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The influence of an automatic and a loose group feeding system on aggression, aberrant behaviour and daily activities of horses

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Summary

This study was conducted to find out if loose feeding systems (LFS) and automatic feeding systems (AFS) can be recommended for group housed horses. Influences of both feeding systems on the behaviour of horses kept in groups was studied. Aggression, aberrant behaviour and daily activities such as feeding behaviour, resting and standing behaviour around the feeding sources were observed.

The study was conducted at two locations in the region Gelderland in the Netherlands. Both group housing systems housed about 50 horses that were observed over a period of 5 weeks; in total 8 days in the LFS (location 1) and 14 days (8 days outside and 6 days inside the feeding stations) in the AFS (location 2). Each observation day consisted of seven hours observation time (10am-6pm). The frequency of aggressive and aberrant behaviour was collected with interval sampling of each two minutes whereas daily activities were recorded with a scan sample of every two minutes.

Data was processed in Windows Excel 2003/2007 and the statistical programme SPSS version 15.0.

Results showed that aggression levels in both systems were very low. The total aggression in the LFS was higher than in the AFS; but the total aggression per horse was significantly higher in the AFS. At both locations threat behaviour was displayed most but physical aggression was higher in the LFS. The physical aggression per horse, however, was not significantly different which means a similar risk of injury at both locations. In the AFS less aggression was displayed outside than inside the feeding station. Also an influence of the feeding systems on feeding, resting and standing behaviour could be determined. Eating behaviour accounted for much more time in the LFS than in the AFS and overall feeding behaviour accounted for 16% less time in the AFS than in the LFS. Standing and resting behaviour accounted for less time in the LFS than in the AFS. It could not be determined if the comforting behaviour was influenced by the feeding system. The aberrant behaviour displayed was significantly higher in the AFS than in the LFS. Further the horses in the AFS showed a broader pattern of stereotypic behaviour. The display of aberrant behaviour was low in both systems.

On the basis of the results of this study both feeding systems could be recommended for group housed horses. The display of aggressive and aberrant behaviour was low and no indicators for a negative influence of the feeding systems on the daily routine of the horses could be found.

Summing up the levels of aberrant behaviour were low but some possible relations between the feeding system and the incidence and display of aberrant behaviour were noticed. Therefore, especially epidemiological studies are needed to identify if the AFS might be a risk factor for the development of stereotypic behaviour. Furthermore, also other observational studies, especially long term studies, would be useful in identifying the kind of stereotypic behaviour (emancipated, learned, coping function) and causal relationships between them and the feeding system.

Samenvatting

Het doel van deze studie was het uitzoeken of los voer systemen (LFS) en automatische voer systemen (AFS) aan te bevelen zijn voor paarden in groepshuisvesting. Tijdens deze studie zijn de invloeden van beide voer systemen op paarden die in groepen worden gehouden bestudeerd. Agressie, afwijkend gedrag, en dagelijkse activiteiten zoals voer gedrag, rust en staand gedrag rond voer plaatsen zijn hiervoor geobserveerd.

Deze studie is uitgevoerd op twee maneges in de provincie Gelderland van Nederland. Beide locaties hadden ongeveer 50 paarden die in groepshuisvesting worden gehouden. Gedurende 5 weken zijn de beide locaties bestudeerd, in totaal 8 dagen in het LFS (locatie 1) en 14 dagen (8 dagen buiten en 6 dagen binnen de voeder stations) in het AFS (locatie 2). Elke observatie dag bestond uit 7 uur observatie tijd (10:00 tot 18:00). De frequentie van agressief en afwijkend gedrag was verzameld met intervallen van twee minuten, en dagelijkse activiteiten zijn verzameld door een scan sample om de twee minuten.

De data is verwerkt in Windows Excel 2003/2007 en het statische programma SPSS versie 15.0

De resultaten lieten zien dat in beide systemen agressie niveaus heel laag zijn. Het totale agressie niveau in het LFS was hoger vergeleken met het AFS. Echter was de totale agressie per paard in het AFS significant hoger wanneer vergeleken met het LFS. Op beide locaties werd dreigend gedrag het meest vertoond, maar fysieke agressie was hoger in het LFS. Er was echter geen significant verschil in de fysieke agressie per paard, dit betekend dat er een vergelijkbaar risico is op verwondingen van het paard op beide locaties. In het AFS werd minder agressief gedrag vertoond buiten dan binnen de voerstations.

Ook kon er een verschil worden geobserveerd tussen de voer systemen op rustend en staand gedrag. In het LFS werd er veel meer tijd besteed aan eet gedrag ten op zichtte van het AFS, en er werd 16% meer tijd besteed aan voer gedrag (wachten, voer zoeken buiten de voer station/voerbak en eten). Er werd in het LFS minder tijd besteed aan rustend en staand gedrag.

Het kon niet worden vastgesteld of het comfort gedrag werd beïnvloed door beide systemen. Het vertoonde afwijkende gedrag was significant hoger in de in het AFS. Verder vertoonde de paarden in het AFS een breder stereotypisch gedrag patroon. Samenvattend was er een lage vertoning van afwijkend gedrag met beide voersystemen.

Op basis van de resultaten verkregen tijdens deze studie, kunnen beide voer systemen worden aangeraden voor groepshuisvesting van paarden. De vertoning van agressief of afwijkend gedrag was laag, en geen indicaties van een negatieve invloed op de dagelijkse routine van de paarden was gevonden voor beide voeder systemen.

Samenvattend waren de niveaus van afwijkend gedrag laag, echter zijn er wel mogelijke relaties tussen de voeder systemen en afwijkend gedrag opgemerkt. Hierdoor, zijn er epidemiologische studies nodig om te bepalen of het AFS een risico vormt voor het ontwikkelen van stereotypisch gedrag in paarden. Daarnaast zijn er studies nodig, met name lange termijn studies om de verschillende stereotypische gedrag patronen ('emancipated', aangeleerd, 'coping' functie) en de relaties tussen deze en de voersystemen te onderzoeken.

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1. Introduction

Just recently there is a noticeable trend towards the welfare of horses. The Dutch government is seeking to increase the welfare of animals, for the first time also including horses.

To improve the welfare of animals new housing systems are developed under the consideration of behavioural key factors. Social contact and an adequate feeding regime and management practice have been identified as behavioural key factors in horses.

The 'active stable' is one of the new group housing developments that also integrates a new feeding approach. It addresses the just mentioned problems and tries to combine economics, human requirements and welfare of the horse. Welfare is increased by offering social contact, movement and more frequent feeding times at smaller portions. The latter is enabled by a computer controlled feeding system. The idea of the whole system is therewith based on group housing and a change in feed supply that should additionally animate the horse to travel throughout the provided space.

As with any other system there seem to be some downsides to the system with regards to the feeding system. Although feed is offered in smaller amounts and more frequent, the automatic feeder represents a limited feed source and impairs the natural feeding behaviour of the horse (Zeitler-Feicht 2004). Because horses are not able to eat at the same time they have to wait to be able to enter the feeder. Consequently, it is expected that horses show increased agonistic behaviour like they do if food resources are limited (McDonnell 2003). Zeitler-Feicht (2004) stated more specific the increase of feed-related aggression if feed sources are limited. This behaviour could cause increased conflicts and therewith increased stress situations. Especially lower ranked horses could be negatively affected as their waiting time might be increased and visiting frequencies as well as rewarded visits might be lower. Coping with the frustration and inability to display natural behaviour could then lead to the display and even development of abnormal behaviour. However, to date there has been little research done on the effect of automatic feeding systems in horses. A study of Gieling et al. (2007) stated that the welfare of the horses observed in two active stables was not impaired. The study was comparing time budgets of horses housed in active stables with free-ranging horses. In regards to waiting time there could be no difference found in rank but visiting frequency seemed related to rank. Therefore, concerns in regards to the development of stereotypies were mentioned caused by the inability of low and middle ranking horses to enter the feeding stations frequently enough to consume their portion. Altogether further research was needed to support the findings. In another study of Streit et al. 2008 automatic feeding systems and feeding stalls were compared. The latter allows simultaneous eating. Streit et al. (2008) found that both systems could be recommended for use, but the visiting frequencies of the feeding area were higher in automatic feeding systems as well as threatening behaviour, displacement activities and the frequency of situations that could cause stress or injury. However, the motivation to move and more frequent meals are advantages of the automatic feeding system in comparison to feeding stalls. But how do feeding systems that prohibit simultaneous eating affect the behaviour displayed around the feeding source? Is there a difference to feeding systems that allow simultaneous eating (e.g. loose feeding systems)? Would horses fed automatically rest and wait more often in the feeding area than grouped housed horses fed loose? Would aggressive behaviour be more frequent in a loose housing system compared to an automatic feeding system? Would horses in a loose feeding system display more physical (risk of injury)

behaviour compared to horses housed in an automatic feeding system? Would the horses in a loose housing system display significantly less aberrant behaviour compared to grouped house horses fed automatically?
In general studies on the influence on feeding systems on the behaviour of horses are limited. To date, only information of the influence of feeding systems on agonistic behaviour (submissive and aggressive behaviour used to establish and maintain the hierarchy within a group of horses) is published. This study therefore focuses on the influence of two roughage group feeding systems on daily activities, aggression and abnormal behaviour displayed around the feeding source. One of the feeding systems allows synchronization of feeding behaviour (a loose feeding system) the other one prohibits this natural behaviour (an automatic feeding system). Results are used to make indications on the suitability of both group feeding systems in regards to welfare.
The following hypotheses are going to be tested:

1. Grouped housed horses display more aggressive behaviour when fed loose than fed automatically
2. Grouped housed horses show more physical aggression when fed loose than when fed automatically
3. Grouped housed horses show more offensive aggression when fed loose than when fed automatically
4. Grouped housed horses fed automatically show more aggressive behaviour outside the feeding stations compared to inside of the feeding stations
5. The feeding system has an influence on the feeding, resting, standing and comforting behaviour of grouped housed horses
6. Grouped housed horses fed automatically show more aberrant behaviour compared to group housed horses fed loose

The following report is build up as follows: In Chapter 2 background information is provided on the assessment of welfare, the identification of behavioural key factors and their integration into group housing and feeding systems. Also possible negative effects of new developed systems are discussed with special focus on group housing. Chapter 3 explains the methodology used in this study. Chapter 4 gives an overview on the results that are discussed in Chapter 5. Chapter 5 compares the results found in this study with published literature and discusses in how far both systems can be recommended for group housing. Chapter 6 provides a conclusion of the study. Chapter 7 is providing the personal opinion of the author on further research and recommendations regarding the two feeding systems.

2. Background Information

2.1 Assessment of welfare and its integration into commercial production systems & management practices

Horses are managed and kept for very different reasons such as sporting (dressage, racing, show jumping, endurance, polo, shows etc.), production of milk, urine or meat or for draught and traction. Therefore methods of keeping and managing horses under commercial conditions differ considerably within and between countries and are mainly based on tradition.

There are three basic types of housing: the stall (also called straight stall), the loose box (also simply called box) and loose housing in barns and yards (Waran 2001).

The straight stall is most restrictive and is usually the length and width of the horse in size. The horse is usually tethered facing a wall or other stalled horses. Besides standing next to other horses and having visual contact there is further no contact as movement and therewith social interactions are restricted. The movement is limited to forward and backward steps and lying down if the tethers allow it. In some countries these kind of systems have been banned but in others keeping horses like this is still in practice (Waran 2001). Horses in the urine industry in the US for instance are mainly kept that way.

The stable or loose box gives the horse some freedom to move, dependent on the design different levels of access to other horses are granted and the horse may be subject to some external stimulation (Waran 2001). In some countries there is a recommendation regarding recommended size of the boxes but there is no legislation with regards to this topic. It is the most common system in Europe. Boxes can be integrated side by side into a barn or may also be build outside for instance side by side into a courtyard design (Waran 2001).

Loose housing systems are mainly used in breeding establishments for mares and their offspring and for youngsters after weaning (Waran 2001). Group housing is a more natural form of keeping horses and with regards to welfare discussions also owners, mainly keeping horses for recreation, choose to keep their horses in groups.

Another possibility to keep individual horses (also possible for group housing) are run-out sheds with continual access to pasture and/or paddock (Waran 2001). This allows the horses to move freely and express natural foraging behaviour.

In contrast to times in which easy handling and economics played the main role when deciding for housing facilities and management practices, in recent years the welfare of the animal within these systems has gained enormous importance. Welfare is still a hot topic in science and among the public/consumers. Also because of pressure arising from the latter, legislation in animal production has been adjusted and changed. Further, a clear trend towards biological farming has been noticed which is associated with good welfare standards of animals. However, welfare is a controversial topic, also in biological production systems, not only because its definition varies greatly. Facts that can be collected about the well being of animals is the basis of science but surely ethics play an important role in the acceptance of a certain procedure or system.

In general there are four main approaches in how to assess welfare that are used or have been used in science: the feeling based approach, the animal choice or preference approach, the nature of the species approach and the functioning based approach.
The feeling based approach is based on welfare deficit due to negative emotional experience of the animal and is used in ethological studies (Désiré et al. 2002).
The animals preference approach is based on the strength of motivation of the animal ('the need of the animal') for a certain resource and is measured by the animals willingness to 'work' for the resource (Barnett and Hemsworth 2003). This approach is highly criticised because of the underlying methodology and the understanding of the principles of the animals decision making (Lawrence and Illius 1997). A simple example would be the difference between a short-term or long-term choice for a resource in comparison to another on the basis of the state of the animal (e.g. motivation for the resource food is higher than for space when the animal is hungry, however, that might be different when it is not) (Lawrence and Illius 1997).
The nature species approach (Webster and Nicol 1998 cited in Barnett and Hemsworth 2003) is based on one of the five freedoms 'the freedom to express natural behaviour' (Brambell 1965). This approach is questionable because not all natural behaviour is desirable with regards to welfare (e.g. adaptation of the animal to extreme environmental conditions) and especially not under commercial conditions (e.g. naturally high mortality rates in pigs) (Barnett and Hemsworth 2003). To define desirable and undesirable natural behaviour and their welfare risks clear definitions are needed that do not exist to date (Barnett and Hemsworth 2003).
The most common and funded approach by scientists is the functioning approach which is based on homeostasis and refers on the one hand to how much has to be done by the animal in order to cope with the environment and on the other hand to which extent the animal coping attempts succeed (Broom 1986). This is done with the help of physiological and/or behavioural responses of the animal to its environment and the biological costs of these responses to the animal (Barnett and Hutson 1987, Broom and Johnson 1993, Hamsworth and Coleman 1998 all cited in Barnett et al. 2001). For instance the stress response is a good example of a physiological and behavioural response, the biological costs of stress can impair growth, reproduction and health (Barnett et al. 2001). These 'costs' have an effect on the ability to survive and are therefore seen as an indicator of biological fitness of the animal (Barnett et al. 2001). Stereotypic behaviour is also appropriate to consider within this approach as it is a biological response to a long term challenge (Barnett and Hemsworth 2003).
Stereotypic behaviours are defined as apparently functionless and repetitive behaviour patterns in stabled horses (McGreevy et al. 1995, Cooper and Mason 1998, Nicol 1999a) that are rarely reported in that form in free-ranging feral animals (Cooper and Albentosa 2005). Some of the stereotyped movement patterns, however, assemble natural behaviour (Lidfors et al. 2005). In cows for instance tongue rolling movements needed for grazing can resemble stereotypic movement patterns that develop when cattle is not provided with sufficient amounts of roughage (Redbo 1992 cited in Lidfors et al. 2005).
There have mainly been two suggestions on the meaning of these behavioural responses, on the on hand it is argued that these activities are an indicator of the failure of an animal to cope with its captive environment and on the other hand it has been argued that they function as adaptation to the captive environment and enable the animal to gain control over its environment or buffer physiological effects of distress (Cooper and Albentosa

2005). There has been found evidence for an association between the prevention of stereotypic behaviour and increased arousal in stabled horses suggesting a coping function (McGreevy and Nicol 1998a, McBride and Cuddeford 2001), however, it is for instance argued that the arising arousal is an indicator for the prevention of the adapted behaviour of the horse that consequently might cause frustration (Cooper and Albentosa 2005). This argument is based on the fact that increased distress after prevention does not indicate that the behaviour originally developed to cope with distress (Cooper and Albentosa 2005). A study from McGreevy and Nicol (1998a), however, showed evidence for a relationship between stereotypic behaviour and reduction in arousal in horses. After removing a crib-biting surface coticosteroids concentrations were elevated in cases no alternative means were offered, however, under provision of a hay net as alternative mean no elevation could be measured. In case of oral stereotypic behaviour has been argued in both ways. Crib-biting, a stereotypy that has been related to digestion, on the one hand has been argued to be an adaptive response to reduce acidity of the digestive tract especially in relation to high concentrate diets as the movement causes saliva excretion (Nicol, 1999a). On the other hand the findings of gut damage despite the continued expression of crib-biting lead to the assumption that animals do not cope sufficiently with the extreme nutritional challenge (Nicol et al. 2002).
Whether, these behavioural responses are having coping function or are adaptive responses to the captive environment they arise from challenges the animal is facing in its actual environment. According to Fraser et al. (1997) the challenges can basically take three forms:

1. Challenges existing in the 'wild' can be avoided by mankind in a captive environment, that however does not necessarily mean that motivation of the animal to perform an adaptive responses is gone. An example would be the provision of a nutritionally balanced diet that provides the animal with all it needs but the motivation of the animal to perform foraging and feed selection behaviour is still present. In stabled horses for instance grazing behaviour has been redirected to bed eating when there was no access to high-fibre forage (Mills et al. 2000).
2. The challenges that can not be controlled by mankind, like environmental challenges, require a certain behavioural response that the animal needs to be able to express also in captivity.
3. The challenges mankind creates that cannot be coped with by the animal. These challenges need to be reduced and adjusted to make it possible for the animal to adapt. For instance the mentioned example of crib-biting that is a behavioural response to the increased acidity of the stomach due to high-energy concentrate diets. However, the saliva secretion by the horse is not enough to cope with the circumstances and ulcers as well as mucosa damage are results of this failure to cope.

