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Der findes én visdommens vej,
det er den, som bør være let at erindre.
Dum dig og dum dig og dum dig igen,
men mindre og mindre og mindre.

Piet Hein

Preface

This thesis is intended to fulfil the requirements for the Ph.D. degree at the Royal Veterinary and Agricultural University (RVAU), Copenhagen, Denmark. The experiment was initiated in June 1997 when purchasing the foals for the first replicate, and the Ph.D. study was initiated in January 2000 as a collaboration between the research unit of Animal Behaviour and Stress Biology, Department of Animal Health and Welfare, Danish Institute of Agricultural Sciences (DIAS) and the Ethology Section, Department of Animal Science and Animal Health, RVAU. Due to my involvement in other projects related to horse behaviour and welfare the study period has been extended.

I would like to express my appreciation to my supervisors: Head of Research Unit Christian C. Krohn, Department of Animal Health and Welfare, DIAS, and Professor Jan Ladewig, Department of Animal Science & Animal Health, RVAU, for their inspiration, guidance and useful discussions before and during the study period. I would also like to thank Dr. Lindsay Matthews and co-workers at AgResearch, Hamilton, and Dr. Margaret Evans, Dr. Cliff Irvine and Dr. Sue Alexander, Lincoln University/Christchurch Hospital, Christchurch, for helping me organise my study period in New Zealand. The financial support from "Forsøgsleder R. Nørtoft Thomsens legat", "Studiefonden for Danmarks Jordbrugsvidenskabelige Ph.D.-forening", "Landlegatet", "Knud Højgaards Fond" and "Dansk Agronomforening" made the study tour to New Zealand possible and is highly appreciated.

Thanks are expressed to colleagues at DIAS, who have contributed with their encouragement, knowledge and technical skills during the project period. Special thanks to Jens Peter Nørgaard, Henrik Jensen, Tine Rytter, Birthe Ømark Jensen, Ellen Fritze, Ulrich Halekoh, Søren Højsgaard, Karen Thodberg, Birte Lindstrøm Nielsen, Lene Munksgaard, Janne Winther Christensen, Morten Kargo Sørensen, Margrethe Therkildsen and last but not least Erik L. Decker for always putting the Ph.D. study in the right perspective. Finally, I would like to thank Jørgen Konge for his hospitality, whenever I was/am in Copenhagen.

Horses have always been my hobby and for the last years my job, too. How many people are lucky enough to be paid to work with their hobby! Studying horses is a life long task; a task I hope to get the chance to proceed with as I feel there is still so much to do in improving the life of our domestic horses in favour of the horses and the many people who fancy them.

July 2003

Eva Søndergaard

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Summary

Horse life has changed from the life of a working animal to the life of a companion animal that is mainly used for sport and recreational purposes. In order to raise horses that are optimally prepared for the various tasks, for which horses are used, it is important to understand the different phases of behavioural development and the factors, which influence this development. It is important that the young horse learns the social communication of horses, and since most domestic horses live in some kind of social relationship with humans, it is equally important that the young horse learns the social communication with humans.

This thesis focuses on the young horse from weaning and onwards, and on the ways in which it is best prepared for adult life as a companion animal for sport or leisure. As background for the experimental part of the study an overview of the life of young horses under natural and domestic situations is given (Chapter 2). Under natural conditions young horses disperse from the harem group when they are about 2 years old and live in all-male bachelor groups or in mixed juvenile groups. For colts in the bachelor group play and other social activities facilitate the development of necessary skills for enabling the horse to take over a harem group usually at the age of 5 years or more. In domestic situations young horses are often deprived of social contact or they live in homogenous groups where the hierarchy may be less obvious due to the similarity in age. Management decisions may influence the development of behaviour for instance around weaning. Stereotypic types of behaviour, which are non-existent under natural conditions, have been shown to develop when the horses are very young. The degree to which management decisions influence the development of young horses is not well known which was the background for the experimental part of the study.

