in group 1 and 19% in group 2). Mild aggressions (with no contact) were the most used aggressions with 78% in group 1 and 66% in group 2. The real contact aggression was considerably low in group 1 (5% of all interactions) and consisted mostly of bites (see Figure 1). In group 2 this contact aggression was three times higher (15%), the amount of biting was similar to group 1 (see Figure 2), however, pushing occurred more often (31 times in group 2; 12 times in group 1). Fighting occurred three times in the Icelandic herd but was not observed in the Akhal-Teke's. No injuries have been recorded in either one of the herds.

These higher contact-aggression rates in group 2 could be explained by the factor space. While the Akhal-Teke herd was held on a 40 ha pasture where horses could retreat on large areas in a circular pattern around the herd, the Icelandic herd was held on a much smaller (less than 2ha) paddock-type area that was configured in an elongated shape. Due to this configuration and space limitation horses could not retreat the same way and there were much more corners where subordinates could get stuck in (and thus receive contact aggression rather than threats as they could not possibly show submission by retreating). Although we did not actively research this question, our results fall in line with Jørgensen et al. (2009) and Hogan et al. (1988) who found that when space decreases aggressive interactions increase and with Flauger & Krueger (2013) who observed that when space increases aggression decrease. Pierard et al. (2018) found in a recent study that density (the ratio between the living space and the amount of horses) has a significant effect on contact and threat aggression but not on passive aggression (such as neutral approaches). These findings could explain why the neutral approach percentage was similar in both groups but the contact aggression was much higher in the group with less space.

To conclude, we can state that horses prefer to show low-intensity agonistic behavior rather than behavior that could result in injury and that neutral approaches are a big part of dominance expression. We can also suggest that aggressions and injuries seen in captive horses are not the result of grouping itself – as accepted by popular belief – but rather an outcome of management practices that increase aggression due to unnatural conditions regarding space, resource availability and social factors. These are not only important findings for the welfare of domestic horses, but it is also crucial information for the management of captive wild populations such as the 43 884 mustangs living in American holding facilities. 7,458 of which are kept in corrals with high group densities (Bureau of Land Management, 2018).

Resource availability is indeed also an important factor as our results in Figure 15 and Figure 16 (8.3.1) demonstrate that the main daily activity of the horses was feeding, occupying more than half of their time (54.64% in group 1 and 56.94% in group 2). Our results join the previous studies by Fly (2007), Henderson (2007) and Boyd (1991) who have shown that the horse's primary activity is foraging, with a time budget of 60% - 70% eating in wild populations. But our results also suggest that abundance of food may not be the only factor in bettering welfare regarding resources. Figure 7 and Figure 8 show that aggression occurred most often in the context of food competition (84% of all aggressions in group 1 and 65% in group 2). Burla et al. (2016) uncovered that limited feeding times increased aggression rates, however, we showed earlier that our study animals mostly had access to food clock round and that their feeding schedule was similar to their wild conspecifics. So what is it that keeps the percentages of food-related aggression this high? We can speculate that the aggression is due, not to limited food access, but rather to the management of food distribution. In both our groups food was abundant (compared to usual feeding practices) and almost constantly available, but the food was still concentrated in one spot, which is very unnatural for horses whose food is normally scattered around the land. This concentration pushes the horses to be closer to each other when foraging than normally seen in the wild. Which could motivate the competition for monopolization of resources and thus explain food-context aggressivity. To minimize food-related aggressions it might thus be interesting that – on top of providing sufficient and constant roughage –

the food is scattered across the paddock when horses cannot naturally forage on pastures, or when pastures are covered in snow (like the Akhal-Teke pasture).

The remaining aggressions were mostly related to the context of space and the protection of the personal environment. For example a dominant individual crossing the paddock would want others to move out of its way, or a resting individual would show agonistic behavior when one comes too close to him. Heitor et al. (2006a) found that horses displayed more aggression in aim to control their space rather than to access limited resources. Although our results claim the opposite, Heitor et al.'s (2016) findings could form an explanation for why in group 2 non-food related aggression was twice as high as in group 1 (35% and 16% in group 1). As previously mentioned the living space was much smaller in the second group, which may have pushed individuals to compete more over their space than in group 1. This brings us back to our previous conclusions that management practices play a crucial role in the diminution of aggressions, and thus in increasing the welfare of our captive equines.

In order to evaluate if there was a benefit in the expression of agonistic behavior – other than rank achievement, resource or space access – we correlated the given and received agonistic acts. Our hypothesis was met in both the Akhal-Teke herd as in the Icelandic herd. We found a significant positive relationship between giving and receiving dominance acts which means that the more dominance acts are given by an individual the less dominance acts are received by this same individual. So, the expression of dominance does indeed have a benefit for the individual as it has a diminishing effect on the reception of aggression. Important to mention is that aggression is here employed in a broad sense that does not only include contact aggression but also threats and neutral approaches. So being an 'aggressive' individual does not necessarily mean hurting another individual.

### 9.1.2 Sociability

Sociability is a term to which many different definitions are associated in the literature but most often it is seen as the tendency to seek close contact with conspecifics (Gibbons et al., 2010; Sibbald et al., 2005). In this study we also adopt this same definition, however, when we speak of 'sociability' the factor of "nearest neighbor" or "distance to nearest neighbor" is never taken into account. Unless mentioned otherwise, we only consider affiliative interactions in the determination of "sociability" in horses and although the "nearest neighbor" variable is not included, proximity (without other affiliative behavior) is also accounted for in our definition by the behavior "standing close (SC)" recorded as affiliative behavior. In this section we will also separately discuss nearest neighbor parameters. Because positive social behavior is the glue that keeps a herd together, it seems relevant to try and get a deeper understanding of the underlying mechanisms and rules of sociability in the horse.