With regards to the cause of stereotypies it is generally agreed on the fact that there are different causes for different stereotypies. All causes are associated with the inability to perform a certain natural behaviour. Horses for instance are social animals that live in groups under free-ranging conditions; a lack of social contact has been proven to be one of the main causes of stereotypic behaviour (Cooper and Albentosa 2005).
Gestating sows for instance are showing intense nesting behaviour pre-farrowing (Jensen 1993), in cases this was prohibited the animals were found to be bar biting (Lidfors 2005). The behavioural response therefore is an

indicator for the welfare of the animal also leading to the suggestion that, in this case, nesting behaviour is an important behavioural factor in a pigs live. This thought is logically followed by the assumption that when designing housing systems for pigs certain key factors, like the ability to build a nest or the expression of patterns of nesting behaviour need to be respected. The latter thought has been integrated in an ethological approach of Stauffacher (1994) that is based on the integration of natural behaviour into housing systems. In calves for instance suckling is one behavioural key factor (Lidfors 2005). In cattle, enough space for lying down and standing up is crucial, if not sufficient abnormal movement patterns are developing (Lidfors 1989). For hens it has been found that a dust bath, a nest and a perch are key factors (Keeling and Svedberg 1999 cited in Lidfors 2005). During studies in Switzerland something to hide under, a lookout spot and something to chin mark on have turned out to be key factors in housing the (white) rabbit (Stauffacher 1994, Lehmann 1989 cited in Lidfors 2005).

2.2 The identification of behavioural key factors in horses

In the following paragraphs stereotypies in horses and consequently key factors that should be considered when improving the welfare in managing and keeping horses are discussed and pointed out.

The two most common locomotory stereotypies are weaving and box walking. They are both associated with a lack of social contact. Both stereotypies as well as similar repetitive activities like pawing the ground or nodding occur commonly in stabled horses just before feeding or during other arousing daily events at the yard. (Mills and Nakervis 1999). The cause of these abnormal behaviour patterns therefore seems to be the restriction of the horse to follow its motivation to move (McGreevy 2004). Therefore it has also been suggested that there might be a relationship between exercise and stereotypic behaviour. The evidence is, however, equivocal. In epidemiological studies exercise was not identified as risk factor (McGreevy et al. 1995) and for the consistent effect of exercise routine on stereotypic behaviour only little evidence has been found (Marsden 1993). On the other hand turning out has been associated with the expression of stereotypic behaviour and cues that signalised turning out caused the expression of the stereotypies weaving and nodding. Therefore it has been concluded that they might function as expression to attempt to socially interact with other horses or that they are learned response to a desirable outcome like turn out or feeding (Nicol 1999a, Cooper et al. 2000).
Social contact, tactile and visual, to other horses seemed most efficient in reducing weaving and nodding compared to keeping horses in the old traditional boxes with solid walls (Cooper et al. 2000). In the short-term the level of weaving could be reduced to zero when social contact on all four sides of the stable was provided (Cooper et al. 2000). Unfortunately, there have been attempts to prevent weaving by designing v-shaped doors (anti-weaving grills) that make it impossible to move the head from one door side to the other. This practice does not solve the underlying problem causing the stereotypy and did not result into reduction of incidence. The horses either moved to the inside of the box to perform weaving (McBride and Cuddeford 2001) or they altered the movement so that they kept the head out the stable door but only the body was swayed or alternatively one foreleg was lifted (Kiley-Worthington 1983). This phenomena is called treading (Kiley-Worthington 1983). Moreover, it has been found that prevention of weaving caused increased stress, physiological responses like increased heart rate and adrenocorticol activity could be measured (McBride and Cuddeford 2001).

The type of diet as well as increased cecal acidity seem to have an influence on abnormal feeding behaviour. Oral stereotypies like crib-biting, wind-sucking and wood-chewing are mostly associated with the diet and the restriction of normal grazing behaviour (McGreevy et al. 1995, Waters et al. 2002, Bachmann et al. 2003).

In general, undisturbed, free ranging horses feed for 59 - 69% of the day which equals about 14-16.5 hours (Duncan 1992). In free ranging horses feeding tends to occur in meals that are separated by periods of different lengths (Mayes and Duncan 1986 cited in Waring 2003).

Stabled ponies that had free access to feed consumed 80% of their daily intake in an average of ten separate meals of 44±10 minutes length (each meal averaged 0.5kg of a pelleted ratio). The average interval between meals was 84 min and half of the intake was consumed between 8.00h and 17.00h (Raslton et al. 1979 cited in Waring 2003). Horses on pasture, however, tend to graze in cycles with three or more prolonged feeding periods a day. In a study of Francis-Smits et al. (1982) a horse grazed in 5-7 major periods with an average total grazing time of 15 hours and 41 min per 24-hour day (cited in Waring 2003).

Stabled horses generally consume their limited feed ratio in one bout and are then unable to perform ingestive behaviour until the next meal is provided (Waring 2003). The high energy diets provided are easily digested compared to the natural poor forage diet of the horse (Cooper and Albentosa 2005). The provision of concentrate diets and following prolonged periods without feed cause an increase in hind gut acidosis which is associated with oral stereotypies like crib-biting (Rowe et al. 1994, Murray and Eichorn 1996). In nature feeding periods are usually scattered over the day that the gut remains relatively filled (Waring 2003). Therefore normal grazing behaviour differs considerably from feeding practices of confined horses in which the caretaker and not the horse itself decides when to feed, what to feed and how much.

Feeding of high energy and low-fibre concentrated feeds without providing high-fibre forage has been associated with a higher incidence of stereotypic behaviour in epidemiological studies as well as experimental ones. In a 4-year prospective study it has been shown that foals provided with concentrates after weaning were at significantly higher risk to develop crib-biting than those not given concentrate (Waters et al. 2002). Weaving also has been observed to occur in bouts just around the feeding time of concentrates. As mentioned above this might be conditioned response to feeding. Providing forage around this time has been shown to decrease the incidence of the stereotypy (Cooper and Albentosa 2005). Also the prevention of crib-biting with crib-biting collars or the removal of the preferred crib-biting surfaces has not been shown to be successful in reducing its incidence but in increasing the number of crib-biting bouts (McGreevy and Nicol 1998b). Also in this case prevention is associated with increased distress of the animal. To avoid the hind gut acidosis ad libitum forage or the regular provision of smaller bouts of food have to be considered.

Wood chewing means the horse chews wood from fences or stall walls, most of the material chewed falls to the ground and only little ingestion occurs (Waring 2003), however, horses can ingest up to 1.5 kg of timber daily (Houpt 1982). In horses that ingest wood intestinal obstruction can occur (Green and Tong 1988). Bark chewing is common in horses that graze on irrigated pastures that have less fibre content than natural pastures (Keenan 1986). Although it is not sufficiently invariant to be classified as stereotypy it is associated with crib-biting or might even lead to the development of it (Nicol 1999b). In general it can be said that horses chew wood significantly

more when they are provided with low-forage diets compared to horses that are provided with hay (Johnson 1998). Also the offer of hay replacers (silage or haylage) could be associated with a significantly higher risk of developing wood chewing compared to a feeding regime based on hay (Waters et al. 2002).
Moreover, wood chewing increased when the stomachs of horses were at their emptiest (Krzak et al. 1991. Like other oral stereotypies wood chewing has also been associated with hind gut acidosis as incidences of wood chewing decreased when virginiamycin was administered (reduces fermentative acidosis in the hind gut) (Johnson et al. 1998).

Dietary deficiencies seem the cause for abnormal ingestive behaviours like corprophagy, hair ingestion and soil licking.
Corprophagy (ingestion of fecal material) in adult horses is rare and mainly associated with food scarcities (Feist and McCullogh 1976 cited in Waring 2003). Corprophagy is usually seen in foals up to a month of age (Tyler 1969, Blekeslee 1974 both cited in Waring 2003), however, mares and their offspring have been seen to eat old pellets from stallion faecal piles during August and winter. In stabled horses fibre restriction (Crowell-Davis 1986, Nagata 1971 both cited in McGreevy 2004), resulting frustration and underfeeding (Ralston 1986 cited in McGreevy 2004) have been associated with the ingestion of faeces.
The voluntary ingestion of soil seen in horses has been found to serve as supplemental sodium source (Salter and Pluth 1980) but in general it is not clear if soil ingestion is caused by nutritional deficiencies or if the horses might also simply enjoy the activity (McGreevy et al. 2001, cited in McGreevy 2004)
If such behaviour is recognized the provision of a mineral block in the stable or paddock is a good solution.

2.3 Discussion of housing and management practices under the consideration of key factors

In regards to identified key factors new housing systems have been developed in production animals as well as in horses. The testing of the facilities with regards to animal welfare also under consideration of the possible negative effects of the system under commercial conditions is very important. Typical points of discussion are: increased risk of injury, increased competition for resources as well as if and how ideas and changes are accepted/ adopted by the animal in practice. Next to the animals welfare the acceptance by the managers of the farms or companies is very important hereby costs, competitiveness on production level and practicality of the system regarding daily management practices are playing a crucial role.

In the following paragraphs management practices and housing facilities are discussed under the consideration of the two main key factors in horses: social contact and adequate nutrition. Special attention is drawn to the integration of these factors in group housing.

Under the consideration of the key factor social contact the owner or stable manager has different options to keep horses. As the name suggests group housing enables the horse to live in a group and therewith resembles the social contact in the wild. Group composition and size usually are different in captivity. In nature horses live either in harems which consist of mares and offspring (usually until puberty) and one stallion or bachelor bands (Waran 2001). Also the existence of multi-male bands has been reported. In captivity breeding mares are kept with their offspring until the foals are 6 months old. Young stock is usually kept together in single-sex groups whereas the male groups resemble most closely the natural composition of a bachelor band. However, mainly geldings are kept in groups. Stallions are usually separated from the others in early live and are kept separate from other horses. At livery yards it is also possible that groups consist of mares as well as younger animals and geldings.

Group sizes vary from two to three to 60 or more in captivity (Waran 2001).

When keeping horses in groups, in practice, some issues need further consideration.

Housing horses in groups is associated with the establishment of a group hierarchy which is natural and highly beneficial. As soon as the hierarchy is established serious aggression is minimized and threat behaviour replaces physical violence in competitive situations (Houpt 1998). In general aggression is used for obtaining food, for access to sexual partners and to establish a place in the social hierarchy of the group (Houpt 1998). However, a key factor for the typically low levels of aggression within a group of horses is the provision of adequate space. If space is a limiting factor aggressive interactions are harder to avoid. Keiper (1988) recorded a higher frequency and intensity of aggressive behaviour in horses kept in small paddocks compared with open ranges. Therefore, Keiper (1988) suggests that also in horse like in other animal species aggressive behaviour increases as space decreases and invasion of personal space is unavoidable. Further, aggression is related to the resources available. Water and food availability and dispersion are important factors. Similar issues have been associated with group housing of pigs. It was suggested that group size has a detrimental effect on production as lower ranking animals might suffer lack of water and food leading to poor performance and decreased body weights but also increased risk of injury because of the increased agonistic behaviour (Blackshaw 1986, English et al. 1988 cited in Schmolke et al. 2003). However it was found that group size has no negative impact on productivity if adequate space and feed resources are provided (Schmolke et al. 2003).

Horses that are kept for professional sport are extremely valuable therefore concerns regarding the risk of injury are in most cases overpowering the needs of the horse. These horses are unlikely to even be turned out regularly both alone or with other horses. Also additional cost for the veterinary might be a concern. Furthermore, horses in groups are thought to be less easy to manage in regards to increased time and labour that needs to be invested in grooming and catching the horses.

For owners or managers that, for whatever reason prefer individual housing above group housing, social contact (tactile and visual) between horses should be a minimum requirement. Direct contact with the neighbouring horses is preferred to only visual contact over the stall door.

Mills and Davenport (2002) as well as McAfee et al. (2002) have studied an alternative to social contact - stable mirrors. They have been shown to have similar effects in the short (Mills and Davenport 2002) and long-term (McAfee et al. 2002) to social contact with other horses. However, horses should not be kept individual just because it is convenient for the owner; as mentioned above social contact is a minimum requirement.

Key factors in regards to nutrition are type of diet (forage vs. concentrates), the offer of smaller bouts of food throughout the day and the expression of foraging behaviour. To increase feeding time and encourage foraging behaviour of the stabled horse foraging devices like the EquiballTM have been invented. Although they have been shown to increase feeding time (Winskill et al. 1996), oral streotypies could not be reduced (Cooper and McGreevy 2002). In a study from Cooper et al. (2000) the feeding management practice was changed and meal frequency of the stabled horses was increased. One group of horses got their normal daily ration divided into two, four or six equally sized meals. In this study the behaviour of the horses was compared with that of a control group that received two meals per day. The results showed an overall decrease in oral stereotypies of the treatment group but an increase in the performance of stereotypies in both the treatment and the control group. In the treatment group pre-feeding stereotypic behaviour increased whereas in the unfed control group stereotypic behaviour increased in visual contact to the treatment group. Therefore it seems recommendable to only feed several meals a day when this management practice can be offered to all horses in the stable. Pre-feeding stereotypic behaviour might be decreased by the provision of forage at feeding time. In general it is recommended to provide horses with ad libitum forage and only very little amounts of concentrate. The provision of ad libitum hay is often accompanied with fear that the horses might get to fat or might not get enough in case forage is provided ad libitum in a group (e.g. low ranking horses). Therefore the owner or manager most of the time prefers to control the feed intake of the animals individually. The latter seems also very important in production systems in which a decreased level of production is an issue. All these factors seem to be a challenge for the management of the business with regards to increased working time and staff resulting in increased costs. One possible solution to solve those problems would be an automatic/electronic feeding system. These systems have been introduced in production systems first and about 15 years ago in the horse industry. Back then automatic feeding was only used for concentrate feeding but can nowadays also be used for provision of roughage. Original systems have been improved and are now used for several different housing systems like individual stalls, paddocks but also for group housing. The automatic feeders used for one individual differ from the ones used in a group housing system. For individual use they can be programmed to provide the horse with little amounts of food several times a day and are mainly used for concentrate. In group housing hay and concentrates can be provided via this system; usually two horses are able to eat next to each other in one feeding station. The others have to wait outside until a space is available. The horses wear collars or chips in which individual data about the diet is saved. The computer recognizes the horse and provides food until the daily portion of the horse is consumed; in that case the horse might still visit the feeding station but the visit is not rewarded. As mentioned this system takes into account important needs of the horse but is also management friendly. However, the automatic feeder represents a limited feed source and impairs the natural feeding behaviour of the horse (Zeitler-Feicht 2004). Because horses are not able to eat at the same time they have to wait to be able to enter the feeder. Consequently, it is expected that horses show increased agonistic behaviour like they do if food resources are limited (Mc Donnell 2003). Zeitler-Feicht (2004) stated more specific the increase of feed-related aggression if feed sources are limited. This behaviour causes increased conflicts which means increased stress situations. Especially lower ranked horses could be negatively affected as their waiting time might be increased and visiting frequencies as well as rewarded visits might be lower. In pigs, it has been found that the availability of food had an influence on live weight gain and feeding behaviour. In a study of Brouns and Edwards (1994) floor fed (restricted feeding once a day) and ad libitum fed groups of sows were observed.