The aim of the study was to evaluate the effect of social environment and handling of young Danish Warmblood horses with respect to their behavioural and physical development with special emphasis on the human-animal relationship. For this purpose 40 Danish Warmblood colts were used in two replicates (Chapter 3). Within each replicate 8 horses were housed singly and 12 horses were housed in 4 groups of 3 horses. Half of the horses were handled 3 times per week during two winter periods, in total approximately 20 hours of handling. Apart from the housing and handling all horses were managed similarly concerning feeding, access to exercise, veterinary treatments etc. During the summer period all horses were pastured in one group. Tests to evaluate aspects of the human-animal relationship were performed throughout the experiment. Likewise, recordings related to the physical development were performed continuously.

The results from the present study are discussed in relation to other studies (Chapters 4 and 5). Social environment affected the level of activity when the horses were in the exercise paddocks. Group housed horses were more active and travelled longer than single housed horses. An expected additional effect in feed intake and parameters related to bone development was not found. Single housed horses showed more interest in humans and were easier to approach in the exercise paddocks than group housed horses. When a test of reactions towards humans was performed in a novel environment there was no difference between single and group housed horses. For the handled horses there was an effect of social environment on the behaviour in the training sessions. Single housed horses bit and kicked more often than group housed horses and passed fewer stages in the training program.

Handling did not affect the way horses reacted to a person in the home environment, but in a novel environment handled horses were caught sooner than non-handled horses. Handling did not affect the behaviour of horses in an arena test but handled horses had a lower basal heart rate and showed a lower rise in heart rate than non-handled horses when exposed to the novel environment. In the training scheme there was no correlation between the number of sessions needed to pass various stages indicating that there was no overall level of learning ability or tractability. Rather, tractability and learning ability seems to depend on factors like previous handling, the interaction with the trainer, the emotionality of the horse etc.

From the results of the present study and the literature it is concluded that group housing and handling exert a positive effect on the behaviour and emotionality of young horses. However, the composition of the group and the time spent in a group versus alone may influence the behavioural development of young horses. Likewise, the content of the training scheme rather than the time of handling should receive more focus.

Sammendrag

Hesten er skiftet fra at være arbejdsdyr til menneskets partner i sports- og fritidssammenhænge. Uafhængig af hestens anvendelse er det nødvendigt at forstå hestens adfærdsmæssige udvikling og hvilke faktorer, der påvirker denne, for at hesten kan være ordentligt forberedt på de oplevelser, den vil blive udsat for i sit voksne liv. Det er vigtigt, at ungheste i deres opvækst lærer at kommunikere med såvel andre heste som med mennesker, da det vil lette arbejdet med dem senere hen og mindske risikoen for, at de udsættes for ubehagelige oplevelser og skader.

Denne afhandling omhandler den unge hest fra fravænning til 2-års alderen, og fokuserer på hvordan den bedst forberedes på sit voksne liv som menneskets partner i sport- og fritidsaktiviteter. Som baggrund for den forsøgsmæssige del af studiet gennemgås i denne afhandling unghestens liv, som det foregår under naturlige og domesticerede forhold (Kapitel 2). Ungheste, der lever frit, forlader familiegruppen, når de er ca. 2 år gamle. Herefter lever de i ”ungkarle”(bachelor)-grupper eller i unghestegrupper, hvor begge køn er repræsenteret. For hingsteplagene i bachelorgrupperne udgør leg og andre sociale aktiviteter en vigtig del af adfærdsrepertoiret, og er med til at forberede hingstene på at kunne overtage en familiegruppe, når de er 5 år gamle eller mere. Domesticerede ungheste afskæres ofte fra muligheden for social kontakt, eller de lever i homogene grupper. I disse grupper kan rangordenen være uklar på grund af aldersligheden, idet alder/erfaring normalt vil være afgørende for rangordenen. Hesteholderen kan påvirke hestenes muligheder for at udvikle og udføre normal adfærd f.eks. i fravænningssituationen. Stereotypier udvikles ofte, mens hestene er ganske unge. Da disse adfærdsformer ikke ses hos vildtlevende heste, er det sandsynligt, at det er faktorer i de domesticerede hestes miljø, der udløser dem. Den manglende viden om, hvordan hesteholderens forskellige beslutninger påvirker unghestes udvikling, var baggrunden for den eksperimentelle del af det nærværende studie.