In their study on Camargue mares, Wells & von Goldschmidt-Rothschild (1979) found that affiliative relationships between horses were characterized mainly by their close proximity rather than by their friendly behaviors such as allogrooming, play, and other positive interactions. Our graphs on the different forms of affiliative behavior (Figure 9 and Figure 10, 8.2.1) support these claims as in both herds the most frequent social behavior was "standing close" to one another (37.55% in group 1 and 36.55% in group 2). Coming into second and third place in both herds were "contact" and "approaching" another individual at less than one body length distance, both behaviors were more important in group 2 than in group 1. Following behavior seemed more important in the Akhal-Teke herd (7.81%) than in the Icelandic herd, perhaps because of the configuration of the pastures/paddocks. There is also the fact that it was more likely to notice following behavior in the Akhal-Teke herd because of the size of the pasture, it was visually more obvious that, when individuals left the herd, one was following the other. Fight play was important in both groups as it represented about 5% of all the affiliative interactions. In group 1, play interactions (fight and

locomotor play) was only observed amongst the two youngest horses (Akargul and Okgunly). In group 2, locomotory play did not occur (perhaps because of the lesser space for galloping or trotting) but fight play occurred most often between adult horses (Tenor, Assa, Sura, Landi). The youngest, Saga did also play with adults, but maybe she did not play as much as the youngsters in group 1 because she did not have any other horses of her age category to play with. Spinka et al. (2001) propose that play is a way to physically and mentally prepare horses for their future socially and environmentally challenging lives and that they willingly create “handicapping” situations through play to learn to solve these challenges. Fagen & George (1977) suggest that play is the main exercise activity of young horses. Moreover, Crowell-Davis et al. (1987) have found that play decreases as the horses get older, according to Budiansky (1997) in natural conditions play would even completely stop at adulthood. These findings are supported in this paper by the results in our Akhal-Teke herd, as we have seen earlier. But not in our Icelandic herd, this could however be explained by Hausberger et al.’s (2012) reporting saying play amongst adults occurs more frequently in captive horses. This would imply that our Icelandic herd experiences a more ‘captive’ life than our Akhal-Teke herd. In this same study Hausberger et al. (2012) observed that ‘playful’ captive horses showed higher of rates stress-indicators than ‘non-playful’ captive horses, suggesting that play in adult horses could be related to welfare issues. Other evidence of play increasing in stressful situations was collected by Held & Spinka (2011). But although they stated that play might be an indicator of poor welfare, they also stated that it translates a ‘happy’ state in the horse. So it is safe to say that more research needs to be done on the subject. But nonetheless, stress-related play could form an explanation to why not one single adult horse played in group 1 while many played in group 2. Although our Icelandic herd had relatively good living conditions in relation to the standard today (group living, enough resources,...) these (and the previous) results might indicate that their living space is too small for a group of nine individuals.

If we get back to our affiliative interaction budget graphs (Figure 9 and Figure 10) we can see that allogrooming was much higher in group 2 than in group 1 (3.78% vs. 0.37%), this is most certainly due to the fact that the Akhal – Teke herd was observed during the winter (begin February) in extreme cold Estonian weather (0°C to -20 °C and complete snow coverage of the pasture) while the Icelandic herd was observed during spring (end of April) in mild Belgian temperatures while the horses were heavily shedding. According to by Kimura (1998) and Lamoot & Hoffmann (2004), allogrooming is dependent on seasonal changes and Lamoot & Hoffmann (2004) found that allogrooming is highest in spring also suggesting that this might be due to the shedding season. Our results can not only be explained by their findings, but they can also support them. Strangely, unidirectional grooming (GR) was higher in the Akhal-Teke herd (2.60%) than in the Icelandic herd (0.84%). Most of these grooming bouts occurred between Akargul and Okgunly, the two youngest of the herd. How this folds together is however unclear.

Similarly to the dominance interactions, we wanted to evaluate whether there was a balance system between given and received affiliative acts. And this time we found not a negative but a positive significant correlation meaning that the more affiliative acts were given, the more were also received in return. This correlation was however only found in group 1. Why this was not found in group 2 is not entirely clear but we can speculate that it is somehow related to the previously mentioned allogrooming rates. Because allogrooming (AG) was collected as one single act, the initiator was the only one recorded as ‘giving’ the behavior and the other horse was than noted as ‘receiver’ despite the fact that both horses are actually receiver and giver in this interaction (since allogrooming = mutual grooming). In group 1 the rates for allogrooming were so low (0.37%) that they could not have impacted the results in this correlation, contrarily to group 2 where the rates were much higher (3.78%). This data show that exhibiting affiliative behavior has benefits and is rewarded by the reception of affiliative acts.

Because studies on humans have suggested that social interactions diminish with age (Marcum, 2013) and Sigurjónsdóttir et al. (2003) uncovered that older horses have fewer social partners than younger horses, we thought it would be interesting researching the effect of age on sociability. So, we correlated the age variable with different sociability parameters: affiliative acts given, affiliative acts received and total sum of affiliative acts received/given. Neither in group 1 nor group 2 was there any significant correlation between age and these parameters. This suggests that an older horse will not necessarily give (or receive) less (or more) affiliative acts than younger horses. Whether our older horses had fewer social partners was not analyzed but our results suggest that, if they had fewer partners as mentioned by Sigurjónsdóttir et al., (2003), this would surely not affect the total amount of affiliative interactions they were part of.

Affiliative interactions are an important part of the group dynamics as they have the benefit of stabilizing the herd and buffering aggression (Cozzi et al., 2010). But it is also suggested that there are many individual benefits to having social interactions (Cameron et al., 2009, Feh & de Mazières, 1999) such as creating long-term alliances and bonds (Feh, 1999). It is particularly in these strong and long lasting bonds that we are interested. We wish to see if affiliative interactions are structured in the way that they occur more often between certain individuals, that we could call 'partners' or 'friends'. In order to gain a better overview of the interactions between our herd members we put up a sociogram (8.2.5), and soon enough we could see that some bonds were stronger than others. In group 1 for example we have strong and mutual relationships between three dyads: Okgunly and Akargul (31+24=55 interactions see affiliation matrix, 8.2.4), Okra and Akkol (13+12=25 interactions) as well as Fragariia and Belentgyz (11+6=17 interactions) in decreasing order of strength. Other lower-level mutualistic relationships were also present however they will not be further discussed as the interactions did not seem frequent enough to be defined as 'strong bond'.