Results showed low ranking sows gained less weight than dominant sows in the floor fed pens but not in the ad libitum fed pens. Further feeding time was increased in ad libitum fed sows to 91 minutes compared to only 20 minutes in the floor fed pens. A correlation between rank and feeding behaviour however could only be determined in highly competitive systems. In this study it might have been possible that sows of low rank increase their feeding rate when competition is high whereas the feeding rate of dominant animals is the same; that would be in accordance with findings in cows (Kenwright and Forbes, 1993). In a study of Melin et al. (2006) cows of low rank were found to have longer waiting times in front of the milking unit (MU) than high ranking cows. In horses this might be true as well and could additionally mean that the lower ranking horses are 'giving up' waiting (observed by Cox 2007, unpublished) which could lead to less entering frequency and therewith less feed intake. Coping with the frustration and inability to display natural behaviour could then lead to the display and even development of abnormal behaviour. In a study of Gieling (2007) it was stated that the concept of the active stable does not impair the welfare of the horses. However, in the conclusion of the study the low visiting frequencies of the hay stations were pointed out and concerns in regards to hunger and frustration causing stereotypies were mentioned. Furthermore, visiting frequencies seemed related to rank and the attempt to relocate high ranking horses to other feeding stations and therewith increase the visiting frequency of middle and low ranking horses did fail. The short acclimatization period of four weeks was stated as possible reason for this outcome and further research was needed also to support the findings in regards to rank. It seems, however, logical that horses of middle or low rank are more easily displaced from the feeder or might even avoid trying to access the feeder if a higher ranking horse is present near or within the feeder. In a study from Krüger and Flauger (2008) it was found that horses tend to return to the same feeding space (if it was a continuously supplied feeding site) but switched to an 'avoidance tendency' when a dominant horse or even when another horse was feeding there. According to Zeitler-Feicht (2005 and 2008) increased aggression can be caused when high ranking horses block the feeding station; lower ranking horses would then not approach this horse but would redirect their aggression to another uninvolved horse in close proximity. To prevent rank related 'discrimination' it has been proposed to offer ad libitum straw next to the hay provided in the feeding stations (Gieling 2007, Zeitler-Feicht 2005 and 2008). This recommendation has already been realised in housing of pigs and controversial findings have been reported. Some evidence could be found for increased aggression due to increased activity but on the other hand activity was also found to be reduced with a high fibre diet (Whittaker et al. 1999 cited in Barnett et al. 2001). Enriched pens with mushroom compost reduced aggressive behaviour and injuries (Durrell et al. 1997). Furthermore, it is not clear if provision of straw in racks or on the ground makes a difference (Barnett et al. 2001). Horses have been shown to eat straw when forage is not sufficient. Bed eating (including the ingestion of straw) is mainly seen as redirected foraging behaviour when low fibre and high energy diets are given. It has been shown that the provision of straw significantly reduces the incidence of crib-biting. So far no increase of agonistic behaviour in group housed horses has been reported in regards to the provision of additional straw.

According to Zeitler-Feicht (2004) the increased stress situations mentioned above could also be avoided by feeding horses in feeding stalls which allows simultaneous eating (providing at least one feeding stall for each horse). In a study of Streit et al. (2008) feeding stalls and automatic feeding systems were compared and although both systems could be recommended for use, the visiting frequencies of the feeding area were higher in automatic feeding systems as well as threatening behaviour, displacement activities and the frequency of situations that could cause stress or injury. However, it was also found that horses could eat less disturbed in automatic feeding systems compared to feeding stalls. Another advantage compared to feeding stalls is the higher meal frequency in automatic systems which additionally animate the horses to move; additionally they are beneficial physiologically seen (Ullstein 1996, Zeitler-Feicht 2008).

As discussed above rank and dominance have a significant influence on feeding behaviour. Further factors that have an influence on feeding behaviour are exercise, water availability, lactation, weather, seasonality, food quality and insect pests (see Waring 2003).

The environment of the animal has shown to have an influence on the time budgets of the horse. As can be seen below the design of the stable/housing and type of diet have an influence on the behaviours standing, lying, eating and time spent on social activities (Adapted from Kiley-Worthington 1987 cited in Waran 2001).

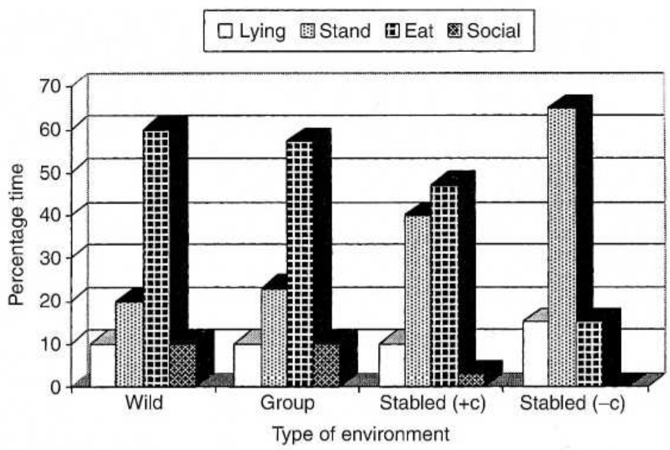


Fig.1: Average time budgets for horses in different environments.
'Wild' = Camargue horses; Group = group-housed horses on a yard with *ad libitum* hay and straw; Stabled (+c) = individually stabled horses fed *ad libitum* hay and straw and able to see and touch each other; Stabled (–c) = individually stabled horses fed restricted fibre and unable to see or touch each other. (Adapted from Kiley-Worthington, 1987.)

The feeding system has, as discussed above, an influence on the intensity and frequency of agonistic behaviour. In a recent study of Motch et al. (2007) it was shown that different concentrate feeding systems for foals have different effects on the number of agonistic interactions which indirectly are related to feeding duration within the different systems. Further, the system can have an influence on the synchronization of feeding and might therefore also have an influence on other daily activity patterns.

To date there is little know about the impact of different feeding systems on feeding behaviour, daily activities and aggression of horses.

The aim of this research is to study the impact of one feeding system that enables simultaneous feeding and one system that does prohibit this natural feeding behaviour. Both feeding systems are compared in regards to feeding, resting, standing and comforting behaviour as well as aggression and abnormal behaviour around the feeding stations/troughs. On the basis of the results of this study suggestions are made about the suitability of the two feeding systems for group housing of horses in regards to welfare.

3. Method

3.1 Description of the experimental group

3.1.1 Group composition and location

Part of this study are two groups of horses managed at two different locations in the region Gelderland in the Netherlands. Both stables are riding schools that keep their horses and ponies in a group. Additionally some livery horses are kept within the group as well. The horses are at both locations of various breeds and ages. In total each of the riding school has about 50 horses each (location 1: 54 horses and ponies; location 2: 44 horses and ponies).

3.1.2 Feeding Management

At location 1, the horses are fed every morning with a big bale of hay, which is divided over two big troughs. One of them is accessible from both sides, the other one only from one side. The horses are able to eat all at the same time until the amount of hay given is consumed. How long a bale lasts is depending on the number of horses that are in the group over the day (dependent on the activity schedule of the riding stable). Within the observation period, hay was always available which equals a period of at least 8 hours a day. Further, there is a covered straw place right next to the feeding place which provides the possibility to eat straw; this area is mucked every Thursday. In a separated area some horses get an extra portion of concentrate once a day. Which horses receive an extra portion is decided by the stable owner according to the condition of the horses. Furthermore, an additional bale of hay is provided in the evening when the owner thinks this might be necessary.

Location 2, has been rebuilt into an active stable. This system is based on automatic feeding. Hay is provided ad libitum and the horses have access to it 24 hours a day. A chip in their neck ensures that the feeding machine does recognise the horse and opens the feeding station up to 20 times a day. There are four hay feeding stations, each provides space for two horses. Three of these stations are of the same type, the fourth differs in its construction. In the latter the horses are only able to eat when the computer recognizes the horse and the automatic wall is scrolling down whereas in the other three stations the horse pulls the hay from the storage space behind the automatic wall into a „bucket“ in front of the wall. This „bucket“ is accessible also when the wall did scroll down and does most of the time still contain some hay. To horses that are not having a chip (some ponies) or already have consumed their portion, this provides the opportunity to eat without being noticed by the computer. As this system allows the horses to still be in the station although their time is up (they are therefore not encouraged to leave the station), the system of the fourth station has been invented. Altogether, the stations allow that a maximum of eight horses can eat at the same time; always two next to each other. The other horses, have to wait outside of the feeding station until it is their turn. To avoid that the horses are disturbed by others when they are eating their portion, there is one plastic bar attached behind each single station that either is allowing or prohibiting access to the station. To ensure the horses have ad libitum hay the stations need to be refilled about three times a day.

Additionally, small portions of concentrates are provided in one automatic feeding station; providing space for two horses at the same time. How much each horse gets is decided by the stable owner who adjusts the feed ratio according to exercise, type of horse/pony and its condition. The ponies of the group have an additional place where they get hay, the amount offered as well as the access to this place differ from day to day but it is always open at night time. Further, the horses are provided with mineral blocks.

3.2 Data collection

3.2.1 Behaviour observed

It is the aim of this study to look at the influence of two different feeding systems on the behaviour of horses. Therefore, only behaviour in a radius of two horse lengths around the feeding stations/troughs was observed. The behaviour recorded was aggressive behaviour, abnormal behaviour and any other behaviour shown around the feeding source within a radius of two horse lengths. The aggressive behaviour was divided in physical contact (offensive, defensive) and threat behaviour (offensive, defensive). According to Van Dierendonck et al. (1995) aggressive behaviour performed with the hindquarters is used defensively, when it is performed with the forehand the behaviour is performed offensively. An ethogram of all aggressive behaviour recorded during this study can be found in Appendix 1.

The abnormal behaviour patters that were observed in this study were identified during a pre-observational period. The ethogram of the abnormal behaviour patterns shown at both stables can be found in Appendix 2. Further, abnormal behaviour was all scored as one and the frequency was scored in 30 seconds intervals.

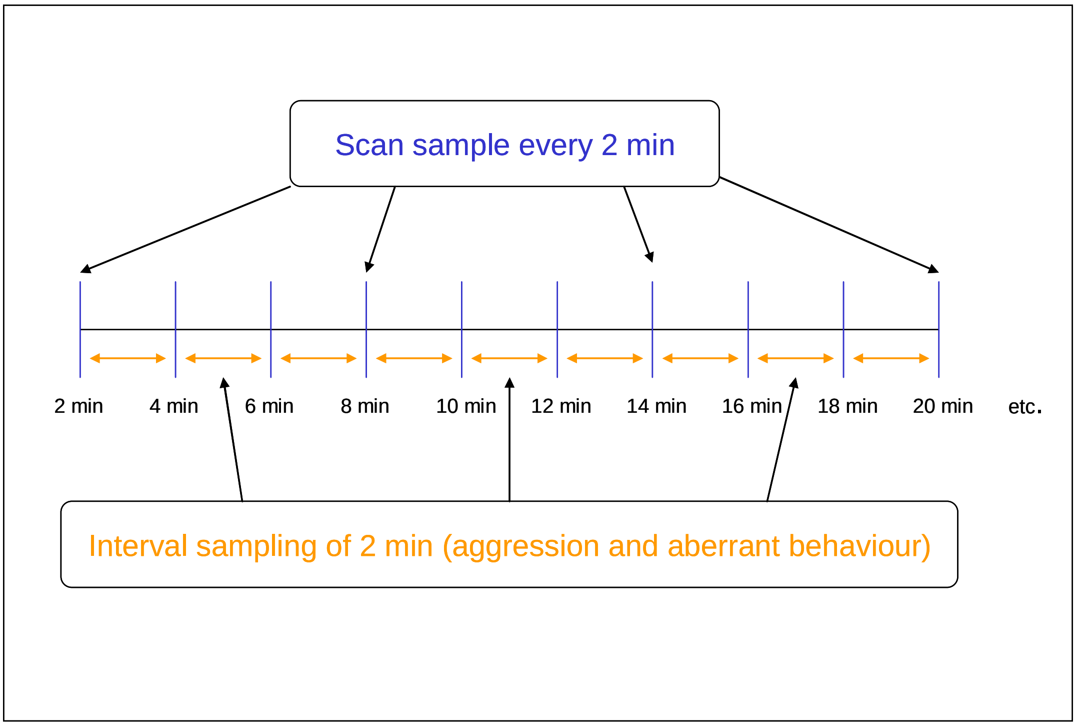
Every other behaviour around the feeding source and within the feeding station was recorded with a scan sampling (See Section 2.3.2). For that purpose a list of variables was established during a pre-observation period (See Appendix 3).

3.2.2 Sampling method

The sampling rule is a mix of different techniques. Focal sampling was used because only the group of horses around the feeding station or within the feeding station were observed. Additionally, behaviour sampling was used as only certain behaviour was observed (See Section 2.3.1).

The recording rule used was time sampling. The frequency of aggressive as well as the aberrant behaviour was recorded continuously within intervals of 2 min (Figure 2). Aberrant behaviour was scored in 30 second intervals . Therefore, a horse could perform aberrant behaviour at a maximum of four times within one interval of two minutes. The other behaviour (Appendix 2) was recorded with scan sampling every two minutes (Figure 2).

Figure 2: Sampling method



3.2.3 Observation period

Data was collected from two riding schools in a time period of 5 weeks in April and May 2009. In total 8 days were observed at location 1 and 14 days were observed at location 2. The 14 days at location 2 were split in two different observation periods; the behaviour outside the feeding station was observed for 8 days (including the scan and interval sampling) and 6 days were used to observe aggressive and aberrant behaviour within the feeding station by making use of a two minute interval for each station. Because location 2 was difficult to overlook the data collection for aggressive and aberrant behaviour (interval sampling) needed to be split up in inside and outside the feeding station. The observation of aggressive behaviour inside and outside the feeding station was crucial to be able to compare the results of both stables.

Every observation day started at 10.00h and ended at around 18.00h; with a break between 12.00h and 13.00h; this equals an observation period of approximately 7 hours a day. In this time interval 105 scan samples were taken, as well as 105 interval samples. That equals a data set of 3.5 hours each day. The difference between 7 hours observing and 3.5 hours of data can be explained by the scan samples that were in reality not just one moment in time but in fact took longer depending on the amount of horses that needed to be scanned.

In total 840 scan samples were made for both locations. For location 1, 840 interval samples were collected, for location 2, however, 1050 interval samples were collected. In the data processing it was accounted for the unequal data sets (see Section 3.3).

3.3 Data processing

The quantitative data set has been typed into Windows Excel 2003 and has been exported to the statistic programme SPSS (version 15.0).

At both locations, the sum of the total aggression displayed was calculated first. Total aggression included both physical and threat behaviour. Then the sum of the defensive (performed with the hindquarters) and offensive behaviour (performed with the forehand) was calculated with regards to how much threat behaviour and how much physical aggression occurred. In the following calculation the sum of the total threat behaviour and the total physical aggression was determined; this time with regards to how much behaviour had been performed with the forehand or hindquarters.

Additionally, the frequency of the defensive and the offensive aggression as well as the frequency of the threat and the physical aggression were expressed in percent.

Further, it was calculated how many times per horse each behaviour was displayed. This measure is important because it shows the aggression displayed in relation to the horses that were present in the radius and could have performed the behaviour (frequency/total horses in the radius). Attention needs to be paid to the fact that no individual data was collected, thus if for instance the frequency four was recorded that could have meant that four different horses performed the aggression but it could have also meant that only two horses performed the behaviour (e.g. one horse once and another horse three times). Therefore the frequency per horse is expressed as average frequency of the population in the radius. The aberrant behaviour displayed at both locations was calculated in the same way. To be able to compare the data to existing data found in literature also the frequency per horse per day was calculated. At location 1 the times per horse per day were calculated as follows: times per horse/(3.5*8)*24. At location 2 the times per horse per day were calculated as follows: times per horse/(3.5*2)*24. This frequency is not reflecting a true 24-hour-day.

At location 1, aggression was measured for 8 days which resulted into a data set of 840 intervals (8*105 intervals).

At location 2, aggression was measured inside (6 days; each 7 hours = 140 intervals a day) as well as outside the feeding station (8 days; each 7 hours = 105 intervals a day). This difference in observation period lead to a different number of intervals collected for the behaviour aggression (840 intervals for outside the feeding station and 210 intervals for inside the feeding station). In order to be able to compare the data measured inside and outside the feeding station in location 2, the data set needed to be weighted. By multiplying the behaviour outside the feeding station with the weighting factor 0.25 the difference between the data set could be eliminated. To make the set comparable to Location 1, both the data set for inside the feeding station and the dataset for outside the feeding station were multiplied by two to obtain a dataset of 840 intervals for Location 2. The multiplication is justified as the data collected is assumed to be representable. The Appendix 4 gives an overview on these calculations. In the following presentation of the results only the adjusted dataset for location 2 has been taken into account.

The comparison of both stables was made in the statistical programme SPSS (version 15.0) with an independent sample t-tests; one each with the variables total aggression per horse, total defensive aggression per horse, total offensive aggression per horse, total treat behaviour per horse, total physical aggression per horse and total aberrant behaviour per horse. Variables were significantly different between locations when $P<0.05$.

Further, the means of the aggression displayed were compared in SPSS (version 15.0) with a one way ANOVA, to see if aggression differed between days ($P<0.05$). To make the differences more visual error bars have been made in SPSS.