Formålet med undersøgelsen var at evaluere effekten af socialt miljø og håndtering på unge Dansk Varmblodshestes adfærdsmæssige og fysiske udvikling og med særligt fokus på dyr-menneskeforholdet. Til dette formål blev anvendt 40 hingsteplage, der indgik i to gentagelser. I hver gentagelse blev 8 heste opstaldet enkeltvis, mens 12 heste blev opstaldet i 4 grupper á 3 heste. Halvdelen af hestene blev håndteret 3 gange ugentlig i to vinterperioder, i alt ca. 20 timers håndtering. Bortset fra opstaldning og håndtering fik hestene samme behandling mht. fodring, adgang til fold, dyrlægebesøg m.m. (Kapitel 3). I sommerperioden var alle heste på fold i én stor gruppe. Der blev jævnligt udført tests til evaluering af dyr-menneskeforholdet, ligesom parametre relateret til den adfærdsmæssige og fysiske udvikling blev registreret.

Resultaterne fra nærværende undersøgelse diskuteres i afhandlingen i relation til andre undersøgelser (Kapitlerne 4 og 5). Det sociale miljø påvirkede hestenes aktivitetsniveau, når de var på fold. Gruppeopstaldede heste var mere aktive og bevægede sig længere end enkeltopstaldede heste. En forventet afledt effekt på foderoptagelse og parametre relateret til

skeletudviklingen blev ikke fundet. Enkeltopstaldede heste var mere nysgerrige overfor mennesker, og var nemmere at komme til end gruppeopstaldede heste, når de blev testet i hjemmemiljøet dvs. motionsfoldene. Når testen på reaktionen overfor mennesker blev udført i et ukendt miljø, var der ingen forskel på enkelt- og gruppeopstaldede heste. For de heste, der blev håndteret, sås en effekt af det sociale miljø på deres reaktioner i træningssituationen. Enkeltopstaldede heste bed og sparkede hyppigere end gruppeopstaldede heste, og de fuldførte ikke så mange trin i træningsprogrammet som gruppeopstaldede heste.

Håndtering påvirkede ikke hestenes reaktioner overfor mennesker i testene i hjemmemiljøet, men i testen i ukendt miljø kunne de håndterede heste fanges hurtigere end de uhåndterede heste. Håndtering påvirkede ikke hestenes adfærd i en arenatest, men håndterede heste havde en lavere puls før teststart, og deres puls steg mindre end de uhåndterede hestes. I håndteringsprogrammet var der ingen sammenhæng mellem de enkelte trin i antallet af træningsgange, der var nødvendige for at fuldføre et trin. Dette resultat indikerer, at der ikke er tale om en generel håndterbarhed eller indlæringsevne hos den enkelte hest. Det ser ud til at såvel håndterbarhed som indlæringsevne påvirkes af faktorer som tidligere håndtering, samspillet med træneren, temperament m.m.

På baggrund af resultaterne fra nærværende undersøgelse og litteraturen konkluderes det, at gruppeopstaldning og håndtering har en positiv indflydelse på unghestes adfærd og temperament. Det vil dog være nærliggende at undersøge, hvordan gruppesammensætning samt den andel af tiden hestene tilbringer i en gruppe – henholdsvis alene – påvirker adfærdsudviklingen hos ungheste. Ligeledes bør fremtidige undersøgelser fokusere på indholdet af et håndteringsprogram fremfor alderen, ved hvilken heste bør håndteres.