In group 2 we also found three bonds that were mutual and stronger than the others, however the overall categories of interaction frequencies were lower than in group 1 as no horse interacted 21 – 31 times with another individual. Because the highest interaction rate (one way) was 16, the highest category was set at 11 – 16. Our three dyads in the Icelandic herd were Tenor and Sura (15+6=21 interactions), Assa and Loa (9+10=19 interactions) as well as Saga and Tenor (6+7=13 interactions). Impressive when we look at the affiliation matrix (8.2.4), is that the Akhal-Teke's showed more affiliative behavior towards each other than the Icelandic herd while they were less observed (only for 17.5 hours and the Icelandic's for 22.5 hours). For some of these friendships, proximity was also evident out of their focal scans, the nearest neighbor matrix (8.2.6) shows that Okra and Akkol as well as Belentgyz and Fragariia spend a lot of time near each other. This was less obvious though for Akargul and Okgunly and the dyads of group 2. Other couples who did not show frequent affiliative behavior towards each other spend a lot of time as nearest neighbor, especially in group 2 (Loa – Sura, Vekka – Assa). This might indicate that proximity as nearest neighbor is not necessarily, but can in some cases be, related to the amount of affiliative interactions between two individuals. But according to Gibbons et al. (2010) this could also mean that Loa – Sura and Vekka – Assa have associated as a dyad even though they do not show many affiliative acts towards each other, because they were identified as nearest neighbor more often than expected by chance. The sociogram also shows some curious relationships where one individual shows a lot of affiliation (11 – 16 times) towards one individual and only receives 2 – 5 or in some cases 1 interaction in return. This happened to Landi towards Drynja, Hannah towards Sura and Sura towards Loa. On the first sight this does not seem to mean anything, but when we confront these results to the nearest neighbor matrix we see that the receivers of the affiliative acts were frequently having the givers as their nearest neighbor during focal scans. And in this case: Drynja stood 8 times next to Landi, Sura 9 times next to Hannah and Loa 10 times next to Loa. This brings us back to Gibbons et al. (2010) and Wells & von Goldschmidt-Rothschild (1979) in their statement that bonds were not always defined by affiliative



behavior but more by the close proximity of two individuals. This could explain the reason for the non-returning of affiliative acts in these “dyads”.

It remains however clear that there were only a few truly strong and mutualistic affiliative bonds in these two herds. Our next goal was to research whether these strong affiliative bonds we spoke of earlier occurred in horses of similar rank, as mentioned by Sigurjónsdóttir et al. (2002; 2003). We paralleled the sociogram data with the rank order in Table 18 (8.5.7) and this clearly showed us that the members of our dyads were of similar rank. Except Tenor and Saga who had Hannah in between them (but still were of similar rank), all the dyads were individuals of following rank numbers. For example Okra and Akkol were first and second in rank as were Assa and Loa, Okgunly and Akargul were twelfth and thirteenth and Sura and Tenor fifth and sixth. These results validate our hypothesis and support the earlier findings by Sigurjónsdóttir et al. (2002; 2003). Van Dierendonck et al. (1994), Kimura (1998) and Heitor et al. (2006b) all found that horses of similar rank stayed spatially close to each other. As seen earlier, not all our dyads were also couples out of our nearest neighbor matrix so based on that alone, we cannot support these studies. However we also know that our affiliative behavior (on which our results are based) also contain the factor ‘standing close’, and that this is the most performed of all affiliative behavior (8.2.1) so proximity has undoubtedly affected the results of a relationship between affiliative behavior within similar rank order. This alone could lead our results in the same directions as the literature. As we know nothing is valid until it has been proven by the data, so when we statistically analyzed if spatial proximity was correlated to proximity in rank we did not find any significant relation (see 8.5.6). Which refuted our initial hypothesis as well as a possible support to the previous studies. In this correlation we analyzed both the nearest neighbor parameter and the ‘standing close’ behavior as a total, meaning that our previous statement about the ‘standing close’ factor seems unlikely. To be entirely sure though, it would be interesting to test this proximity in rank with ‘standing close’ alone.

To conclude, what these results really uncover is that strong bonds such as friendships do exist and that they play an important part within equine groups. They show that friendships can be characterized by frequent affiliative interactions but also by the close proximity of two individuals, and that the choice of a close friend is often influenced by rank in the way that it is more likely that an individual associates with a horse of similar rank. Horses who spend a lot of time in close proximity to each other do however not necessarily belong to the same rank categories. Moreover, our data suggests that strong bonds are accessible to all ranks and that low-ranking individuals will also enjoy the benefits of friendship. This is an important finding because low-ranking horses often have last access to all essential resources (Giles et al. 2015; Vehrencamp, 1983), and them not getting limited access to positive social interactions means an added value for their welfare (as we have seen that social behavior has a beneficial effect on cooperation’s (Feh, 1999), reproductive success (Cameron et al., 2009) and physiological parameters such as the reduced heart rate during grooming (Feh & de Mazières, 1993)).

Budiansky (1997) spoke of the personal space of a horse, and how friends surpassed these barriers of personal space without being the target of any agonistic behavior. We have now discussed nearest neighbor relationships and how, not all of them translate a friendship. The identity of the nearest neighbors of each horse have helped us come to this conclusion, but what is also interesting to learn about is the mean distance one keeps from its nearest neighbor. As this could tell us how big this “personal space” mentioned by Budiansky (1997) really is for each individual. In group 1 the mean distances varied between 0.56 body lengths and 1.59bl with Kichitorgai and Akkol showing the smallest personal spaces and Sara and Fliki the biggest. In group 2 the range was 0.65bl – 1.65bl with Sura and Loa being the most tolerant towards their space (although less tolerant than the four first horses in group 1) and Assa and Hannah keeping the most distance with their nearest neighbors (or their neighbors with them). But what makes one individual keep a larger space towards its neighbor and not the other one? We could speculate that this is somehow influenced by the spatial positions

these horses occupy in the group as a horse that stands out of the herd might be further from possible neighbors than a horse standing in the epicenter of the group. If we look at figure 13 (8.2.8) we can see that in group 1 this spatial distribution does not seem to completely match up with our results as Fliki and Sara do not have the biggest percentage of standing in periphery. However, Fliki and Sara both spend most of their time in peripheral positions (70% and 75% of their time respectively), and Akkol and Kichitorgai spent least of their time in periphery of the herd (30% and 35%, respectively). In group 2, Assa and Hannah who kept the biggest mean distance to their neighbors were also the two horses spending the most time in periphery of the herd (Assa: 55% and Hannah: 80%). Sura was one of the three horses who spend the less time in periphery (27.5% of the time) so the explanatory theory matches up for these three individuals, however Loa did not spend less time in periphery than 6 of the other horses although she did spend less than half of her time in periphery (45%). Putting these results up against each other, we could suggest that these two variables are linked to some extent. This is however not statistical, moreover only the four ends of each herd were considered. We can thus not know for sure if some horses keep bigger distances to their neighbors because of their spatial position or just because they tolerate less the closeness of others. Therefore, we cannot make any solid suppositions that mean distance to nearest neighbor and spatial position in the group are linked before this is statistically proven. So, perhaps another variable might affect this "personal space". Heitor et al. (2006a) suggested that personal space and inter-individual distance is a very important aspect in a horse's life as a horse display more competitive behavior (aggressions) in order to control its space rather than to access resources. It seems evident that dominants would be more successful in this competition than subordinates as they – by definition – evoke more submission (and thus also when it comes to aggression related to space) than low-ranking horses. In the light of this literature our hypothesis suggested that dominant horses had higher mean distances to their nearest neighbors, this was however not substantiated by our data as the results showed no significant relation, in either groups. These results show us that a high (or low) ranking horse does not necessarily show a higher prevalence of standing closer to (or further from) another herd member.