Additionally, the correlation between the aggression and the horses in the radius was calculated in SPSS. A Scatter/Dot Graph was made to make the results visual.

Also the weather was recorded and the means of the aggression displayed were compared to the records of the weather to see if there was any relation between the two factors.

The activities of the horses that were recorded with the scan sample every two minutes were calculated in percentages (activity/horses in the radius * 100) and then reflected in a pie chart. The charts were made in Windows Excel 2007). The legend next to the chart starts with the most displayed activity, the one below that the second most and so forth. The pie chart can be read clockwise in relation to the legend.

To be able to compare both locations on the same basis the legends have been adjusted. In location 1 the activity drinking was excluded from the chart because the horses at location 2 did not have the possibility to drink. Further, similar activities that were first divided into inside and outside the feeding station at location 2 were merged (e.g. resting, standing, waiting, selfgr. etc.). Finally both locations were compared at the basis of 13 different activities. In the discussion only eating, resting, standing, waiting, foraging and comforting behaviour like self-grooming and allo-grooming are discussed because of the hypothesis tested.

4. Results

4.1 Results Location 1

4.1.1 Aggressive behaviour

At location 1, aggression was performed 2,517 times in 8 days. In relation to the total number of horses present in the radius, which were in total 31,174 horses, total aggression occurred in average 0.08 times per horse. The average frequency of the total aggression per horse per day was 0.07 times. (Table 1)

Table 1: An overview of the aggressive and aberrant behaviour at Location 1

	Frequency (expressed in how many times the behaviour did occur)	**Frequency** (expressed in how many times the behaviour did occur)	**Aggression in times/horse** (frequency/total horses in the radius)	**Aggression in times/horse/day**
Total aggression	2517	100,0	0.08	0.1
Defensive aggression	190	7,6	0.006	0.01
Threat behaviour	156	6,2	0.005	0.004
Physical aggression	34	1,4	0.001	0.001
Offensive aggression	2327	92,4	0.074	0.1
Threat behaviour	1815	72,1	0.058	0.05
Physical aggression	512	20,3	0.016	0.01
Threat behaviour	1971	78,3	0.063	0.1
Forehand	1815	72,1	0.058	0.050
Backside	156	20,3	0.005	0.004
Physical aggression	546	21,7	0.018	0.02
Forehand	512	20,3	0.016	0.014
Backside	34	1,4	0.001	0.001
Aberrant behaviour	219	100,0	0.007	0.01

Table 1 shows that the total offensive behaviour (all aggression performed with the forehand) accounted for 92.4% of which threat behaviour with the forehand accounted for 72.1% and physical contact made with the forehand accounted for 20.3%.

The total defensive behaviour (aggression performed with the back) therefore accounted for 7.6% of which the threat behaviour performed with the back accounted for 6.2% and the physical aggression performed with the back accounted for 1.4% (Table 1).

In relation to the horses that were present in the radius, offensive behaviour occurred in average 0.074 times/horse (threat behaviour 0.058 times/horse; physical aggression 0.016 times/horse) and defensive behaviour occurred in average 0.006 times/horse (threat behaviour 0.005 times/horse; physical aggression 0.001 times/horse).

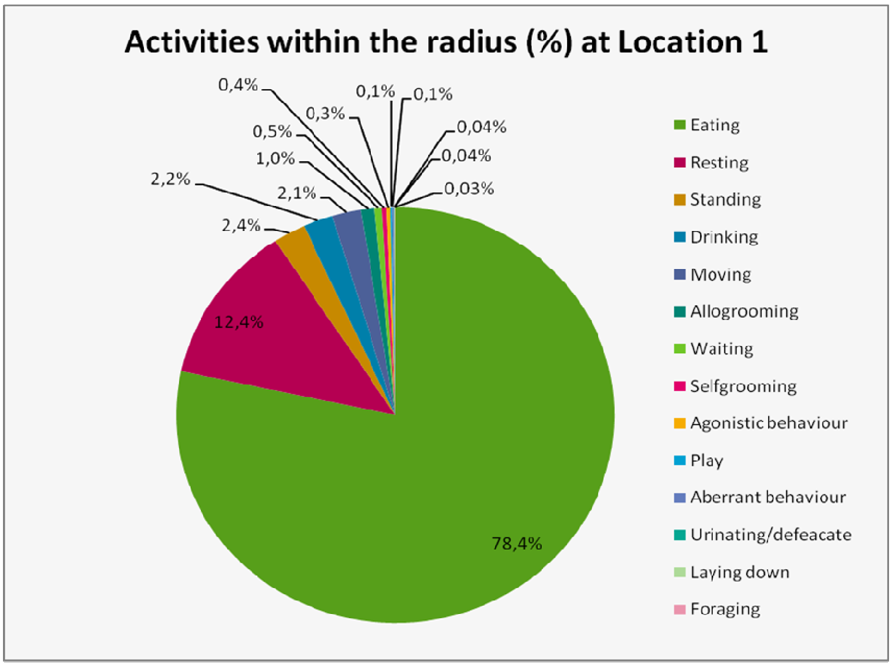
In total all threat behaviour accounted for 78.3% and was mostly performed with the forehand (72.1%).
The total physical aggression accounted therewith for 21.7%. Also here the most physical aggression was performed with the forehand (20.3%).
Under consideration of the number of horses that were in the radius and able to perform the aggressive behaviour measured, the average frequency of the total threat behaviour was 0.063 times/horse (with the forehead 0.058 times/horse and with the backside 0.005 times/horse). The average frequency for the total physical aggression measured was 0.018 times/horse (with the forehand 0.016 times/horse and with the backside 0.001 times/horse). (Table 1)

The aggression shown was not found to be correlated to the number of horses within the radius (Pearson correlation coefficient = 0.223) (See Appendix 5). Further the aggression varied between days ($P<0.001$) but differences were not found to be dependent on weather (See Appendix 6 and 7).

4.1.2 Aberrant behaviour
The average frequency of the aberrant behaviour per horse was very low with 0.007 times. The average frequency of the aberrant behaviour per horse per day was 0.01 times. (Table 1)

4.1.3 Daily activities
In location 1, the activities of the horses within the radius around the troughs has been recorded every 2 min with a scan sample. The time period of observation was 7 hours for 8 days. Each day it was observed from 10.00h – 12.00h and from 13.00h – 18.00h; in that time 3.5 hours of data were collected which equals 150 scan samples each day.
Figure 3 shows the percentage of the activities the horses performed. Eating accounted for 78.4%, resting for 12.4%, standing for 2.4%, drinking for 2.2%, moving for 2.1% and allo-grooming for 1%. Waiting, self-grooming, agonistic behaviour, play, aberrant behaviour, urinating/defecating, laying down and foraging did account each for less than 1%.

Figure 3: Activities scored at location 1 in percent (%)



4.2 Results Location 2

4.2.1 Aggression

4.2.1.1 Aggression outside the feeding station

Table 2 shows that outside the feeding station aggressive behaviour was in total displayed for 537 times. Threat behaviour with the forehand was performed most with 78.5%.

Total offensive aggressive behaviour outside the feeding station (aggression performed with the forehand) accounted for 93.3% of which 78.5% was threat behaviour and 14.8% was physical aggression (Table 2).

Total defensive aggressive behaviour outside the feeding station accounted therewith for 6.7% of which 5.3% was threat behaviour and 1.4% physical aggression (Table 2).

The average frequency of the total offensive behaviour outside the feeding station was 0.084 times/horse (threat behaviour 0.07 times/horse; physical aggression 0.01 times/horse). The average frequency of the total defensive behaviour displayed outside the feeding station was 0.006 times/horse (threat behaviour 0.005 times/horse; physical aggression 0.001 times/horse).

Table 2: An overview of aggressive behaviour outside the feeding station (FS) in Location 2

	Frequency (expressed in how many times the behaviour did occur)	**Percentage (%)**	**Aggression in times/horse** (frequency/total horses in the radius)	**Aggression in times/horse/day**
Total aggression	537	100,0	0,023	0,08
Defensive aggression	36	6,7	0,002	0,005
Threat behaviour	28,5	5,3	0,0012	0,0041
Physical aggression	7,5	1,4	0,0003	0,0011
Offensive aggression	501	93,3	0,021	0,07
Threat behaviour	421,5	78,5	0,018	0,062
Physical aggression	79,5	14,8	0,003	0,010
Threat behaviour	450	83,8	0,019	0,07
Forehand	421,5	78,5	0,018	0,062
Backside	28,5	5,3	0,001	0,003
Physical aggression	87	16,2	0,004	0,01
Forehand	79,5	14,8	0,0033	0,011
Backside	7,5	1,4	0,0003	0,001
Aberrant behaviour	426	100,0	0,018	0,1

As can be seen in Table 2, the total threat behaviour outside the feeding station accounted for 83.8% of which most behaviour was performed with the forehand (78.5%).

The total physical aggression accounted for 16.2% of which most was performed with the forehand (14.8%) as well.

The average frequency of the total threat behaviour outside the feeding station was 0.075 times/horse (with the forehand 0.07 times/horse and with the backside 0.005 times/horse). The average frequency of the total physical aggression outside the feeding station was 0.015 times/horse (with the forehand 0.013 times/horse and with the backside0.001 times/horse).

4.2.1.2 Aggression inside the feeding station

Inside the feeding station aggressive behaviour was in total displayed for 620 times (Table 3).

In total threat behaviour was performed significantly more than physical aggression. Threat behaviour with the forehand was displayed most with 58.9% followed by threat behaviour performed with the backside with 38.5%. The total threat behaviour therewith accounted for 97.4% compared to the physical aggression accounting for 2.6% (1.8% with the forehand and 0.8% with the backside). (Table 3)

The average frequency of the threat behaviour per horse was 0.37 times (0.23 times/horse with the forehand and 0.15 times/horse with the back). The average frequency of the physical aggression was 0.01 times/horse (0.007 times/horse with the forehand and 0.003 times/horse with the backside).

As can be seen in Table 3, the total offensive behaviour accounted for 60.7% (58.9% treat behaviour; 1.8% physical aggression) compared to 39.4% total defensive behaviour (38.5% threat behaviour and 0.8% physical aggression).

In relation to the horses in the feeding station the average frequency of the total offensive behaviour was 0.23 times/horse (threat behaviour 0.226 times/horse; physical aggression 0.007 times/horse) and the average frequency of the total defensive behaviour was 0.15 times/horse (threat behaviour 0.148 times/horse; physical aggression 0.003 times/horse).

Table 3: An overview of the aggressive behaviour inside the feeding station (FS) in Location 2

	Frequency (expressed in how many times the behaviour did occur)	**Percentage (%)**	**Aggression in times/horse** (frequency/total horses in the radius)	**Aggression in times/horse/day**
Total aggression	1240	100,0	0.38	1.3
Defensive aggression	488	39,4	0.15	0.5
Threat behaviour	478	38,4	0.148	0.51
Physical aggression	10	0,8	0.003	0.01
Offensive aggression	752	60,7	0.23	0.8
Threat behaviour	730	58,9	0.226	0.77
Physical aggression	22	1,8	0.007	0.02
Threat behaviour	1208	97,4	0.37	1.3
Forehand	730	58,9	0.23	0.8
Backside	478	38,5	0.15	0.5
Physical aggression	32	2,6	0.01	0.03
Forehand	22	1,8	0.007	0.02
Backside	10	0,8	0.003	0.01
Aberrant behaviour	146	100,0	0.045	0.2

4.2.1.3 Total aggression at location 2

Table 4 shows that inside as well as outside the feeding stations the offensive aggression was higher than the defensive aggression. Inside the feeding stations, however, the percentage of defensive aggression (39.4 %) was considerably higher than outside the feeding stations (6.7%). Inside the feeding stations there was less physical aggression performed (2.6%) compared to outside the feeding stations (16.2%) but in both cases most aggression was threat behaviour. (Table 4)

Table 4: A comparison of the percentages of the aggression shown inside and outside the feeding stations

	Percentage (%) outside the feeding station	Percentage (%) inside the feeding station
Total aggression	100,0	100,0
Defensive aggression	6,7	39,4
Threat behaviour	5,3	38,4
Physical aggression	1,4	0,8
Offensive aggression	93,3	60,7
Threat behaviour	78,5	58,9
Physical aggression	14,8	1,8
Threat behaviour	83,8	97,4
Forehand	78,5	58,9
Backside	5,3	38,5
Physical aggression	16,2	2,6
Forehand	14,8	1,8
Backside	1,4	0,8

Table 5: Total frequency of aggression at Location 2 also expressed in % and Times/horse

	Total location 2	Percentage %	Times/horse
Total aggression	1777	100	0.40
Defensive aggression	524	29.5	0.15
Offensive aggression	1253	70.5	0.25
Threat behaviour	1658	93.3	0.39
Physical aggression	119	6.7	0.01
Aberrant behaviour	572	100	0.06

The total frequency of the aggression at location 2 can be seen in Table 5. In total offensive aggression accounted for 70.5% compared to only 29.5% of defensive aggression. Threat behaviour was with 93.3% prevalent in comparison to physical aggression which was low with only 6.7%.

Table 6, shows a comparison of aggression and aberrant behaviour shown inside and outside the feeding station in times/horse.

The aggression outside the feeding station was very low (total aggression: 0.023 times/horse) compared to the aggression shown inside the feeding station (total aggression: 0.38 times/horse) (Table 6).

Table 6: A comparison of the aggression and aberrant behaviour inside and outside the feeding stations (FS) at Location 2

	Aggression inside the FS in times/horse (frequency/total horses in the radius)	**Aggression outside the FS in times/horse** (frequency/total horses in the radius)*0.25 (weighting factor)	**Total aggression for location 2 in times/horse** (frequency/total horses in the radius)
Total aggression	0.38	0.023	0.4
Defensive aggression	0.15	0.002	0.15
Offensive aggression	0.23	0.021	0.25
Threat behaviour	0.37	0.019	0.39
Physical aggression	0.001	0.004	0.01
Aberrant behaviour	0.045	0.018	0.06

As shown in Table 6, the average frequency of the total aggressive behaviour of location 2 was 0.4 times/horse.

The average frequency of the total offensive aggression per horse was with 0.25 times higher compared to the defensive behaviour displayed per horse (0.15 times). (Table 6)

The average frequency of the threat behaviour was with 0.39 times/horse considerably higher than the average frequency of the physical aggression (0.014 times/horse). (Table 6)

The average frequency in times/horse is the average frequency of times that aggressive or aberrant behaviour occurred per horse within one observation day.

Table 7 shows the total aggression at location 2 in times per horse per day. However, it has to be kept in mind that this calculation is only based on data collected between 10am and 6pm and is therewith not truly representative for one 24 hour day.

Table 7: Aggression at location 2 in times per horse per day

	Aggression inside the feeding station in times/horse/day	Aggression outside the feeding station in times/horse/day	Total aggression location 2 in times/horse/day
Total aggression	1,3	0,08	1,4
Defensive aggression	0,51	0,01	0,5
Offensive aggression	0,79	0,07	0,9
Threat behaviour	1,27	0,07	1,33
Physical aggression	0,003	0,01	0,02
Aberrant behaviour	0,15	0,06	0,2

Furthermore, no correlation could be found between both, the total aggression shown outside the feeding station and the number of horses within the radius (correlation coefficient = 0.005) and the total aggression shown inside the feeding station and the number of horses within the radius(correlation coefficient = 0.144) (See Appendix 8 and 10).

The aggression further varied between days ($P<0.001$) but was not found to be influenced by weather (See Appendix 9 and 11).

4.2.2 Aberrant behaviour

The aberrant behaviour inside the feeding station was low with an average frequency of 0.045 times per horse and an average frequency per day of 0.2 times per horse.

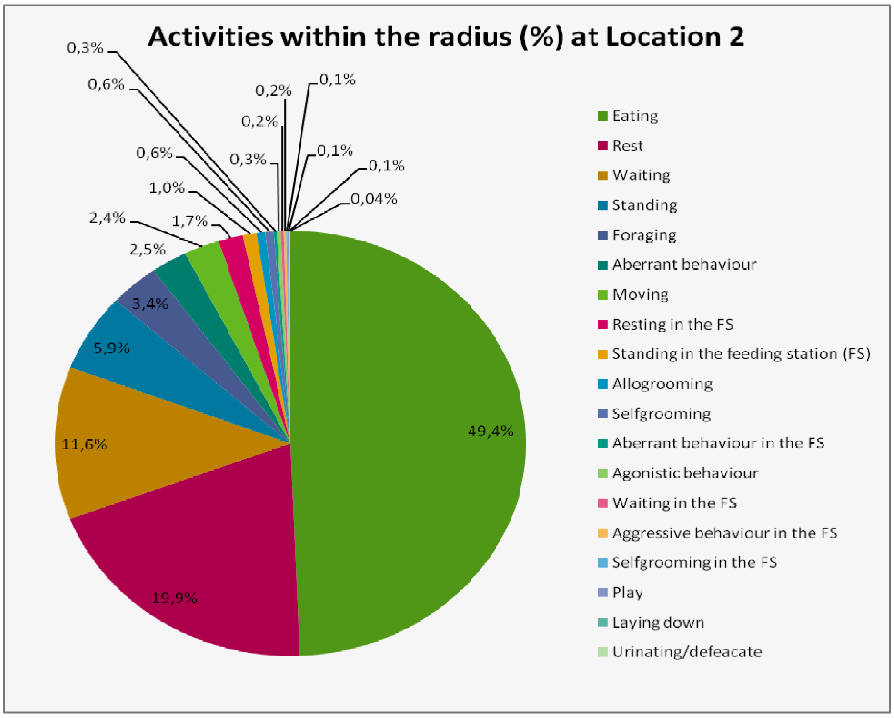
The aberrant behaviour outside the feeding stations was low as well with an average frequency of 0.018 times per horse and an average frequency per day of 0.08 times per horse.