Uanset hullerne i vores viden kan det fastslås at gruppeopstaldning for ungheste og måske også for voksne heste bør fremmes. Ligeledes bør heste håndteres og selvom den ideelle metode endnu ikke er fastlagt er det vigtigt at give ungheste nogle tidlige og positive erfaringer med mennesker, så den senere træning lettes.

Photo by Eva Søndergaard

1. Introduction

Horse life has changed from the life of a working animal to the life of a companion animal that is mainly used for sport and recreational purposes. However, breeding and rearing of horses is still a farm issue and in some countries it constitutes an increasing importance in the rural economy (EU-Equus, 2001). In Denmark the number of horses is estimated to be about 175,000 horses, which are owned by approximately 72,000 families. Our knowledge of how these horses are kept and managed is very limited. Methods for keeping horses vary throughout the world. In Europe most adult horses are kept individually as indicated in surveys from Switzerland (Bachmann and Stauffacher, 2002a) and Denmark (Søndergaard and Christensen, 2002). Both surveys showed that most horses have access to pasture on a regular basis. In general horses have been successful in coping with intensive management practices. However, there is an increasing awareness of welfare and a concern about the high percentage of horses showing abnormal behaviour (McGreevy et al., 1995b; Bachmann and Stauffacher, 2002b; Søndergaard and Christensen, 2002; Waters et al., 2002), often at the expense of their health and performance.

In order to raise horses that are optimally prepared for the various tasks, for which horses are used, it is important to understand the different phases of behavioural development and the factors, which influence this development. It is important that the young horse learns the social communication of horses, and since most domestic horses live in some kind of social relationship with humans, it is equally important that the young horse learns the social communication with humans. In addition, the way young horses are housed is important because – in many cases – normal development requires specific features of the environment. Considering the importance of these different aspects of horse husbandry, it is somewhat surprising that relatively few studies have looked at the behavioural development of the young horse and that most of our knowledge is based on general experience alone.

This thesis focuses on the young horse from weaning and onwards, and on the ways in which it is best prepared for the adult life as a companion animal for sport or leisure. In the experimental part of the study the effect of the social environment and handling was studied in young Danish Warmblood horses in respect to the behavioural and physical development with special emphasis on the human-animal relationship.

The thesis comprises:

- An overview of the life of young horses under natural and domestic conditions (Chapter 2)

- A description of the experiment (Chapter 3)

- A review of effects of the social environment and handling on the behavioural and physical development of young horses. Whenever appropriate the results from the experimental part of the project (Paper I-III) are used in the discussion. (Chapters 4 and 5)

- A conclusion on the experimental study and the literature review, and the perspectives of the results. (Chapter 6)

Manuscripts prepared for publication

- Paper I. Activity, feed intake and physical development in young Danish Warmblood horses in relation to the social environment. Submitted for publication in Livestock Prod. Sci.
- Paper II. Young horses' reactions to humans in relation to handling and the social environment. Appl. Anim. Behav. Sci. (Accepted).
- Paper III. Group housing exerts a positive effect on the behaviour of young horses during training. Submitted for publication in Appl. Anim. Behav. Sci.

Photos by Janne Winther Christensen

2. Young horses in natural and domestic situations

The ontogeny of natural behaviour patterns has been investigated in a number of studies with the result that our present understanding of the process is primarily based on systematic analysis. But regarding the behavioural development of those behaviour patterns that are important for an adult horse in order to function harmoniously in a domestic environment, our understanding is primarily based on practical experience rather than systematic analysis.
This chapter will give an overview of the life of young horses under natural as well as domestic conditions.

2.1. The 'natural' life of young horses
Under natural conditions horses live in herds consisting of several groups of horses. The main groups are the reproductive units, i.e. the harem groups, and the bachelor groups, which are non-reproductive units. Mixed juvenile groups are relatively unstable units and do not occur in all herds (Waring, 2003).