Nevertheless, we can conclude that each horse has its own personal space and that this mean distance an individual keeps from its nearest neighbor can vary a great deal but does not seem to go under 0.5 body lengths and above 1.7 body lengths in either groups. Which shows us that horses do form cohesive groups and are generally not found too far from another horse. The mean distance towards the nearest neighbor is not related to rank but could potentially be related to spatial position. Further research is needed to explore this last suggestion.

### 9.1.3 Social parameters and dominance

Heitor et al. (2006b) observed that horses who had strong social bonds and frequently stood near each other did not show less aggressiveness towards one another. Based on these findings we suggested a derivate theory that horses who spend a lot of time as nearest neighbor would be more forgiving and gentler towards each other in the sense that they would submit much faster after the expression of a dominance act. Our hypothesis was rejected by our results in both the herds as seemingly no correlation existed between these parameters. We can however not say that we support the findings by Heitor et al. (2006b) as we did not exactly research the same objects, we looked at the total of submissions after aggression and they researched the total of aggressive acts (even those not resulting in submissive behavior). Our results propose that horses who spend more (or less) time as nearest neighbor to each other do not have a bigger (or smaller) tendency to show submission after aggression from the nearest neighbor partner. What this clearly means is that friendships in the form of spatial proximity (as defined by Wells & von Goldschmidt-Rothschild

(1979)) do not have the benefit of making the other individual more tolerant towards aggressions than any other herd member. There is no power benefit in being each other's nearest neighbor.

We have seen earlier that strong dyads form mostly between horses of similar rank, but now we also wish to know if rank order is a factor in the overall expression of affiliative interactions and if a dominant horse would have more affiliative relationships than a subordinate horse. It turned out that there was no correlation found between rank order and affiliative behavior which supports the previous findings by Van Dierendonck et al. (2004) and the results by Kimura (1998) who focused only on rank in relation to allogrooming. We discussed earlier that strong dyadic bonds occurred in all rank categories and how this was beneficial for the welfare of subordinate individuals (9.1.2). The present results show that this is also the case for overall affiliative interactions, a subordinate has equal chances of frequently interacting with herd members than dominant horses.

Recently, Pierard et al. (2018) found a correlation between affiliative acts and agonistic acts. They are the only ones who have published research on this subject. Their results suggested that horses who receive a lot of aggression give less affiliative acts and that horses who receive many affiliative acts also give a lot of agonistic acts in return. We did find some significant correlations in group 2, these did however not support the findings by Pierard et al. (2018). Our results uncovered that amongst the Icelandic horses, the more aggressive acts were given, the less affiliation was received in return. So according to these findings aggressive behavior would be punished in the form of deprivation of receiving affiliative acts. We have seen earlier that performing agonistic acts had a benefit for the individual as it diminished the amount of received aggression, here we see that aggressive behavior also has a down side and that it is not rewarding when it comes to positive social interactions. Another trend has been seen in our herd and it shows that a horse that received a lot of aggressive acts surprisingly gives many affiliative acts in return. This could be explained by the fact that horses have been found to reconcile after fights (Cozzi et al., 2010). It is possible that Pierard et al. (2018) used other agonistic behavior acts than ours and/or that they also included aggressions who were not followed by submission in their correlation. And that this was one of the reasons that our studies show conflicting results. The difficulty of finding valid similarities in scientific research lies in the variety of research methods and study animals, groups used. These are all factors that make comparison non-objective.

#### **9.1.4 Spatial distribution**

When horses are kept in groups certain patterns develop regarding the distribution of individuals over their living space. Although generally horses form cohesive groups, we can see that some horses stay more in periphery of the herd and that others tend to spend more time in a central position. We wanted to test if this distribution was anyhow related to social parameters such as sociability and dominance. First, we supposed that centrally positioned horses would give/receive more affiliative acts than horses in peripheral positions, as central horses have more horses closely surrounding them and thus more occasion to interact. The statistical analyses showed no such correlation in any of the groups and for any of the variables (given and received affiliative acts) The hypothesis was thus not supported by our results and out of these findings we can suggest that it is not because a horse stands more frequently in a peripheral/central position that it is more/less prone to expressing or receiving affiliative behavior. It also shows that horses who stand further from the epicenter of the group still experience close contact with other horses, whether this is with other peripheral horses alone or with other herd members as well is however unclear as we did not look into this matter. We cannot confront our results with the literature as seemingly no research has yet been conducted on the subject.

Secondly, we researched a possible link with rank order. Because high-ranking horses have priority access to fitness benefits (Keeling, 2001) and because having a central position within the herd reduces the predation risk (Hamilton, 1971; Morrell, et al., 2011) we suggested that dominant horses spend more time in central positions and that subordinates were more likely to be found in periphery of the herd. Our hypothesis was met in group 1 only, meaning that the Akhal-Teke distributed according to their rank order. These results support the study by Ingólfssdóttir & Sigurjónsdóttir (2008) on Icelandic horses as well as the theoretical studies performed by Barta et al. (1997) and Hemelrijk (2000). Nevertheless, in the literature review (5.2) we uncovered that Krueger et al. (2014) found no such correlation and we concluded that more research needed to be conducted to clarify these contradictions. Our study however does not bring these clarifications as our two study groups showed opposite results. In group 2, all horses were equally likely to be found in peripheral or central positions, i.e. rank did not have any effect. Once again, the heterogeneity of the research groups and study locations may have played a role. We have said earlier that the configuration of the paddock in group 2 was much narrower and more elongated than in group 1 where the pasture was open and large. This might have led the horses to having different distribution patterns, in fact it was frequently observed that the herd (group 2) spatially split up in two different sub-groups. One 'sub-group' was for example eating in the walk-in stable while the other was resting or eating in the bigger area (food was found at the two extremities of the paddock). When this occurred, the "peripheral/central" parameters of the focal scans were collected in relation to these sub-groups and not the whole herd as no single cohesive group was determinable. This was much clearer in group 1, where either an individual stood in periphery or centrally of (most part of) the group. This division in group 2 and the corresponding data collection may have clouded the results. Finally, we mentioned earlier that space is an important factor in the rate of aggressive behavior between herd members, and that when the living environment is not big enough subordinates are mostly to suffer the consequences. The present results in our Akhal-Teke herd suggest that subordinates keep a certain distance from the epicenter of the herd by nature. Which means that in a captive environment it is essential that low-ranking horses have the necessary space to retreat (Van Dierendonck & Spruijt, 2012; Heitor et al., 2006a), as they could otherwise suffer from stress, increased aggression and a higher chance of injury (Grandin et al., 1999) which would strongly impede on their welfare. We can conclude that, although the previous and current research show a solid trend towards the existence of a correlation between rank and spatial distribution, more research is needed to support this claim.