The average frequency of the aberrant behaviour shown per horse and per horse per day was higher inside the feeding station than outside. The total aberrant behaviour of location 2 was low with 0.06 times/horse.

4.2.3 Daily activities

At location 2, the activities of the horses within the radius (including the behaviour in the feeding stations) have been recorded in 8 days with an observation period of 7 hours each. The observation intervals were always from 10.00h - 12.00h and from 13.00h – 18.00h in which a data set of 3.5 hours was collected which equals 105 scan samples each day. Figure 4 shows the percentage of the activities scored of the horses in the radius.

Figure 4: Activities scored in Location 2 in percent (%)



Eating was the main activity with 49.4% followed by resting behaviour with 19.9%. The waiting behaviour accounted for 11.6%; 5.9% of the time the horses were standing and foraging accounted for 3.4% of the time. The horses in the radius outside the feeding station displayed aberrant behaviour for 2.5% of the time. Moving accounted for 2.4%, resting in the feeding station for 1.7% and standing in the feeding station for 1.0%. The following behaviours measured accounted each for less than 1%: allo-grooming, self-grooming, aberrant behaviour in the feeding station, agonistic behaviour, waiting behaviour within the feeding station (FS), aggressive behaviour in the FS, self-grooming in the FS, play, laying down and urinating/defecating.

4.3 A Comparison of both locations

4.3.1 Aggressive behaviour

Table 8: A comparison of the total aggression at both locations, also expressed in percent (%)

	Total location 1	Aggression location 1 in %	Total location 2	Aggression location 2 in %
Total aggression	2517	100.0	1777	100.0
Defensive aggression	190	7.6	524	29.5
Offensive aggression	2327	92.4	1253	70.5
Threat behaviour	1971	78.3	1658	93.3
Physical aggression	546	21.7	119	6.7

As can be seen in Table 8 the total aggression at location 1 is higher than at location 2. When, however, taking into account the horses within the radius that could have performed the behaviour the average frequency per horse was significantly higher in location 2 with 0.4 times/horse significantly higher than in location 1 with 0.08 times/horse (Table 9). As can be seen in Table 8, the threat behaviour was at both locations higher than the physical aggression but the physical aggression at location 1 was considerably higher (21.7%) than at location 2 (6.7%). The offensive aggression was at both locations higher than the defensive aggression but the defensive aggression was considerably higher at location 2 with 29.5% compared to 7.6% at location 1 (Table 8).

Table 9: A comparison of the aggression and aberrant behaviour of Location 1 and 2 in times/horse

	Total aggression at Location 1 in times/horse	**Total aggression at Location 2 in times/horse**	**Sign. (P-value)**
Total aggression	0.08	0.4	<0.001
Defensive aggression	0.006	0.15	<0.001
Offensive aggression	0.074	0.25	<0.001
Threat behaviour	0.063	0.39	<0.001
Physical aggression	0.018	0.014	0.870
Aberrant behaviour	0.007	0.06	<0.001

As mentioned above the average frequency of the total aggression per horse is significantly lower in location 1 compared to location 2 ($P<0.001$). The average frequencies of the defensive and the offensive aggression as well as the threat behaviour were in all cases significantly higher ($P<0.05$) in location 2 than location 1. As can be seen in Table 9, the P-value for all just mentioned aggressive behaviours was <0.001. Only the average frequency of the physical aggression was not significantly different ($P>0.05$) between the locations with a P-value of 0.870 (Table 9). (see Appendix 12)

The average frequency of the total aggression per horse per day was considerably higher in location 2 with 1.4 times than location 1 with 0.1 times.

4.3.2 Aberrant behaviour

The total aberrant behaviour at location 2 was with 572 times (426 times outside the feeding station and 146 times inside the feeding station) considerably higher than at location 1 with a total of 219 times. Table 9 shows that the aberrant behaviour in location 2 was with 0.06 times/horse significantly higher ($P<0.001$) than at location 1 (0.007 times/horse). As can be assumed, also the average frequency per horse per day was higher at location 2 with 0.2 times than at location 1 with 0.01 times.

4.3.3 Daily activities

As can be seen in Figure 3 and 4 the main activities in both locations were eating and resting. In location 1 the horses spent considerably more time eating (80%) than in location 2 (49%). The resting behaviour accounts for about 22% in location 2 and only for 13% in location 1. In location 2 waiting was the third most displayed behaviour with about 12%, in location 1 waiting ranked 6th with 0.4%. Standing was the third most displayed activity in location 1 (2%) and the 4th most in location 2 (12%). Eating, resting, waiting and standing in location 2 accounted for the same amount of time as eating, resting and standing did in location 1.

Foraging was the 5th most displayed behaviour in location 2 whereas this activity scored last in location 1. The aberrant behaviour displayed ranked 6th in location 2 with almost 3% whereas it was on one of the lower ranks at location 1 with only 0.1%.

Grooming behaviour like self-grooming and allo-grooming rank higher in location 1 compared to location 2, however, the activity self-grooming was with 0.7% higher in location 2 than location 1 with 0.4%. Allo-grooming, however, was displayed more often in location 1 with 1% than in location 2 with 0.6%.

Although moving scored rank 4 in location 1 and rank 7 in location 2, the activity accounted for 2.5% in location 2 and only 1% in location 1.

All activities each accounting for less than 1% (self-grooming, agonistic behaviour, play, urinating/defecating, laying down) are similar in location 1 and 2 apart from allo-grooming that accounted for 1% in location 1 but below 1% in location 2; and foraging, waiting and aberrant behaviour that ranked 3rd, 5th and 6th in location 2 with more than 1% but accounted for less than 1% in location 1.

Figure 5: Activities scored in location 1 (thirteen categories) in percent (%)

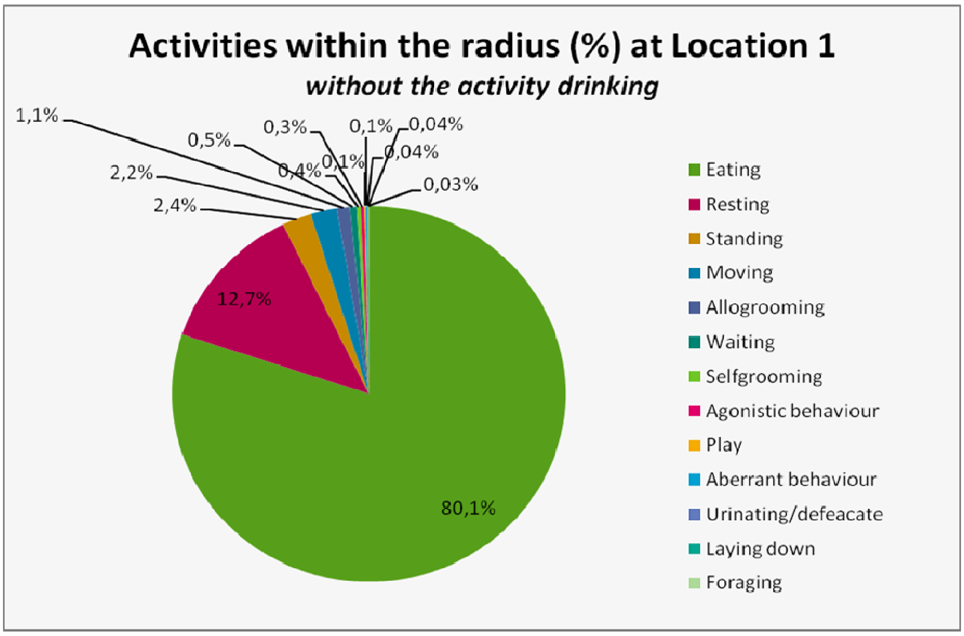
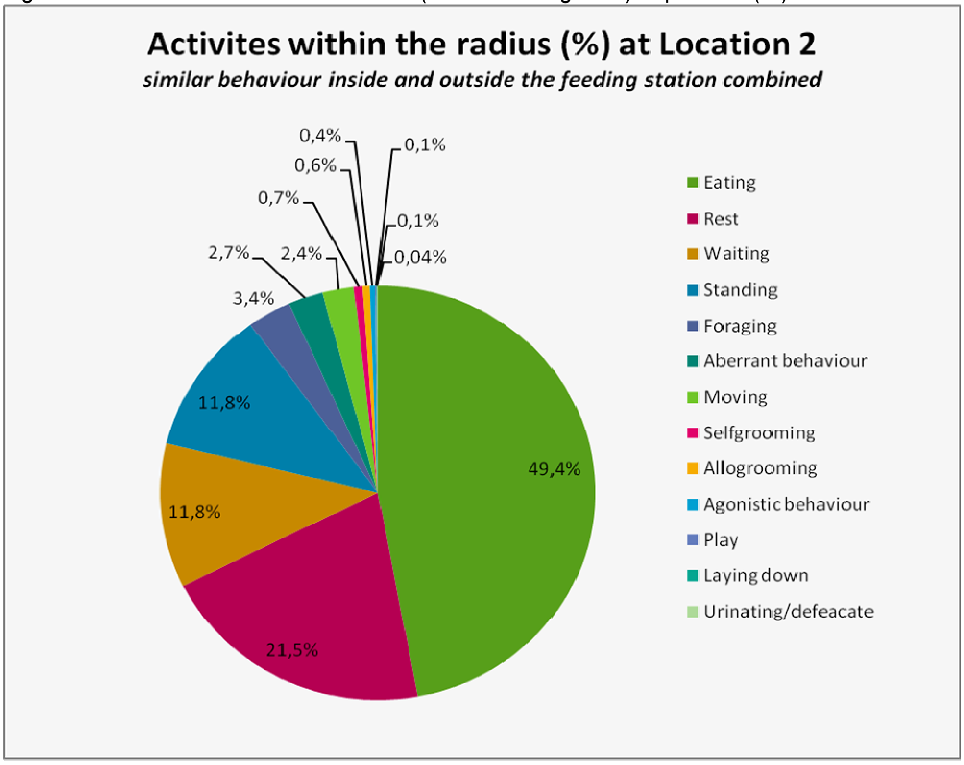


Figure 6: Activities scored in location 2 (thirteen categories) in percent (%)



5. Discussion

5.1 Aggressive behaviour

The aggression at location 2 (the automatic feeding system), was higher inside with 1.3 times/horse/day compared to 0.1 times/horse/day outside the feeding stations. Threat behaviour inside the feeding stations were higher than physical aggression. The offensive aggression inside and outside the feeding stations was higher than the defensive aggression but the defensive aggression was higher inside the feeding stations than outside. This could mean that the horses inside the feeding stations felt more threatened by other horses leading to more offensive behaviour to avoid that they would come closer. The increased defensive behaviour might be an indicator for the fact that the use of the hindquarters is more efficient in defending the feeding station against waiting horses. The findings do not correspond with the findings of Streit et al. (2008) which showed that the horses inside the feeding stations did not display as much aggressive behaviour as outside the feeding stations and could compared to horses in feeding stalls eat more undisturbed. In fact, the frequency of aggression showed inside the feeding stations was similar in this study (1.3 times/horse/day) and the study of Streit et al. (2008) (1.4 times/horse/day). However, physical aggression was higher in the study of Streit et al. (2008) with 0.9 times/horse/day compared to 0.003 times/horse/day in this study. Threat behaviour logically was then higher in this study (1.27 times/horse/day) compared to the study of Streit et al. (2008) (0.5 times/horse/day). The differences might have been caused by the definition of physical behaviour, in this study only kicks and bites with contact were scored as physical aggression whereas in the study of Streit et al. (2008) all bites, kicks and attacks were scored as threats with risk of injury which does not necessarily mean that they include physical contact.

Altogether, total aggression recorded was much higher in the study of Streit et al. (2008) with 13.8 times/horse/day compared to a total of 1.4 times/horse/day at location 2 in this study. One might assume that the group size played a role as in the study of Streit et al. only middle sized groups of 9-21 horses were used an in this study the group was as big as 50 horses. However, in this study the number of horses in the radius was not correlated to either the aggression shown inside the feeding stations nor the aggression shown outside the feeding stations. A possible cause for the large differences might be the observation period of only seven hours in this study, which might not reflect the true frequency of aggression in a 24-hour-period that was used in the study of Streit et al. (2008).

At location 2, threat behaviour was higher than physical contact which was also found by Streit et al. (2008). However, the percentages of threat behaviour per day were much higher in this study with 97% compared to 70% in the study of Streit et al. (2008). This might have been also related to the above mentioned differences in definitions of aggression.

Overall, aggression in both locations of this study was mainly threat behaviour which corresponds to findings in feral horses. Usually threats are prevalent even in situations where resources are restricted like for instance at a water hole where Berger (1977) recorded 24 percent aggressive behaviour that was more than a mild push or threat, or in winter when food is scarce Baskin (1976) recorded a 22.6 percent occurrence of 'violent' aggression. These figures are comparable with the physical aggression found at location 1 (21.7%) before that frequency was adjusted to the amount of horses present. The physical aggression at location 2 was much lower with only 6.7%. Also Keiper and Receveur (1992) found that within the herd of Przewalski-horse they observed in the Netherlands, displacements or threats were much more prevalent than kicks or bites. Physical aggression also means an increased risk of injury which is in this case higher at location 1 than 2.

At both locations offensive behaviour thus behaviour displayed with the forehand was higher than defensive behaviour (displayed with the hindquarters). Also Waring (2003) states that bite threats are most common of the mid-level aggressive behaviours. Kicks are considered the most aggressive act of a horse (Tyler 1972) thus they are only displayed if really necessary which would explain their low incidence also in this study. The higher incidence of defensive aggression at location 2 might be explained by the increased use of the hindquarters when the horses were in the feeding stations. It can be assumed that threats with the hindquarters are in this position more effective when used against a waiting horse than the threats with the forehand probably also because of visuality.

Overall the aggression at location 1 was higher than at location 2 which can be explained by the fact that more horses are present near the troughs at the same time resulting in more aggression as the space is limited and the invasion of the personal space of certain individuals can not be avoided. Further, within the area observed there were two resources provided, water and feed. Therefore, the aggression recorded also includes competition for the resource water and might therefore in reality also be lower for feeding. When looking at the aggression frequencies per horse it was shown that the aggression level per horse at location 1 was significantly lower with 0.08 times per horse compared to 0.4 times compared to location 2. This result indicated that simultaneous eating is less stressful to the individual horse than is an asynchronic feeding system. The risk of injury, however, is not significantly different between both systems looking at the frequency of physical aggression displayed per horse.

As in this study no individual data has been collected it is difficult to determine certain factors that might have had an influence on the display of aggressive behaviour.

The weather did not have an influence on the different frequencies of aggression displayed between days.

One might assume that the frequency of aggression displayed was dependent on the number of horses present. In this study, however, no correlation was found between the aggression displayed and the number of horses in the radius; that was true for location 1 and location 2 for both inside and outside the feeding stations. This might suggest that there was sufficient space provided overall. Other factors related to management that could have had an influence were stable design and management practices (Streit et al. 2008). However, as in this study the feeding systems were only tested in one setting (= in one location) the influences of those factors could not be determined. The amount of hay could have had an influence on aggression (Streit et al. 2008) at location 1 where the amount of hay decreased throughout the day. Also the activities at the yard (lesson schedule, competitions etc.) might have had an influence in terms of the disruption of the homeostasis of the group by increased numbers of people within the area of the horses or increased flux of horses leaving or rejoining the group.

Another factor that might have influenced the display of aggression was the rank of the individual horses inside the group. In the studies of Cox (2007, unpublished) and Streit et al. (2008) the rank had an influence on the aggression displayed. In both studies the horses higher in rank displayed the most aggression. That would mean that some horses are displaying more aggression than others and that the frequency of aggression is therefore dependent on which kind of horses are present within the radius.