Young horses under free-living conditions are usually weaned by the mare before her next foal is due (Feh, 2002; Waring, 2003), but will stay as part of the harem group. Fillies may become adult members of the group or disperse to other harem groups or mixed juvenile groups. Dispersal usually takes place when the fillies are 2 to 3 years old during an oestrous period in order to avoid inbreeding (Jezierski et al., 1998; Feh, 2002). The colts will usually leave the group when they are 2 to 3 years old and join other youngsters in a mixed juvenile group or other males in bachelor groups. Dispersal often takes place after an unsuccessful attempt at taking over one or more mares from the harem stallion whereafter the young stallions will leave voluntarily or be chased away by the harem stallion. (Feh, 2002). In a study by Boyd and Keiper (2002) 97% of young animals dispersed between the age of 1 to 4 years, fillies at an average age of 24.6 months and colts at 20.8 months of age. Young males may disperse alone or with peers (Boyd and Keiper, 2002). If they leave their harem group together with one or more fillies or meet fillies from other groups they may form a mixed juvenile group (Boyd and Keiper, 2002). Otherwise they will form or join a bachelor band where they will stay for 1 to 3 years (Feh, 2002). The bachelor group may contain older stallions as well. These may be old or sick males which have left their harem group or lost it to a younger stallion (Klingel, 1975). The mixed juvenile groups are non-reproductive due to the young age of the horses and tend to be unstable in composition (Boyd and Keiper, 2002). Occasionally horses, often males, are seen solitary (Pacheco and Herrera, 1997) but in general horses prefer to remain with companions (Waring, 2003).

In the harem group where most new individuals are born into the group there will usually be a stable linear hierarchy as demonstrated by the access to limited resources such as water, food or wind shelter although reversal relationships and triangles are seen. In small groups the hierarchy will usually be linear (Crowell-Davis, 1993). Key factors for determining the rank are age and order of arrival in the reproductive group i.e. experience (Crowell-Davis, 1993;

Dierendonck et al., 1995; Feh, 2002) although aggressive horses tend to achieve higher ranks than predicted by their size or age (Crowell-Davis, 1993; Boyd and Keiper, 2002). Adult stallions are usually dominant over the mares whereas the mothers' rank will influence the rank of their sons (Feh, 2002) and daughters (Jezierski et al., 1998) in the herd and correlate with their reproductive success. Dominance is different from leadership since it is often a mare that leads the group by initiating the movement for changing feeding ground or going to a drinking place (Feh, 2002). Also in the bachelor groups a hierarchy exists, and age and order of arrival in the group will be the key factors for determining rank together with individual temperament (Tilson et al., 1988).

The main social activity in the bachelor group is play fighting to measure strength, develop and train muscles and co-ordination, and establish a rank in the hierarchy (Hoffmann, 1985; Feh, 2002). Play is an important part of the behaviour repertoire for young horses. From the first day of life foals are seen to play solitary by galloping, high speed turns and sudden stops (Crowell-Davis et al., 1987). Object play or manipulative play appears early in the behavioural development of foals. Foals as young as two hours can be seen manipulating objects in their environment (Waring, 2003). Later object play can be performed alone or in a group (Goodwin and Hughes, 2002). Social play consisting of play fighting, neck wrestling and chasing has been seen from the first or second week (Tyler, 1972; Crowell-Davis et al., 1987). In the first month of life fillies and colts play the same but later colts play more than fillies. Solitary play is mostly seen in very young foals whereas social and object play can be seen in juveniles and in domestic situations also in adult horses (Goodwin and Hughes, 2002).

Social attachment is important for horses. Each horse usually has one or more preferred associates in the group. These associates receive more total aggression but in a milder form than other horses in the group (Crowell-Davis, 1993). Foals develop attachments during mutual grooming and playful interactions with other foals. These bonds may or may not persist into adulthood. In the bachelor group ties appear weaker than in the reproductive units. The young stallions will eventually shift their social organisation until they become members of a reproductive unit. This may require more than one change in social group and corresponding changes in social bonds (Waring, 2003). Mutual grooming is a means of bonding (Crowell-Davis, 1993), and as such an important part of the behavioural repertoire. It is especially frequent among immature horses (Waring, 2003).