### 9.1.5 Social isolation

As seen earlier, many horses today are kept in unnatural conditions where they are separated from their conspecifics. Some individuals never experience any social interaction, are never turned out on pasture with other horses or even less, get to live in a herd. These social restrictions put upon the highly social species that is the horse could heavily disrupt its wellbeing (Van Dierendonck & Spruijt, 2012; Goodwin, 2007; Henderson, 2007; Waring, 2003). In order to gain some deeper understanding of the effects of social isolation we performed an isolation test on the members of our Icelandic herd (group 2). Due to practical reasons, a similar test on the Akhal-Teke's was not possible.

The stress caused by isolation does not only have a psychological effect on the horse but is also directly linked to its health (Roggen et al., 2014; Dhabhar, 2002). This stress can be detected through physiological parameters, but luckily horses also show behavioral responses to isolation stress. The signals are what we show interest in in this section, as we measured and inventoried different behavioral responses during our isolation test. According to the literature, these behavioral stress signals can vary from overall abnormal excitement such as freezing (Alexander et al., 1988; Harewood & McGowan, 2005) to vocalizations (Lansade et al., 2008), nervous locomotion and

defecating (McCall et al., 2006). The graph in Figure 19 (8.4.1) presents the different reactions to isolation, it is clear that nervous locomotion (as mentioned by McCall et al., 2006) was the frontrunner of all stress signals for isolation with 61 manifestations. This nervous, high calorie burning locomotion is very unnatural when it is the main activity occupying a horse. When horses are not under stress they spend most of their time eating (56.94% in group 2) and resting (24.17% + 5.28% in group 2) and locomotion is only a small part of their day when foraging is not done through grazing but through eating food that is assembled in one spot as in our Icelandic herd (4.17% walking and 0.83% trotting in group 2).

Among the reactions, freezing also showed a high occurrence (40 times) and was performed by all the horses (table 17, 8.4.2) followed by snorting (27 times). Neighing occurred the less of all reactions (3 times) and in only one horse (Landi, see Table 17, 8.4.2) while Lansade et al. (2008) suggested that this was a highly used signal in gregarious horses. Perhaps neighing occurs more when locomotion is not possible? Considering our isolation area was bigger than a normal stall and the horses could easily pace or even trot. Another type of vocalization, snorting, occurred a lot (12 times) and was performed by half of the horses. As predicted by McCall et al. (2006) defecation was a big indicator of stress, as seven out of eight horses defecated during the five minute test, some of them even twice (Vekka, Hannah and Landi). Three out of eight horses nervously and repeatedly pawed the floor during the test, clearly showing frustration and restlessness. Table 17 demonstrates how much stress behavior each individual showed during the isolation period. Most horses showed more than 20 reactions in five minutes, meaning at least four stress behaviors per minute. Some horses even over six per minute. Saga and Sura seemed to be the most disrupted by the isolation while Drynja and Loa were the less affected. Drynja and Loa were the oldest horses in the herd (22 and 23 years old) and Saga the only youngster (4) so the results could have something to do with age, however Sura was in the same age ranks as the majority of her herd mates so her increased distress could have been related to other factors such as previous life experiences. Deeper analysis needs to be done to confirm any of these suggestions. Other, statistically-tested influence factors will be discussed below.

These high reactions to isolation support the previous studies and suggest that isolation, even only for a few minutes has a severely increasing effects on horse's stress levels. And as seen in the literature, stress is directly related to psychological distress and bad health in horses, translating serious welfare issues (Goodwin, 2007; Henderson, 2007; Roggen et al., 2014; Dhabhar, 2002).

Because the reactions to social isolation differ between each individual (as seen in Table 17) we wanted to uncover what parameters in the herd could affect these responses. So we looked at three different factors: dominance rank, sociability and spatial distribution as a possible explanation for the varying reactions to isolation. No published scientific studies have been found on any of these relationships, so this is a pioneer subject. One popular magazine article has been presented on the relation between rank and isolation anxiety, stating that a dominant horse would present more separation stress than a subordinate horse, however it is unclear if this material is trustworthy as no record of the referenced research could be found.

We correlated the sum of reactions to isolation with each of the parameters. We found no significant correlation between social isolation anxiety and rank as suggested by the magazine article (McAllister, 2008). Meaning that it is not because a horse is high/low in rank that it will show more/mess stress in isolation. Our results are however not fully objective as our dominant horse Assa was not taken into account for the correlation. Since she did not want to enter the isolation area, no data was recorded for our highest ranking horse. Further research will thus be needed to support our findings. Next, we hypothesized that horses who spend a lot of time in periphery of the herd (so in some sense further "away" from the herd) would experience less anxiety when they were separated from the group, this was however not supported by our statistical analysis as no significant correlation was found. In other words, centrally positioned horses are not more/less prone to

experiencing isolation stress than individuals positioned in periphery of the herd.

Regarding sociability we looked at a relationship between isolation and the given/received affiliative acts, and we suggested that the more an individual is part of social interactions the more it will suffer from the isolation. It did not seem to matter if a horse received a lot (or a few) affiliative acts but a positive correlation was found between total responses to isolation and the amount of given affiliative acts. These results suggest that a horse who initiates a lot of positive interactions will be more anxious when separated from its herd. This seems logical as giving affiliative acts is a more active behavior than receiving them, since the horse takes the decision and initiates the behavior himself. This urge cannot be fulfilled in isolation, and the loss of control in its turn could create stress and insecurities in the horse.

It is safe to say that much more studies need to be conducted on this matter as our research has been conducted on a very small test population ( $n=9$ ) and more importantly as the group was not complete for the isolation test, which has undoubtedly affected the validity of the results.

To conclude, our data suggests that isolation has an immediate and intense effect on horses. The frequently performed behavioral stress indicators uncover that isolation could severely reduce welfare in horses. It is important that researchers combine their efforts and fields of study, so physiological- and behavioral empirical evidence can help owners understand the true nature of their horses and convince them to make changes in their management practices to eradicate welfare issues in captive equines.