Further, group composition might have had an influence on the frequency of aggression displayed. In both studies (Streit et al. 2008 and Cox 2007, unpublished) the sex of the animals played a role; geldings in general were displaying more aggressive behaviour than mares. In a study of Wells and Goldschmidt-Rothschild (1979), however, mares were found to be most aggressive. Also breed might have had an influence as in the study of Streit et al. (2008) breed was partly influencing the display of aggression (warmbloods tended to display more aggressive behaviour than other breeds). Another group composition factor might have been the residency, thus the date of the last introduction of new animals might have played a role. At location 2, for instance two new young horses were introduced into the group during the observation period and at location 1 the last horse was introduced in April 2009. Interesting might be as well what kind of influence the genetic factor had on aggression. At location 1 for instance a lot of horses were related to each other which might have had an influence on how well other horses were accepted in the group but might also have had an influence on the level and kind of aggression within the group altogether.

5.2 Aberrant behaviour

At both locations the frequency of aberrant behaviour was low with 0.2 times per horse per day at location 2 and with 0.01 times per horse per day at location 1. The total aberrant behaviour was significantly higher at location 2 than at location 1. One reason for the increased display of aberrant behaviour at location 2 could be the increased meal frequency that can only be provided to a few horses at the same time. Others therewith might react similar to the horses in the study of Cooper et al. (2000) in which the frequency of stereotypic behaviour increased in the control group that was in visual contact with the animals that received several meals a day. As horses in an automatic feeding system constantly are exposed to other horses eating this might also be true for group housed horses fed sequentially. Considering that the aberrant behaviour shown at location 1 was significantly lower it can be assumed that the feeding system of group housed horses has an impact on the aberrant behaviour displayed. However, the history of the horses play an important role in the question on how high the impact of the feeding system on such behaviour might be.

Also interesting was that the aberrant behaviour patterns where quite different with regards to both locations. At location 1 only crib-biting was performed whereas at location 2 twelve different aberrant behaviour patterns were displayed (See Appendix 2). The locomotor stereotypies shown are known to be expressed pre-feeding and are mainly seen as learned behaviour to positive reinforcement through the following provision of food. The latter could develop because of the plastic barriers regulating access to the feeding stations. During the observations it seemed that especially when a feeding station was empty and the restricting barrier had not opened yet to allow access to the available feeding spot, often pre-feeding locomotor stereotypies were performed. The same seemed to happen within feeding station 4 in which horses first needed to wait until the wall, that provided access to feed scrawled down. The stereotypic behaviour would then finally be reinforced by the provision of feed through either the wall that scrawled down or the barrier that opened. Oral stereotypies like the ingestion of faeces suggest deficiencies although mineral stones are provided. This behaviour, however, was displayed at very marginal level. Other oral stereotypies like wood-chewing, crib-biting and mouth movements like licking and sham-chewing are implicated with the motivation to eat or the restriction of fibre access. This behaviour was shown by several horses at location 2. The limited control of the animal on time and length of feeding, that has been mentioned earlier, could be a reason for that. In the study of Gieling (2007, unpublished) it was mentioned that the entering frequencies were low and related to rank. This would in practice cause prolonged periods in which no forage is consumed that again would increase stomach acidity which is known to be one of the main causes of oral stereotypies. Social factors thus seem to have an influence on how well the electronic stations work in practice. As in this study no data on individuals was recorded such causation, however, can only be assumed. Another difference that especially might explain the increased patterns of oral stereotypies could be the provision of additional straw that was provided at location 1 but not at location 2. Straw was recommended to decrease aggression but also has been shown to decrease oral stereotypies as it provides the animal with the possibility to display natural foraging behaviour. In sows various studies proved that provision of straw can reduce aggression, tail biting but also other stereotypic behaviour (Fraser 1975, Burbidge et al. 1994, Spoolder et al. 1995, all cited in Tuyttens 2005) and also in cattle straw was shown to increase eating and ruminating behaviour and to cause a decrease in oral stereotypies (Tuyttens 2005).

At location 2 the aberrant behaviour inside the feeding station was slightly higher than outside the feeding station; 0.15 vs. 0.06 times/horse/day. Also here it needs to be taken into account that “outside the feeding station” is only the restricted area around the feeding stations thus the frequency of aberrant behaviour shown in the whole area will be higher. Why the aberrant behaviour inside the feeding station is higher than outside the feeding station has at first sight no obvious reason or cause. Usually stereotypic behaviour is found pre- or post feeding. There are however two possible reasons: 1. in cases the feeder, especially feeder 4, was not recognizing the horses or their portion was already consumed the horses might have performed increased pre-feeding stereotypic behaviour like pawing. Also after the feeding barrier closed and no food was accessible anymore some horses stayed within the feeding station, some of them also might have performed aberrant behaviour because they wanted to regain access to feed; therewith the restricted control about the length of the feeding period as well as the time of feeding might play a role. However, it was not recorded if horses were able to eat (rewarded or unrewarded visits) during this study –therefore this data might be useful and should be recorded in future studies. 2. the aberrant behaviour displayed is already in a stadium where it is independent from its original causes/cues, this process is called emancipation (Cooper et al. 1996). With age the stereotypies seem to be triggered by an increased set of stimuli than in their early stages and further seem difficult to control by normal control mechanisms of the horse. Emancipation can be seen in older animals that already had some experience with stabling, it is known that stereotypic behaviour can not be extinguished anymore even in an environment in which the causes for the development of the stereotypy are eliminated (Cooper and McGreevy 2002). Therefore, also the history of the animals might play an important role with regards to how much influence emancipation has on the aberrant behaviour displayed.

5.3 Daily routine

The behavioural activities observed directly around the feeding stations differed between locations. At both locations eating and resting were the main activities which corresponds to information found in literature; Waring (2003) for instance stated that in general eating and resting occupy most of the horses day. Waring also mentioned that one increases proportionally when the other decreases. At location 1, feeding accounted for 80% whereas resting accounted for about 13 %, at location 2, however, eating accounted only for 50% and resting therefore was increased and accounted for about 22%. Horses at both locations were spending most of the time eating and horses at location 2 spend 50% eating which lies in the natural span of time spend for eating which is according to Zeitler-Feicht (2004) 50-70% of the day. The horses at Location 2 spent a rather large amount of time eating with 80%. Reasons for this high percentage could be that the observation hours were only during feeding time (10 am – 6 pm), as the amount of hay provided would be consumed until the evening it can be assumed that no foraging behaviour is performed during night time and that during a true 24-hour-day the resting activity therefore would be higher which would cause a proportional decrease in feeding behaviour. The same can be assumed for location 2, just that here the time accounting for feeding might increase when taking into account a 24 hour period as all hay stations are accessible 24-hours a day. There have not been a lot of studies on the nocturnal foraging behaviour of horses. It can be said that there have been studies in which extensive nocturnal foraging of horses have been recorded (Keiper and Keenan 1980, Rubenstein 1981) and that grazing during night time is usually common in summer but not in winter. In how far a feeding system forces the horse to change its rhythm through eating or not eating at night time and the corresponding welfare implications are therefore not applicable, Zeitler-Feicht (2004), however, states that horses might be more flexible in their time budgets that one would expect. Furthermore, the increased time spend on feeding at location 1 might also be related to the quality of the diet. This might have been influenced by the low quality forage fed; horses have been found to spend about 10% more time feeding a day when the quality of feed provided ad libitum was poor compared to high forage quality (Berger 1986). However, it was found that 12 hours a day is the minimum time span a horse spends eating also if quality forage is provided (Zeitler-Feicht 2004). Another possible factor could be increased competition for food. In a study of Kiley-Worthington (1989) 8 grouped housed horses fed ad libitum hay and straw were found to eat for 57% of the time. The increased group size of 50 horses at location 1 might have had an influence on the competition in regards to food and therewith the amount of time spend for feeding needed to be increased to ingest the required amounts of forage.

Standing under natural conditions accounts for about 15 – 40% of the day of which 5-20% are spend awake and 10-20% in a dozing state (Zeitler-Feicht 2004). Around the feeding stations resting mainly occurred in a standing position only one or two youngsters at location 1 were laying down to rest and at location 2 only a pony was resting while laying down. The resting in a standing position at both locations therefore lies within the time budget of 10 – 20% mentioned by Zeitler-Feicht (2004). As just mentioned these behaviour patterns could change slightly in a true 24-hour day if feeding behaviour increases or decreases also it has to be kept in mind that only horses in a restricted area near the feed sources were scanned and that therewith the total resting but also standing time budgets might be different for the whole group. Standing awake accounted for only 2.4% at location 1 compared to about 12 % at location 2. Therewith the results of location 1 are just below the percentages spent standing under natural conditions which, however, might again be influenced by the observation period and that of course only horses within the radius were observed in contrast to figures mentioned by Zeitler-Feicht (2004) that are based on interactions within a group. Zeitler-Feicht (2004) mentioned that horses at pasture usually spend a considerable amount of time standing when there is no vegetation or other stimuli to move. Therefore, it can be assumed that in both systems enough stimuli is provided to keep the animal active in its environment. Interesting is that altogether eating, resting and standing at location 1 accounted nearly for the same amount of time (93%) as eating, resting, waiting and standing at location 2. Behaviour directly related to feeding which would mean foraging, waiting and eating accounted in total for 80.6% at location 1 of which 80.1% were spend on feeding. At location 2 these behaviours accounted in total for 64.6% which is means about 16% less time than at location 1. About 12 % were spent on waiting and about 3 % on foraging which accounts for about one quarter of the total feeding behaviour displayed. Thus, horses at location 2 are spending only 16% less time feeding (incl. waiting, foraging and feeding) but are actually waiting for food for a considerable period of time. Waiting expresses that they would like to eat but are not able to at that moment because the station is occupied. The motivation of the horse to eat is at that moment that high that it will wait actively in front of the feeding station and not do anything else. That foraging scores the 5th rank after eating, resting, waiting and standing shows that the horses natural behaviour to forage is still expressed although hay is offered several times a day. One reason for that could be that the horse is not able to control its feeding periods, that are scattered over the day, on its own; the length is determined by the computer and the number of bouts/entrances and the time at which the feeder may be accessed is determined by social factors like for instance rank (Gieling 2007, unpublished; Krüger and Flaugher 2008) and the amount of horses motivated to eat.

Allo-grooming was slightly higher at location 1 with 1.1% than at location 2 with 0.7%. The total comforting behaviour (allo-grooming and self-grooming) recorded around the feeding stations, however, was nearly the same at both locations (1.5 % at location 1 and 1.3% at location 2). According to this data the feeding system either has no influence or similar influence on comforting behaviour. As with all other behaviour observed exempt the eating and waiting behaviour the total frequency of comforting behaviour might be higher when considering the time budget of the whole group. There is very little information available on how much time accounts for comforting behaviour in feral horses. In a study of Pereladova (1999) a stallion in semi-wild conditions was found to spend 3% of his day displaying comforting behaviour (self-grooming, rolling, scratching, rubbing). In this study, however, comforting behaviour consisted of scratching, rubbing, self-grooming and mutual grooming and as the behaviour was only recorded around the feeding stations and not in the whole area, it is difficult to draw a conclusion from these figures.

6. Conclusion

With regards to aggression grouped housed horses displayed more aggressive behaviour during daytime when fed loose than when fed automatically; the frequency of the total aggression per horse, however, was significantly lower in the loose feeding system than within the automatic feeding system. This meant that the simultaneous feeding system is less stressful for the individual horse than the automatic feeding system. Altogether, the level of aggression in both systems was very low.

However, grouped housed horses showed slightly more threat behaviour when fed automatically than when fed loose. The physical aggression therewith was higher in the loose feeding system than in the automatic feeding system. The physical aggression per horse, however, did not differ significantly between groups which meant a similar risk of injury in both groups.

Grouped housed horses showed more offensive aggression when fed loose than when fed automatically. The increased defensive aggression in the automatic feeding systems is probably related to the increased use of the hindquarters within the feeding stations to effectively defend a the feeding space against waiting horses approaching from the back.

Grouped housed horses fed automatically showed more aggressive behaviour inside the feeding stations compared to outside the feeding stations. Thus the horses inside the feeding stations felt threatened and felt the need to defend their feeding space. The aggression outside the feeding station is, however, low which indicates that there is not a lot of competition within the radius around the feeding stations for a space within the feeding station.

The feeding system was shown to have an influence on the foraging, resting and standing behaviour of grouped housed horses. The percentage of standing awake was much lower around the feeding source in the loose feeding system compared to the automatic feeding system. The resting behaviour in the loose feeding system was lower than in the automatic feeding system and eating behaviour was higher in the loose feeding system compared to the automatic feeding system. Behaviour directly related to feeding which would mean foraging,

waiting and eating accounted for 16% less time in the automatic feeding system than the loose feeding system. Most time was spend on eating in both systems but especially the waiting periods were considerably higher in the automatic feeding system. The waiting periods take up 12% of the daily routine; during that time the motivation to eat is higher than any other motivation. Although the feeding system obviously has an influence on the expression of the just mentioned activities no indications poor welfare could be found when comparing the data of this study to results found in feral horses.
It was not clear if the feeding system had an influence on comforting behaviour or not as percentages at both locations were the same and data on the incidence of this behaviour is scarce.

Grouped housed horses fed automatically showed significantly more aberrant behaviour compared to group housed horses fed loose. Further more, they showed a broader pattern of aberrant behaviour mainly consistent of pre-feeding locomotor stereotypies and oral stereotypies associated with low fibre diets. These stereotypies might be related to the feeding system as the feeding station could cause pre-feeding stereotypies by positive reinforcement in the form of food. Oral stereotypies might be caused by the limited control of the animal over the lengths and frequency of the feeding periods. Additionally, the history of the horses might have an important influence on the incidence of aberrant behaviour in both systems. Further, the general level of aberrant behaviour was very low in both systems. Because of the low frequency of aberrant behaviour both systems can be recommended for feeding group housed horses.

Altogether, on the basis of the results of this study both group feeding systems can be recommended for group housed horses with regards to welfare.

7. Recommendations

Both feeding systems can be recommended for grouped housed horses because of the low incidences of aggressive and aberrant behaviour. Further, the systems have not shown to have a negative influence on the daily activities of the horses.
Although the overall incidence of aberrant behaviour was low, it seemed no coincidence that the aberrant behaviour in the automatic system was on the one hand higher but also occurred in a broader spectrum. Because of the type of stereotypies observed it is recommended to conduct some further research in this area. It would be for instance interesting to follow newly introduced horses that do not have a history of stereotypic behaviour and follow them over a longer period of time to see how they might react to the automatic system. Further it would be interesting to know if this feeding system would be a risk factor for the development of stereotypic behaviour; this information could only be provided with an epidemiological study. Because only the aberrant behaviour around the feeding stations was recorded it is assumed that the real frequency of aberrant behaviour is much higher when looking at the entire area and might therefore also contribute to the daily activities at a much higher percentage.

In relation to the above mentioned suggestions it is recommended to provide straw as additional source of feed in the automatic feeding system to enable the horses to gain back some control on when to eat and to express foraging behaviour. The straw rack therefore would not be offered because of high levels of aggression but because of the type of stereotypies observed (oral stereotypies). It would, however, be good to observe if a straw rack would increase competition and therefore aggression and if it in fact reduces stereotypic behaviour. In this way also emancipated stereotypies could be identified. Because the stomach would be less acidic and the motivation to feed hay would therefore not be that high, also a reduction of pre-feeding stereotypies is expected. If an additional straw rack can not be provided additional feeding stations would be another solution. Although aggression was low around the feeding stations and therewith it seemed that enough feeding stations were provided it might still be a possible cause of stereotypies that the horses' resting periods between feeding periods is too long. However, the occupation of the feeding stations has not been studied in this research, that is why this information should be included in the collection of data in future studies. As far as I am informed producers currently work on a combination of individual feed intake and simultaneous feeding which would basically be feeding stalls next to each other with the same mechanisms used in the automatic systems. That in fact, seems the best solution from a welfare point of view.

The higher levels of aggression inside the feeding station are likely to be related to rank with regards to what other authors recorded. However, there is a chance that within the feeding stations not the horses with the higher ranks show most aggression, it could also be that especially the horses at low and middle rank might be more disturbed during feeding because they feel threatened; horses at higher rank would not feel the need to express aggressive behaviour because they are avoided by other animals. Therefore, the aggression of low ranking animals might be higher and also the bite rate might increase compared to higher ranking animals like in pigs and cattle. Therefore, the reasons for why horses within the feeding stations express more aggressive behaviour in this study would be another topic for further research.

Moreover, the influence of feed restriction over night and its consequences for animal welfare would need further consideration. However, in the loose system a straw bedding was provided so that the horses could express foraging behaviour over night if they wanted to.

As the aggression in the loose feeding system did not seem to be related to the number of horses in the radius and therewith not to space provided, there are some other factors that might have influenced the overall incidence of aggression like for instance the group composition or the design of the stable. Further research is recommended with regards to these factors.