At the age of 4 to 5 years, colts from the bachelor group are often seen in the proximity of reproductive units where they try to take over a mare or two. High-ranking stallions are on their own while two low ranking animals may co-operate and share the mares they take over (Feh, 2002). Young mares usually give birth to their first foal at an age of 4 years or more (Waring, 2003). This marks the end of the life as a young horse.

2.2. Young horses in domestic situations

The basic behavioural patterns of horses seem to be relatively unchanged by domestication (Christensen et al., 2002b). Essentially, all the types of behaviour seen in wild or feral horses are also seen in domestic horses unless management is preventing the expression of the behaviour. This will for instance be the case for sexual behaviour in castrated males or social behaviour in horses kept alone. The extent to which we manipulate the opportunities for the horses to express their natural behaviour pattern may depend on the use of the horse, e.g. in order to prevent injuries expensive competition horses may never be let loose in paddocks or allowed company with other horses. However, also a lack of knowledge of what it means to the horse not to be able to perform certain types of behaviour may affect management decisions. In many cases a precaution against obvious physical injuries may cause psychological damage to the horse.

Except for the interactions with humans the life of a domesticated foal until weaning is not very different from its wild living conspecifics. The foal is entirely dependent on the mare for feed but may be more protected than if living in the wild. Weaning of the domestic foal occurs when the foal is permanently separated from the mare. Apart from the separation weaning implies other changes for the foal, such as changes in feeding and in management. Weaning is considered to be stressful for the foal (Apter and Householder, 1996; Waters et al., 2002) and various experiments have investigated the possibilities of minimizing weaning stress. Habituating foal and mare to separation by separating them in short-term periods prior to weaning was found to have no effect on either mare or foal behaviour or cortisol response at weaning (Moons and Zanella, 2001). However, there may be an effect of experience as short-term separation affected first parity mares more than mares of later parity and younger foals reacted less than older foals (Søndergaard, 1998). Partial weaning in which mare and foal had visual, auditory and olfactory contact seems to be less stressful than abrupt weaning (McCall et al., 1985), but unfortunately it was not investigated how these foals later reacted to total separation from their mothers. In this study foals were weaned in pairs or triplets, which – in other experiments – has been shown to be more stressful than weaning singly (Malinowski et al., 1990; Hoffman et al., 1995). However, Houpt et al. (1984) found that foals weaned alone vocalised more than foals weaned in pairs indicating that they were more stressed although there was no difference between treatments in other types of behaviour or plasma cortisol. Heleski et al. (2002) compared foals weaned singly in stalls to foals weaned in groups on pasture and concluded that the latter had a better welfare. Perhaps the least stressful method of weaning is the gradual weaning described by Holland et al. (1996). They compared abrupt weaning where all mares were removed from a group of foals and mares, to gradual weaning where mares were removed 1 or 2 at a time every two days. All foals reacted to weaning behaviourally, but abruptly weaned foals reacted more than gradually weaned foals. The authors concluded that foals adapted to weaning better when left on pasture than when weaned in stalls, a method they had tried in a previous experiment (Hoffman et al., 1995). In the present experiment (Chapter 3) foals weaned singly or in groups of three showed no difference in lying or eating behaviour two weeks after abrupt weaning (Matthiesen, 1999).

After weaning, young horses may be kept individually or in groups or in a combination e.g. in a group during part of the day and individually housed at night. Only rarely are horses kept in natural group structures like the harem group or the mixed age bachelor group. Rather the tendency is towards keeping horses in uniform groups concerning sex and age, i.e. mares are kept from males, youngsters from adult horses etc. The castrated males are an exception as they may be put in any kind of group. The homogeneous group composition may result in less obvious hierarchical structures as the usual determinants of dominance, age and order of arrival in the group, are similar for all horses in the group. This may lead to aggression becoming the important factor, as it has been seen in pigs, where uniform groups tended to result in more aggression (Hayne and Gonyou, 2003). In practice, this has lead to tyrannical leaders. Nevertheless, also in groups of horses in domestic situations a hierarchy is found, and as in the wild it is often linear in small groups and seems to be rather stable (Haag et al., 1980; Houpt and Wolski, 1980).