## CONCLUSION

In this paper we have searched for a broader understanding of social behavior in horses. We have found that the hierarchy was linear in both our research populations, meaning that each individual was subordinate to the horse(s) above in the rank order and dominant to the horse(s) below in the rank. Once linearity was established, we researched which personal characteristics could have affected the social position of each individual and we found that height and body condition were not linked to rank, but that age and time of residency were. Older horses and horses who were in the group for a longer time had higher rank positions. This is an important finding for the management of equine groups because – according to our results – when a new member is added to an existing herd it will automatically receive the lowest rank in the hierarchy and thus possibly be exposed to higher rates of aggression. In these situations, the availability of sufficient retreat space for the subordinate individual is thus essential.

Secondly, we uncovered that – contrarily to popular belief – horses who are kept in groups are not automatically exposed to higher risks of injury or high contact-aggression rates. Horses prefer to communicate through subtle signals and ritualized behavior rather than through high-intensity aggressions that could result in injury, in our herds most of the aggressions were of low-intensity and in the form of threats (66% - 78%) or neutral approaches (-/+ 20%). Our results align with previous studies and show that aggression only increases and possibly escalates when group-housed horses are kept under suboptimal management practices (regarding resource- and space availability as well as group stability and composition). Injury-avoidance is one of the major arguments used by owners to defend the isolating living conditions of their horses, but this claim is not substantiated by the existing empirical evidence. Isolation has proven to be a serious concern for equine welfare, our isolation test shows that horses – even when isolated for only five minutes – show high rates of distress behavior. Individuals showed different reactivities to the test, and according to our study, the intensity of the reaction to isolation is not related to rank or spatial distribution in the herd but to the amount of given affiliative acts. We suggest that the more affiliative acts a horse gives, the intenser stress it will endure whilst isolated from its group.

We have spoken of resource availability as a welfare factor, and during this study our horses have given us some additional food for thought. It seemed that they displayed most of their aggression in the context of food, while resources were abundant, and the horses ate for about 55% of their time in both herds, which comes close to the feeding times of their wild conspecifics (60% - 70%). We suggest that the food-related agonistic behavior in this case is related – not to the abundance – of resources but to their distribution. In natural conditions food is scattered across the land, which removes the need (or possibility) for competition or monopolization of resources. Concentration of the food in one spot, as frequently observed in captivity, might motivate such behaviors. As mentioned earlier, management of food is thus an essential component of having a herd with low-aggression rates and with better welfare.

In both study groups, our findings suggested that horses receive less aggression when they express a higher amount of agonistic behavior. In other words, an aggressive individual is relieved of aggressions. This could seem to contradict our previous claim that horses use as less aggression as possible, but we must keep in mind that aggression in this case means all types of agonistic acts, including threats and neutral approaches. Moreover, we have found that showing agonistic behavior has disadvantages too, as it seems that it might diminish the reception of affiliative acts. Aggressive behavior is thus rewarded on one side, and punished on the other, creating a balance system. We also found an indication that horses might reconcile after confrontations to keep stability in the herd, as (in group 2) horses who received a lot of aggression also gave many affiliations. The expression of affiliative behavior also seems to be beneficial, as (in group 1) horses who gave more

affiliative acts also received more in return. It appears that these positive interactions can lead to some strong affiliative bonds between herd members. Horses are by instinct driven to interact with each other, but some horses affiliate more frequently with each other than could be expected by chance and these strong bond preferences could be defined as friendship. Wanting to know how these bonds originate and how a partner is chosen, we looked at personal characteristics such as rank and we uncovered that strong bonds always took place between horses of similar rank order. Moreover, these strong bonds appeared to be accessible to all ranks, meaning that low-ranking individuals can also enjoy the benefits of friendship. Similarly, our analyses show that dominant horses are not necessarily inclined to have more affiliative interactions than low-ranking horses, i.e. subordinates have equal chances of frequently interacting with other herd members than dominant horses, which is a positive note to their welfare. Furthermore, it seems that chances of participation in affiliative interactions are not just equal between rank categories but also between age categories as the total amount of affiliative acts given/received has been found not to decrease with age. Social interactions are important for horses of all age ranges, which means it is not more acceptable to keep a young, old or adult horse in isolation.

When horses are grouped, very quickly spatial organization patterns can be detected. Most often this organization results in the formation of a dense core with some individuals on the outskirts who keep a certain distance from the epicenter. We found that this spatial distribution is not linked to sociability or the amount of positive interactions an individual is part of but that it is instead related to rank. In one of our two groups, higher ranked horses were found to occupy central positions within the herd and low-ranking horses peripheral positions. The results suggest once more that space is a crucial factor in horse welfare, subordinates clearly need sufficient space to maintain a certain distance between them and the higher-ranking horses to avoid aggression, injury and distress. The different spatial positions within the group are one aspect of distribution, the other is that of how horses distribute in relation to each other. It is widely accepted that horses have a well-defined personal space, for some this is bigger than others and we have researched if this had anything to do with a horse's rank. This was however not the case and a high (or low) ranking horse did not show a higher prevalence of standing closer to (or further from) another herd member. The personal space limits of a horse can also vary from which individual approaches, between two 'friends' for example the personal space barrier can sometimes completely disappear. However, we found that when two individuals spend a lot of time near each other this did not mean that they would be gentler towards one another, they did not show more submission after aggression towards each other when they went into confrontation. Not much research has yet been conducted on this subject and further studies are necessary to give meaning to these results.

The purpose of this study was to gain better insight into the horse's social behavior, with the hope that the results could have a signification for equine welfare. A part of these findings has not yet found their specific place within the welfare dialogue but have meaning nonetheless because they give us all-round information of how horses function in groups and of which dynamics affect their behavior. The other part of our results does have immediate welfare-implications, and based on what we have uncovered in this study a few suggestions can be made regarding the management of captive horses: horses should be kept in group rather than alone, as isolation has significant negative effects on the horse and because grouping does not necessarily result in injuries. When kept in groups, horses should be given the appropriate living space to reduce aggressions and injury risks, new introductions should be done carefully and only when space requirements for retreat are met. Roughage (hay) should be continually available and abundant enough for the whole herd to feed on as much as wanted, if possible, the food should be scattered around the living area to reduce food-related aggressions and monopolization of resources.



It has to be kept in mind that this study has been done on a relatively small study population and over a short observation period, and that therefore more research needs to be conducted to support any of our findings. Especially the section about social isolation deserves more attention and merits to be reproduced on a larger study population, as the subject could have substantial implications for equine welfare.