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Appendix 1: Ethogram of aggressive behaviour observed in both locations

Type of Behaviour	**Behaviour**	**Description**
Physical aggression	Attack (offensive)	One horse runs towards the other with clear speed (faster than walk) and bites, usually ears pinned
	Bite (offensive)	Opening and rapid closing of the jaws with the teeth grasping the flesh of another horse. Ears are pinned and lips are retracted
	Kick (defensive)	One or both hind limbs used to contact another horse. Ears often laid back.
Threats	Head threat (offensive)	Head lowered with ears pinned, neck stretched or extended toward the target. Lips often pursed. The pointing extension of the head and neck may be interrupted with momentary tossing, rotating gestures of the head
	Bite Threat (offensive)	Is similar to a bite but no contact is made. Neck is stretched ears are pinned back
	Kick Threat (defensive)	See kick. In kick threat, no contact is made with another horse.

Source: Adjusted from McDonnell (2003), Motch *et al.* (2007) and Gieling (2007, unpublished)

Appendix 2: Ethogram of all stereotypic behaviour recorded

Type of aberrant behaviour	**Name of aberrant behaviour**	**Definition**
Locomotor stereotypy	Weaving	Lateral swaying of the head sometimes combined with the swaying of the rest of the body including shoulders and picking up the front legs
	Head shaking, bobbing, tossing, nodding	Repeated, rhythmic head movements
	Stereotypic pawing	One foreleg lifted from ground, extended quickly in a forward direction, followed by movement backward dragging the toe against the ground in a digging motion – repetitive, seemingly aimless
	Stereotypic stomping	Lifting and lowering of a hind legs if deliberately striking the substrate, using one or both hind legs one at a time
	Wall kicking	Deliberate extension of the hind leg to contact the wall of the feeding station, using one or both hind legs alternately or simultaneously.
Oral stereotypy	Crib-biting	Grasping a surface (usually horizontal) with the teeth combined with the apparent engulfing of air accompanied with an audible ‘grunt’
	Grasping	The horse holds or bites stable fittings without apparent air ingestion
	Bar sliding	The horse slides along a metal bar with its teeth
	Wood chewing	Chewing and/or ingesting wooden objects such as fences or stall construction materials
	Sham chewing or tooth grinding	Repetitive tongue, mouth or jaw movements without any obvious food substrate in the mouth
	Repetitive licking of non-food items	Licking of the stable wall, floor, sides of the food buckets or other stable furniture
Abnormal ingestive behaviour	Coprophagy in adults	Ingestion of faeces

Source: Adjusted from McDonnell (2003) and Cooper and McGreevy (2002)

Appendix 3: List of Variables that have been recorded during scan sampling

Variable	Variable Description	Description of the activity
Feed_S	How many horses do eat within the feeding station, or around the trough	
Stand_S	How many horses are standing within the feeding station	
Rest_S	How many horses do rest in the feeding station	No locomotion; at minimum two of the following characteristics: one hind leg flexed, lower lip relaxed, ears aside and partly lowered, eyes partly completely closed; posture: standing
AB_S	How many horses display abnormal behaviour in the feeding station	
Aggr_S	How many horses do display aggressive behaviour in the feeding station	
Selfgr_S	How many horses do groom themselves in the station	comfort behaviour like nibbling, nibbling at the foreleg plus tail switching, scratching and rubbing
Wait_S	How many horses wait for the door of the feeding station to open (only observed in station 4 because of impeded access to forage)	Standing alert with ears/eyes focused on the feeding station/trough
Feed	How many horses do eat outside the feeding station or not out of the trough	
Rest	How many horses do rest in the radius of 2 horse lengths around the feeding station or trough	No locomotion; min. two of the following characteristics: one hind leg flexed, lower lip relaxed, ears aside and partly lowered, eyes partly completely closed; posture: standing
Allogr	How many horses do groom each other	Reciprocal coat care
Wait	How many horses do wait to get to the feeding station or the trough	Standing alert with ears/eyes focused on the feeding station/trough; and/or actively trying to get to the feed
Stand	How many horses are standing in the radius of the feeding station or trough	
Moving	How many horses are moving at the sample point in the radius of the feeding station or trough	
Play	How many horses do play in the radius around the feed source	Alone with object or with other individual, ears pointed sideways or to front
Selfgr	How many horses do groom themselves in the radius of the feeding station or trough	comfort behaviour like nibbling, nibbling at the foreleg plus tail switching, scratching and rubbing
Drink	How many horses do drink at time of sampling (only location 1)	
Faeces	How many horses do urinate or defecate	
AB	How many horses do show aberrant behaviour in the radius of 2 horse lengths around the feeding station or trough	stereotypic behaviour or abnormal ingestive behaviour
Agon	How many horses display agonistic behaviour at the sampling point	agonistic behaviour = avoidance, retreat, threat behaviour, physical aggression
Laying down	How many horses are laying down in the radius of the feeding station or trough at the sampling point	
Total No	total no. of horses are in the group at the sampling point (100% - not only horses in radius)	

Appendix 4: Calculations made to obtain the total dataset of location 2

	Data location 2 inside the feeding station (original values ≈ 210 intervals)	**Data location 2 outside the feeding station** (original values ≈ 840 intervals)	**Data location 2 outside the feeding station** (with weighting factor 0.25)	**Total of location 2 inside the feeding station *2**	**Total of location 2 outside the feeding station*2**	**Total location 2** (Total of location 2 inside the feeding station *2 + Total of location 2 outside the feeding station*2)	**Percentage (%)**
Total aggression	620	1074	268.5	1240	537	1777	100.0
Defensive aggression	244	72	18	488	36	524	29.5
Threat behaviour	239	57	14.25	478	28.5	506.5	28.5
Physical aggression	5	15	3.75	10	7.5	17.5	1.0
Offensive aggression	376	1002	250.5	752	501	1253	70.5
Threat behaviour	365	843	210.75	730	421.5	1151.5	64.8
Physical aggression	11	159	39.75	22	79.5	101.5	5.7
Threat behaviour	604	900	225	1208	450	1658	93.3
Forehand	365	843	210.75	730	421.5	1151.5	64.8
Hindquarters	239	57	14.25	478	28.5	506.5	28.5
Physical aggression	16	174	43.5	32	87	119	6.7
Forehand	11	159	39.75	22	79.5	101.5	5.7
Hindquarters	5	15	3.75	10	7.5	17.5	1.0
Aberrant behaviour	73	852	213	146	426	572	100.0

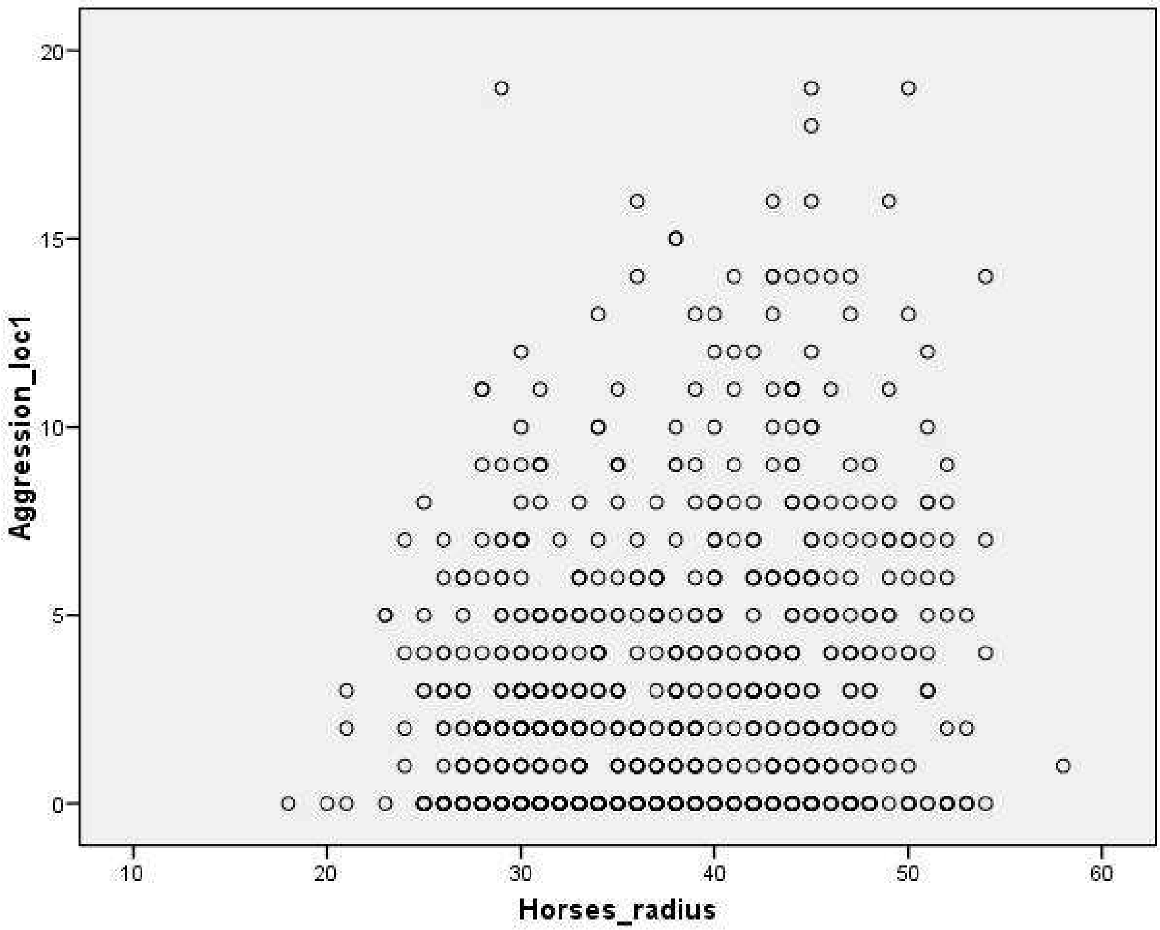
Appendix 5: Correlation between the aggression shown at location 1 and the number of horses in the radius

Correlations

		Aggression_loc1	Horses_radius
Aggression_loc1	Pearson Correlation	1	.223(**)
	Sig. (2-tailed)		.000
	N	840	840
Horses_radius	Pearson Correlation	.223(**)	1
	Sig. (2-tailed)	.000	
	N	840	840

** Correlation is significant at the 0.01 level (2-tailed).

Graph



Appendix 6: Comparison of means of aggressive behaviour at location 1 with a 'One way ANOVA'

Descriptives

Aggression_loc1

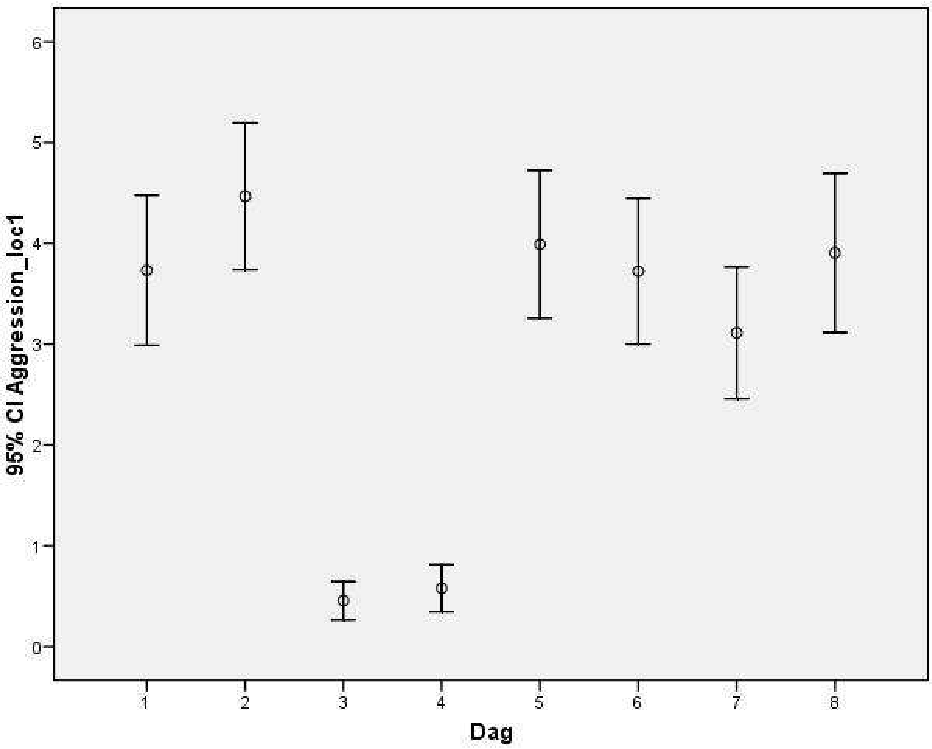
	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
	Lower Bound	Upper Bound	Lower Bound	Upper Bound	Lower Bound	Upper Bound	Lower Bound	Upper Bound
1	105	3.73	3.851	.376	2.99	4.48	0	16
2	105	4.47	3.760	.367	3.74	5.19	0	16
3	105	.46	.981	.096	.27	.65	0	5
4	105	.58	1.207	.118	.35	.81	0	7
5	105	3.99	3.786	.370	3.26	4.72	0	16
6	105	3.72	3.738	.365	3.00	4.45	0	19
7	105	3.11	3.378	.330	2.46	3.77	0	19
8	105	3.90	4.066	.397	3.12	4.69	0	19
Total	840	3.00	3.610	.125	2.75	3.24	0	19

ANOVA

Aggression_loc1

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1821.046	7	260.149	23.749	.000
Within Groups	9113.943	832	10.954		
Total	10934.989	839			

Graph



Appendix 7: The weather during the observation periods and the mean aggression

Location	Weekday	Date	Day	Cloudiness	Average temperature (Celsius)	Temp. max (Celsius)	Temp. min (Celsius)	Precipitation (mm)	Average airpressure (hPa)	Average wind speed (m/s; Bft)	Mean Aggression
1	Monday	06.04.09	1	half	13.3	19.5	5.2	0	1013.2	3.2/2Bft	3.73
1	Friday	10.04.09	2	half till heavy	17.6	24.6	11.3	0.1	1007.6	4.7/3Bft	4.47
1	Tuesday	14.04.09	3	Light	13.5	20.8	6	0	1010.1	2.7/2Bft	0.46
1	Thursday	16.04.09	4	heavy	15	20.1	10.1	0.9	1005.9	3.1/2Bft	0.58
1	Saturday	18.04.09	5	not cloudy	11.8	18.8	4.2	0	1015.1	5.7/4 Bft	3.99
1	Monday	20.04.09	6	not cloudy	13.7	20.5	4.8	0	1024.6	3.6/3Bft	3.73
1	Wednesday	22.04.09	7	half	9.9	15.8	4.9	0	1024.5	4.0/3Bft	3.11
1	Sunday	17.05.09	8	heavy	13.3	17.2	10.9	5.6	1012.4	3.7/3Bft	3.9
2[1]	Tuesday	07.04.09	1	heavy	11.5	16.4	8.5	0	1009.5	3.3/2Bft	3.5
2[1]	Saturday	11.04.09	2	half till heavy	16.9	22.7	11.4	3.8	1009.5	2.5/2Bft	2.58
2[1]	Monday	13.04.09	3	half	12.6	19.6	7.8	0	1009.7	2.5/2Bft	0.94
2[1]	Friday	17.04.09	4	half till heavy	12.6	17.9	8.2	2.8	1006.4	4.3/3Bft	0.79
2[1]	Sunday	19.04.09	5	light	11.6	17.8	6.7	0	1022.4	3.2/2 Bft	0.7
2[1]	Tuesday	21.04.09	6	not cloudy	12.8	20.8	4.3	0	1024.5	2.9/2Bft	0.51

2[1]	Wednesday	06.05.09	7	heavy	12.1	14.4	10.4	4.6	1015.4	4.7/3 Bft	0.72
2[1]	Thursday	07.05.09	8	half till heavy	13.4	17.6	10.4	0	1014.6	4.2/3 Bft	0.48
2[2]	Monday	04.05.09	1	half till heavy	9.5	14.8	1.9	0.2	1024.7	3.1/2Bft	0.7
2[2]	Tuesday	05.05.09	2	cloudy	11.1	13.5	8.2	7.6	1018.3	5.0/3Bft	0.96
2[2]	Thursday	08.05.09	3	half	12.3	17.8	7.7	0	1012.9	5.5/4Bft	1.05
2[2]	Friday	09.05.09	4	half	11.1	17.1	4.5	0	1017.7	2.5/2Bft	0.97
2[2]	Monday	27.04.09	5	heavy	12.1	15.7	8.9	2.8	1001.5	4.3/3Bft	0.48
2[2]	Tuesday	28.04.09	6	heavy	9.7	13.5	2.7	2	1003.1	3.1/2Bft	0.26