On pasture domestic horses display nearly the same behaviour pattern as wild living horses (Christensen et al., 2002b). In a Finnish study (Malin and Jansson, 1997) two-year old colts showed more aggressive behaviour than one-year old colts but they also showed more mutual grooming and sought more contact with other horses. When one-year old horses and two-year old horses were pastured together most interactions occurred between horses of the same age. Playing constituted a major part of the behavioural interactions between the young horses and also nibbling, biting and chasing had a high frequency. The better the horses knew each other the less severe were the aggressive interactions and the higher the frequency of mutual grooming (Malin and Jansson, 1997). In a study where an artificial bachelor group consisting of 15 stallions from 2 to 21 years of age were put together to design an ethogram one stallion acted as a harem stallion by guarding an area within the stallion pasture along the fence line facing nearby mare pastures. The remaining stallions interacted as a bachelor group (McDonnell and Haviland, 1995).

Due to management decisions a separation of bonded animals may occur, a decision resulting in frustration and potentially dangerous situations (Crowell-Davis, 1993). When new groups are formed the level of aggression is higher (Christensen et al., 2002a) leading to an increased risk of injury (Crowell-Davis, 1993). Transient social isolation e.g. when a horse is left alone in a stable is stressful for horses and may even lead to the horse performing stereotypic behaviour (Jezierski and Górecka, 1999). Aggression towards humans is a common problem, which may be induced by pain, fear, maternity etc. (Crowell-Davis, 1993).

In addition to the development of natural behaviour patterns, domestic horses must learn an additional behavioural repertoire. Much of this learning occurs unnoticed e.g. feeding from a trough, but part of it is brought about through training. Learning about the domestic environment possibly follows the pattern of the development of natural behaviour. If so, this learning as well as the training of various skills may occur more effectively during specific periods. This is addressed in chapter 5.

The human-animal relationship is another important factor for the domestic horse. As the word indicates the human-animal-relationship can be evaluated from two perspectives - the horse or the human. In this thesis I will concentrate on how horse factors can influence this relationship irrespective of the behaviour of humans involved, although there is no doubt that there is an interaction between the behaviour of the horse and the humans. The human-animal relationship is addressed in chapters 4.1.3. and 5.1.1.

Abnormal types of behaviour are non-existing in feral or wild horses indicating that the environment is the main reason for the development of these types of behaviour. Waters et al. (2002) found that horses initiated weaving at a median age of 60 weeks, box walking at 60 weeks, wood-chewing at 30 weeks and cribbing at only 20 weeks indicating that the rearing period is very important in the development of abnormal behaviours. Abnormal behaviour was found in 34% of the studied population. The mechanism behind the development of abnormal types of behaviour is not established but learning may be an important feature (Mills, 1999) as well as physical problems like gastric ulceration and mucosal inflammation (Nicol et al., 2001). The latter may be an effect of feeding concentrate as Waters et al. (2002) found that feeding concentrates after weaning was associated with a 4-fold increase in the rate of development of crib-biting. Also social factors may be important. Waters et al. (2002) found that foals of low- or middle –ranking mares were less likely to develop abnormal behaviour than foals of dominant mares. The reason for this is not known but may relate to the mare-foal relationship or genetic factors determining behaviour. As stated previously weaning is a stressful event for the foal and has been suggested as one of the main periods when horses are more prone to develop abnormal types of behaviour than during other periods. This is confirmed in the study by Waters et al. (2002) where not only weaning itself but also the method of weaning was found to be an important factor influencing the development of stereotypic behaviour in young horses. Weaning by confinement in a stable or barn was associated with an increased rate of development of abnormal behaviour, compared to paddock weaning. Housing in barns or stables rather than at pasture after weaning was associated with a further increase. This is in accordance with results from retrospective studies where the frequency of stereotypic behaviour is higher for horses that lack social contact (McGreevy et al., 1995a; Bachmann and Stauffacher, 2002b). On the other hand, it is likely that the occurrence of stereotypic behaviour or traits leading to stereotypic behaviour is hereditary to some degree (Vecchiotti and Galanti, 1986) although it has not been investigated to which degree a foal will learn the behaviour from the dam.