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## APPENDIX A

### ABSTRACT

Modern husbandry practices have been found to present serious threats to horse welfare. Therefore, here we have decided to research equine social behavior, this study will not only help us understand the effects of social isolation and of high-density grouping, but it will also give us a deeper insight into the horse as a social being. Hopefully the acquired knowledge will lead us to solutions that will deliver a better outcome for managed horse populations. Our results revealed a linear hierarchy in both groups, moreover, rank was significantly correlated to age and residency time, but not to height or body condition. Agonistic behavior consisted mostly of threats and neutral approaches, and contact-aggression was higher (15% vs. 5%) in the group with the smallest space availability. Spatial distribution was linked to rank in one of the two groups, subordinates were found to stay in periphery of the herd. In each group, strong affiliative dyads had formed between horses of similar rank order. All-round sociability however was not related to rank nor age, meaning that horses of all age- and rank categories had a strong behavioral need to participate in affiliative interactions. Our isolation test revealed acute responses to the separation, some horses exhibited more than six stress indicators per minute, which revealed high anxiety levels amongst the test animals. The stress responses were higher in horses who initiated more affiliative interactions in the herd. We conclude that social isolation – even for short periods of time – has tremendous effects on the horse and therefore we strongly discourage the use of single housing. Moreover, we suggest that aggression- and injury rates in grouped horses are directly related to human management practices, and we recommend that horses be kept in stable groups on sufficient space. We also propose that resources should be spatially scattered and constantly available to the herd.

*Equine; welfare ; isolation ; aggression ; social behavior*

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## APPENDIX B

### PRESS ARTICLE

# Het verborgen leed van paarden

*“De laatste vijftig jaar is er een toename van het aantal mensen met paarden en een afname van het aantal paardenmensen.”*

**Paarden maken al eeuwen deel uit van onze maatschappij, en nu is de paardensport nog populairder dan ooit. Maar hoe goed kennen we onze paarden eigenlijk? En in hoeverre weten we wel of ze gelukkig zijn? Ten einde het paard en zijn welzijnsnoden beter te begrijpen, heb ik tussen februari en mei 2018 een onderzoek gedaan naar het natuurlijk kuddegedrag van paarden, en naar de effecten van sociale isolatie. De studie heeft aangetoond dat paarden hoog sociale dieren zijn die sterke vriendschapsbanden met elkaar vormen en acute stressreacties tonen wanneer ze van de kudde worden weggehaald. Dit wijst erop dat paarden alleen houden ernstige gevolgen kan hebben voor hun welzijn. Bovendien blijkt dat leefruimte en voedselbeschikbaarheid zeer belangrijke factoren zijn voor kuddebeheer, gebrekkig management kan namelijk verhoogde stresslevels en onnodige conflicten veroorzaken.**

Hoe komt het dat paardenliefhebbers enerzijds overal posters en illustraties hebben hangen van vrij rennende paarden, en zich anderzijds geen vragen stellen wanneer ze paarden rij op rij in bekrompen en solitaire stallen zien staan? Stalling wordt bovendien als een wel aanvaarde norm door elke nieuwe eigenaar blindelings overgenomen. Maar wat voor effect heeft dit op de dieren? Hoe ervaren zij het leven dat we hun opleggen? Het blijkt dat de meerderheid van de mensen die paarden houden onvoldoende (of geen) kennis hebben van de basisbehoeften van het paard. Nu er meer wordt gesproken over dierenwelzijn, proberen sommige eigenaars nochtans ‘natuurlijker’ om te gaan met hun paarden door ze nu en dan eens op de paddock te zetten met een hoop andere paarden, of door ze zonder voorzorgen te integreren in een willekeurige kudde. Deze trends ontstonden ongetwijfeld uit goede intenties, maar of deze wel rekening houden met de ware aard van het paard en met de natuurlijke groepsdynamieken is een geheel andere kwestie.

#### **De studie**

Omdat er merkkelijk nog een groot tekort aan bewustzijn heerst i.v.m. het gedrag en de soort specifieke behoeften van paarden, heb ik besloten het onderwerp op te nemen in mijn bachelorproef. Het onderzoek dat hier gepresenteerd zal worden heeft dus als doel het paard beter te leren kennen en ons de nodige kennis te geven om paarden een leven te bieden dat aangepast is aan hun natuurlijke behoeften. Bovendien willen we weten of het sociaal gedrag van paarden ons al iets kan vertellen over hoe paarden onze huidige houderij-systemen ervaren.

Om deze studie te kunnen uitvoeren, werden er twee onderzoekspopulaties ingezet: het eerste deel van het onderzoek nam plaats in het Zuiden van Estland met als onderwerp een kudde van veertien Akhal-Teke paarden, gehouden op 40 hectaren land. Tijdens het tweede deel van de studie werden er negen IJslandse paarden geobserveerd, de dieren waren gehuisvest op een paddock met inloopstal te Stabroek, België.

We hebben de twee kuddes uitvoerig geobserveerd met als doel alle gedragingen in kaart te brengen. Er werd gekeken naar de positieve interacties en de negatieve (dominantie) interacties



tussen de kuddeleden maar ook naar de ruimtelijke verdeling en het activiteitenbudget van elk dier. Dit zou ons informatie geven over de verschillende relaties tussen de paarden, over de structuren en regels van het kuddeleven en over de algemene bezigheden van het paard. Bovendien hebben we in één van de twee groepen (IJslanders) een isolatie test uitgevoerd om te weten te komen hoe paarden reageren wanneer ze gescheiden worden van hun kudde. Gedurende deze test werd elk paard vijf minuten in een grote stal gezet, zonder contact of zicht op hun soortgenoten. We nodigen u uit om in de volgende paragrafen te ontdekken wat ons onderzoek aan het licht heeft gebracht.

### **Vriendschap**

De resultaten toonden dat paarden hoog sociale dieren zijn die frequent contact zoeken met hun kuddemaatjes. Zo zullen paarden elkaar krabben en poetsen, dicht bij elkaar gaan staan om te rusten of samen spelen. Bovendien nemen paarden van alle rang- en leeftijdscategorieën deel aan deze sociale interacties, wat betekent dat sociaal contact voor alle individuen zeer belangrijk is. Verder hebben we ondervonden dat paarden ook hechte vriendschappen vormen, in beide kuddes waren er meerdere duo's die veel meer met elkaar omgingen dan met andere kuddeleden. Ze waren bijna altijd samen te vinden, ze volgden elkaar, sliepen en aten in elkaars buurt en toonden geen restricties van persoonlijke ruimte naar elkaar toe. Deze 'beste maatjes' waren steeds van gelijke rangorde (bv. 1<sup>ste</sup> en 2<sup>de</sup> ; 12<sup>de</sup> en 13<sup>de</sup> in rang), en zowel hoog- als laag rankende paarden toonden de behoefte om hechte banden te vormen met andere paarden.