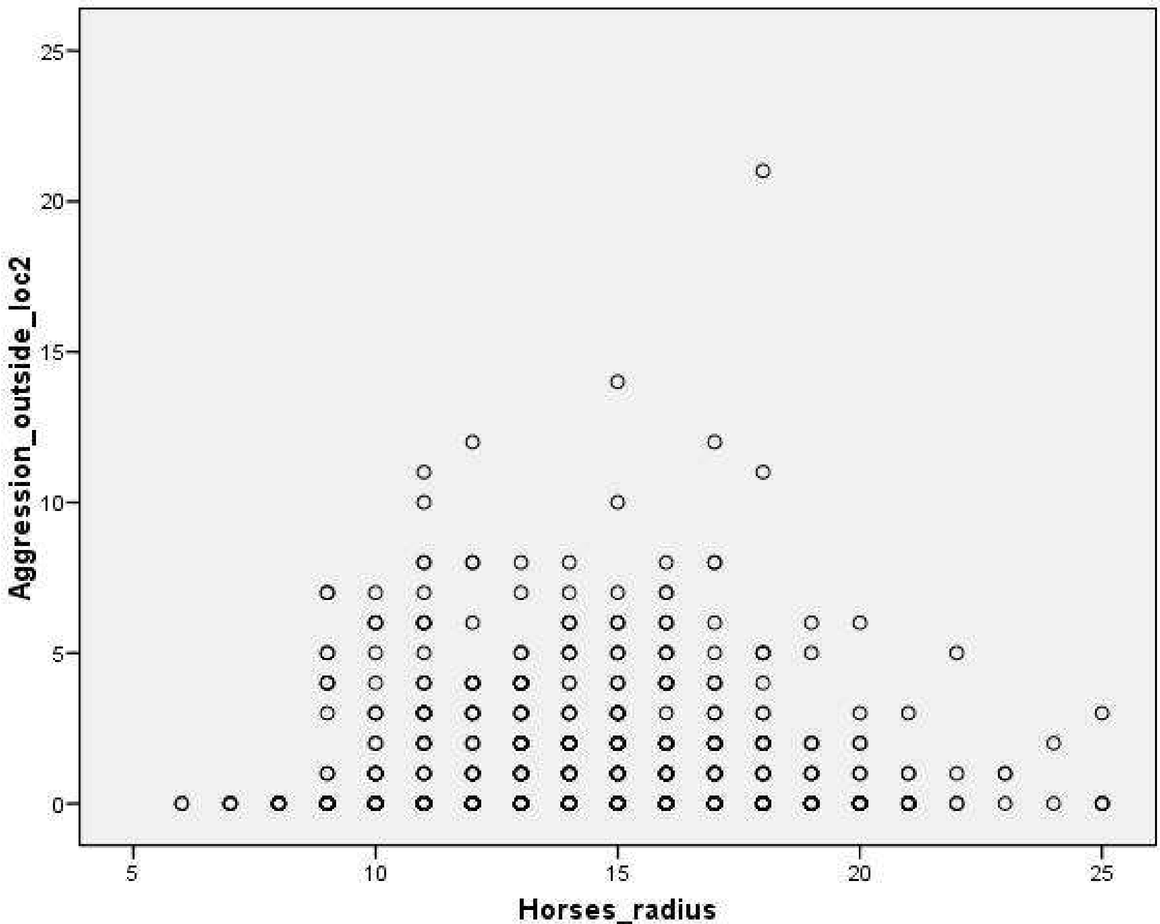
[1] Location 2 outside the feeding stations
[2] Location 2 inside the feeding stations

Appendix 8: Correlation between the aggression shown outside the feeding station at location 2 and the number of horses in the radius

Correlations

		Aggression_outside_loc2	Horses_radius
Aggression_outside_loc2	Pearson Correlation	1	.005
	Sig. (2-tailed)		.881
	N	840	840
Horses_radius	Pearson Correlation	.005	1
	Sig. (2-tailed)	.881	
	N	840	840

Graph



Appendix 9: Comparison of means of aggressive behaviour outside the FS at location 2 with a 'one way ANOVA'

Descriptives

Aggression_outside_loc2

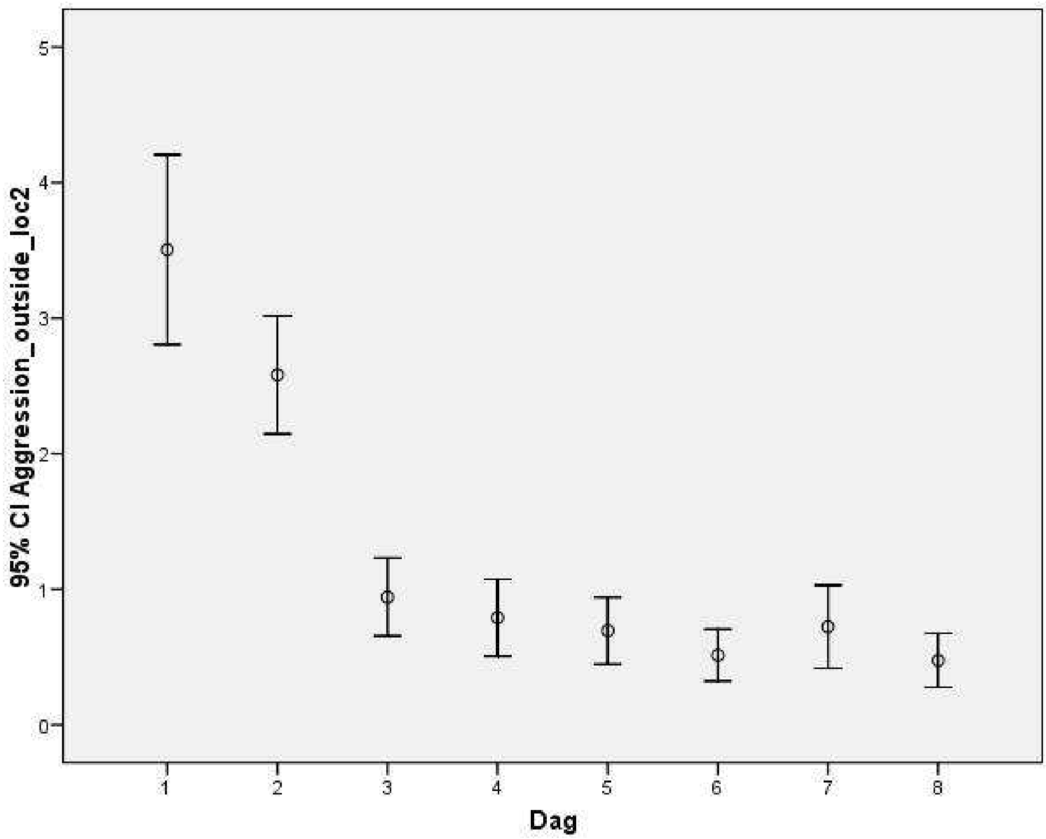
	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
1	105	3.50	3.617	.353	2.80	4.20	0	21
2	105	2.58	2.244	.219	2.15	3.02	0	8
3	105	.94	1.486	.145	.66	1.23	0	6
4	105	.79	1.466	.143	.51	1.07	0	7
5	105	.70	1.279	.125	.45	.94	0	6
6	105	.51	.982	.096	.32	.70	0	4
7	105	.72	1.578	.154	.42	1.03	0	12
8	105	.48	1.029	.100	.28	.68	0	6
Total	840	1.28	2.158	.074	1.13	1.42	0	21

ANOVA

Aggression_outside_loc2

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	932.300	7	133.186	37.228	.000
Within Groups	2976.514	832	3.578		
Total	3908.814	839			

Graph



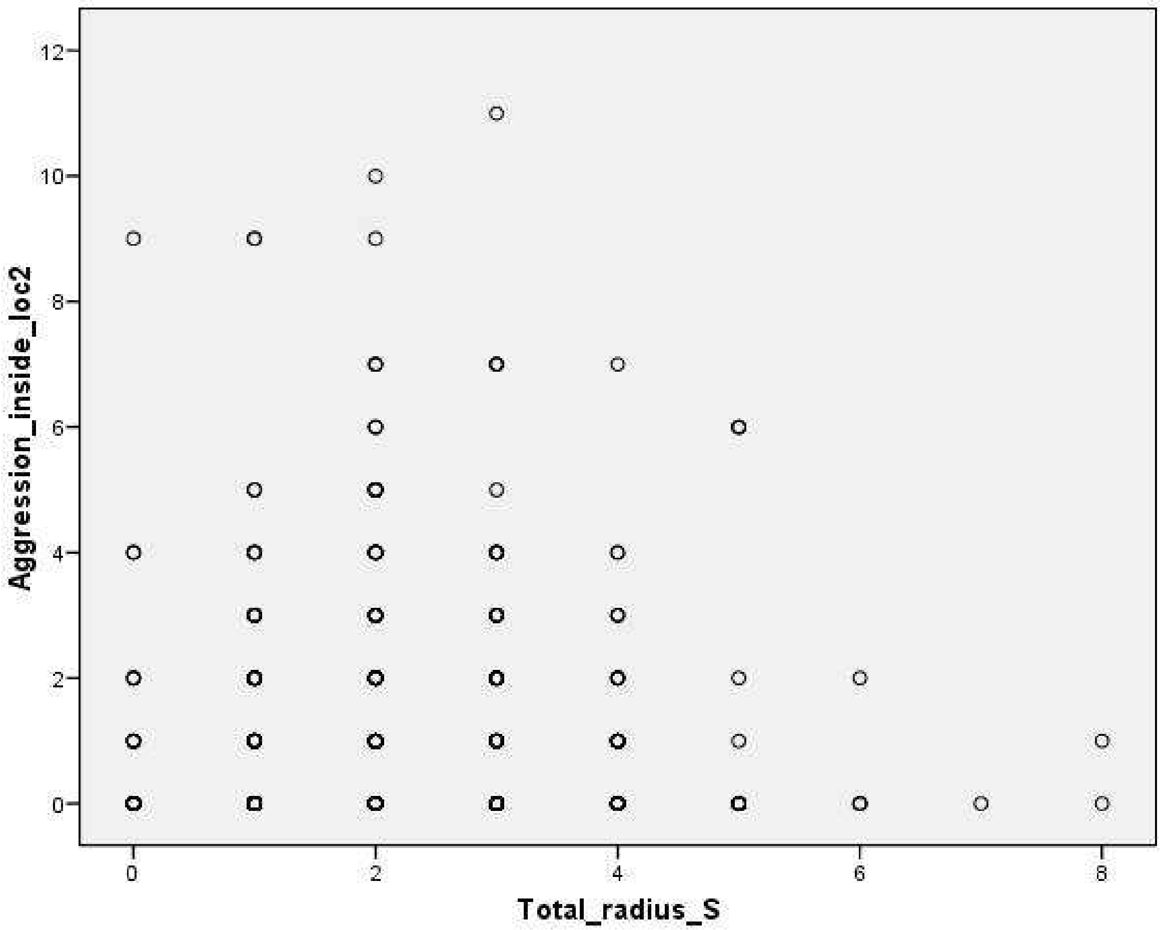
Appendix 10: Correlation between the aggression shown inside the feeding stations and the number of horses within the radius outside the feeding stations

Correlations

		Aggression_inside_loc2	Total_radius_S
Aggression_inside_loc2	Pearson Correlation	1	.144(**)
	Sig. (2-tailed)		.000
	N	840	840
Total_radius_S	Pearson Correlation	.144(**)	1
	Sig. (2-tailed)	.000	
	N	840	840

** Correlation is significant at the 0.01 level (2-tailed).

Graph



Appendix 11: Comparison of means of aggressive behaviour inside the FS at location 2 with a 'one way ANOVA'

Descriptives

Aggression_inside_loc2

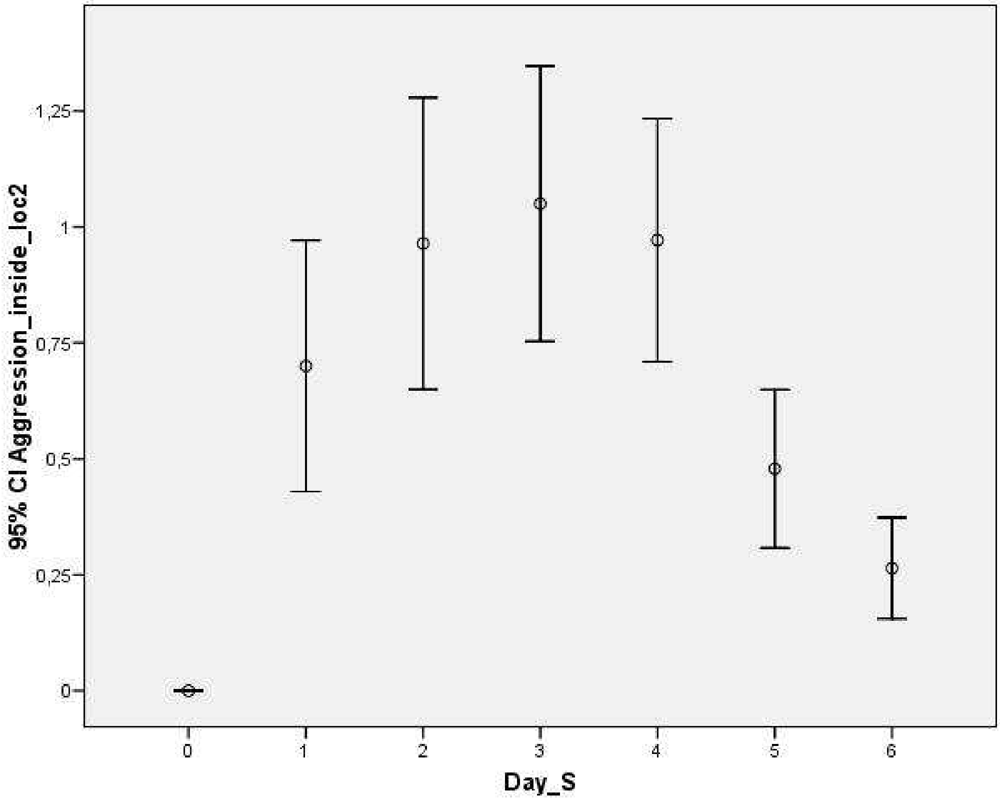
	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
1	140	.70	1.621	.137	.43	.97	0	11
2	140	.96	1.883	.159	.65	1.28	0	10
3	140	1.05	1.776	.150	.75	1.35	0	9
4	140	.97	1.568	.133	.71	1.23	0	9
5	140	.48	1.021	.086	.31	.65	0	5
6	140	.26	.653	.055	.16	.37	0	4
Total	840	.74	1.510	.052	.64	.84	0	11

ANOVA

Aggression_inside_loc2

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	69.467	5	13.893	6.287	.000
Within Groups	1842.914	834	2.210		
Total	1912.381	839			

Graph



Appendix 12: Comparison of the two locations with an Independent Sample T-test

Group Statistics

	Location	N	Mean	Std. Deviation	Std. Error Mean
total_defensive_perHORSE	1	840	,000007259	,0000213348	,0000007361
	2	840	,000181440	,0005496666	,0000189653
total_offensive_perHORSE	1	840	,000088867	,0001056797	,0000036463
	2	840	,000301881	,0006474977	,0000223408
total_threat_perHORSE	1	840	,000075274	,0000921903	,0000031809
	2	840	,000467187	,0008946565	,0000308686
total_physical_perHORSE	1	840	,000020855	,0000418381	,0000014436
	2	840	,000016130	,0001737504	,0000059950
total_aggression_perHORSE	1	840	,000096123	,0001158040	,0000039956
	2	840	,000483321	,0009345205	,0000322440
total_aberrant_perHORSE	1	840	,000008365	,0000284078	,0000009802
	2	840	,000075048	,0002580586	,0000089039

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
total_defensive_ perHORSE	Equal variances assumed	347,241	,000	-9,177	1678	,000	-.00017418	.000018980	-.00021141	-.00013695
	Equal variances not assumed			-9,177	841,528	,000	-.00017418	.000018980	-.00021143	-.00013693
total_offensive_ perHORSE	Equal variances assumed	376,618	,000	-9,410	1678	,000	-.00021301	.000022636	-.00025741	-.00016861
	Equal variances not assumed			-9,410	883,667	,000	-.00021301	.000022636	-.00025744	-.00016859
total_threat_perHORSE	Equal variances assumed	582,221	,000	-12,629	1678	,000	-.00039191	.000031032	-.00045278	-.00033105
	Equal variances not assumed			-12,629	856,816	,000	-.00039191	.000031032	-.00045282	-.00033101
total_physical_ perHORSE	Equal variances assumed	,027	,870	,766	1678	,444	.000004725	.000006166	-.00000737	.000016820
	Equal variances not assumed			,766	935,968	,444	.000004725	.000006166	-.00000738	.000016827
total_aggression_ perHORSE	Equal variances assumed	511,234	,000	-11,917	1678	,000	-.00038720	.000032491	-.00045092	-.00032347
	Equal variances not assumed			-11,917	864,761	,000	-.00038720	.000032491	-.00045097	-.00032343
total_aberrant_ perHORSE	Equal variances assumed	124,067	,000	-7,444	1678	,000	-.00006668	.000008958	-.00008425	-.00004911
	Equal variances not assumed			-7,444	859,331	,000	-.00006668	.000008958	-.00008426	-.00004910