### **Isolatie**

Alhoewel de isolatie-test enkel vijf minuten duurde, wekte de afzondering extreme stressreacties op bij de paarden. De dieren toonden allen signalen van abnormale spanning, angst en frustratie. Ze begonnen rusteloos over en weer te lopen, angstig rond te kijken, luid te briesen en te mesten van de stress. Sommige paarden probeerden de deur te forceren, anderen sloegen heftig tegen de grond met hun hoeven of begonnen in het rond te bokken. Zulke reacties ondanks het feit dat de afzondering enkel een paar minuten duurde vertalen ernstige stress, we kunnen ons dan ook inbeelden hoe de situatie is voor paarden die hun gehele leven alleen doorbrengen. Onderzoekers hebben gevonden dat langdurige isolatie ernstige problemen met zich kan meebrengen zoals de ontwikkeling van stereotiep (abnormaal) gedrag, moeilijkheden bij het trainen en gezondheidsproblemen (wetende dat stresshormonen een verzwakkend effect hebben op het immuunsysteem en de prevalentie, de duur en de ernst van infecties kunnen verhogen). Deze proef illustreert in ieder geval dat een gebrek aan sociaal contact extreme effecten heeft op onze viervoeters en dat dit zware gevolgen kan hebben voor hun welzijn. Paarden zijn niet gemaakt om alleen te worden gehouden.

### **Groupshuisvesting, maar hoe?**

Als paarden niet geschikt zijn om een solitair leven te leiden, dan moeten ze wel in groep gehouden worden, maar op welke manier? Veel eigenaars willen hun (soms heel dure) paarden niet bij andere paarden zetten uit angst voor blessures. Ze zijn ervan overtuigd dat paarden onderling veel agressie naar elkaar tonen en dat er dus hoge kansen zijn op verwonding. Onze studie (en andere voorheen) toont echter dat paarden die in stabiele kuddes leven vooral communiceren aan de hand van subtiele signalen en dat dominantie en agressie hoofdzakelijk wordt geuit door dreigingen en neutrale benaderingen. Werkelijke contact-agressie (zoals bijten of schoppen) die zou kunnen resulteren in verwonding, vertegenwoordigd in feite maar één twintigste van alle agressieve gedragingen. Dit is echter enkel waar in kuddes die in goede condities leven, zoals onze Akhal-Teke paarden. We hebben namelijk ondervonden dat de mate van agressie in een kudde sterk afhankelijk is van het menselijk beheer, van "hoe de paarden gehouden worden". Zo kunnen er meerdere factoren inspelen op agressie:

### *Leefruimte*

We hebben ontdekt dat contact-agressie drie keer hoger was (15% vs. 5% van alle agressies) in de kudde die op een kleiner oppervlak werd gehouden. Bovendien suggereren onze resultaten dat de paddock-paarden veel meer agressie toonden in de context van ruimteverdediging dan de paarden die gehuisvest waren op een weide van 40ha. We vermoeden dus dat de factor omvang van leefruimte een considerabele rol speelt in de toename (of afname) van agressief gedrag. We hebben tevens ook gevonden dat ondergeschikte paarden meestal in periferie van de kudde bleven en dat anciënniteit gelinkt was aan rangorde, nieuwkomers zouden steeds een lage positie krijgen in de rangorde. Onze resultaten wijzen er dus op dat – om agressie te verlagen en een goed welzijn te bekomen – elk individu over voldoende ruimte moet beschikken om zich te kunnen terugtrekken bij confrontaties en om zijn gewenste (en natuurlijke) interindividuele afstand te houden t.o.v. andere kudde leden. We suggereren ook dat er extra aandacht moet gegeven worden bij het introduceren van nieuwe paarden, en dat dit enkel gedaan mag worden wanneer er voldoende bewegingsruimte is voor de groep. In dit licht is het ook niet aangeraden om paarden vaak van groep te veranderen of “nu en dan” eens in een kudde te zetten.

### *Voedsel*

In het wild spenderen paarden 60% - 70% van hun dag aan foerageren. Onze kuddes, die quasi continu hooi ter beschikking hadden, aten gemiddeld 55% van de tijd dat ze geobserveerd werden, en op alle tijdstippen van de dag. Wat al dicht bij de natuurlijke normen komt en aantoont dat paarden in gevangenschap dezelfde voederbehoeften hebben als hun wilde soortgenoten. De meeste paarden krijgen echter enkel beperkte hoeveelheden voedsel, op welbepaalde momenten van de dag (meestal twee keer per dag). De kuddeleden moeten dus als het waren ‘vechten’ om voldoende voedsel te kunnen opnemen. Deze verhoogde competitiedruk veroorzaakt machtsstrijden die onvermijdelijk leiden tot meer agressie. Alhoewel de kuddes uit ons onderzoek goede voedselcondities hadden, werd agressief gedrag toch het meest geuit in de context van voedsel(competitie). Dit zou vermoedelijk gerelateerd kunnen zijn aan de verspreiding van het voedsel. In het wild eten paarden namelijk voedsel dat in kleine porties over het land groeit, terwijl het hooi van onze paarden op één plek werd gecentraliseerd. Deze onnatuurlijke opeenhoping zou de drang tot competitie en monopolisering van voedselbronnen kunnen opwekken. Waardoor hogere agressie geobserveerd kan worden. Bijgevolg stellen we voor dat het voedsel best op meerdere plaatsen wordt verspreid. Het belangrijkste aspect rond agressievermindering en algemeen welzijnsverhoging blijft uiteraard de constante beschikbaarheid van ruwvoeder (hooi).

### **Wat moeten we hieruit begrijpen?**

Zoals u het al kan raden, neen, u paard is niet gelukkig in zijn stal! We hebben de convictie dat dit de juiste manier is, iedereen doet het toch zo...maar in werkelijkheid plaatsen we onze viervoeters telkens weer op een sombere en eenzame lijdensweg. Vergis u niet, gebrekkig groepsmanagement kan ook ernstige gevolgen hebben voor het welzijn en de gezondheid van onze paarden. Daarom sluiten we dit artikel met een aantal welzijnssuggesties: 1) houdt u paard niet alleen! 2) als u paard in groep leeft, geef dan de voorkeur aan a/ een ruime leefomgeving, b/een constante aanwezigheid van ruwvoer dat op verschillende plekken wordt verspreid en c/ aan minimale veranderingen in de samenstelling van de kudde.

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