The beginning of adult life may vary considerably in domestic horses as some horses are broken very early e.g. racehorses, whereas others are broken quite late e.g. Icelandic horses.

Many mares used for breeding give birth to their first foal at 4 years of age but a large number of domestic horses will never reproduce.


Photo by Eva Søndergaard


Photo by Janne Winther Christensen

3. Description of experiment

The aim was to evaluate the effect of handling and social environment from weaning until 2½ years of age on the behavioural and physical development including the human-animal relationship.

The experiment was conducted at the Danish Institute of Agricultural Sciences, Research Centre Foulum, Denmark. Forty Danish Warmblood colts were used in two replicates of 20 horses. Twenty Danish Warmblood (DW) male foals were purchased from 19 private farms in 1997 and 1999, and brought to the experimental station at weaning at an age of 4.3 (± 0.5) and 5.0 (± 0.5) months of age, respectively. All foals were born in April and May and raised mainly on pasture with their dams and no access to additional feed. The foals were offspring from 6 sires, 4 sires in each replicate. From the time of purchasing at an age of approximately 2 months until weaning the foals were handled minimally. At the age of 3.0 ± 0.5 months all foals were tested in a reactivity test as described by Søndergaard (1998).

At Research Centre Foulum all foals were housed in the same building during the experimental period of two years. In each replicate, 8 horses were housed singly in boxes of $9m^2$, and 12 horses were housed in 4 groups of 3 horses in boxes of $27m^2$ (Figure 1). Separation between boxes allowed the horses to see, hear, smell and touch but not physically interact with neighbouring horses. The front of each box consisted of vertical bars with a distance of approximately 30cm allowing the horses to feed from the floor in front of each box. Horses were fed *ad libitum* every morning with a Total Mixed Ration of chopped grass silage, chopped hay, chopped straw and concentrate, molasses and minerals. The Total Mixed Ration was adjusted during the experiment according to the body condition of the horses by increasing the amount of forage and changing the relation between ingredients. Feeding regime and recordings of growth and physical development are described in **Paper I**.

During the housing period, horses were given 3 hours of daily exercise in paddocks according to their housing, i.e. single housed horses alone and group housed horses in groups of 3 (Figure 1). The size of the paddocks was 20 x 40 m^2 for single housed horses and 45 x 90 m^2 for group housed horses. The horses were housed from mid-September to mid-May. The first summer period was spent on pasture in one group whereupon they were again housed singly or in the same groups of three during the following winter period. In the second summer period singly housed horses were pastured in one group and group housed horses in another group for six weeks due to studies on social behaviour (Christensen et al. 2002a; 2002b) whereupon the groups were joined for another 4 weeks. In August after the second summer period horses were housed and handled until the end of the experiment in the middle of September. During the housing period several tests on human-animal relationship were performed. These tests are described in **Paper II**.

Half of the single housed horses and half of the group-housed horses were handled for 10 minutes three times per week during each housing period i.e. 50 times in the first and 70 times in the second winter period in total approximately 20 hours of handling. Handling was performed in an arena in the same building as the stable (Figure 1). Five persons (two males and three females) were involved in the handling during the four-year period, but one of two main trainers (one male and one female) was always present during handling. Handling involved leading, tying up, touching, lifting feet etc. The handling scheme is described in details in **Paper III**. Non-handled horses were only handled for monthly weightings, farrier and veterinary treatment.

Description of experiment

Fig. 1. Overview (not scaled) of stable, handling arena, paddocks and test arena.

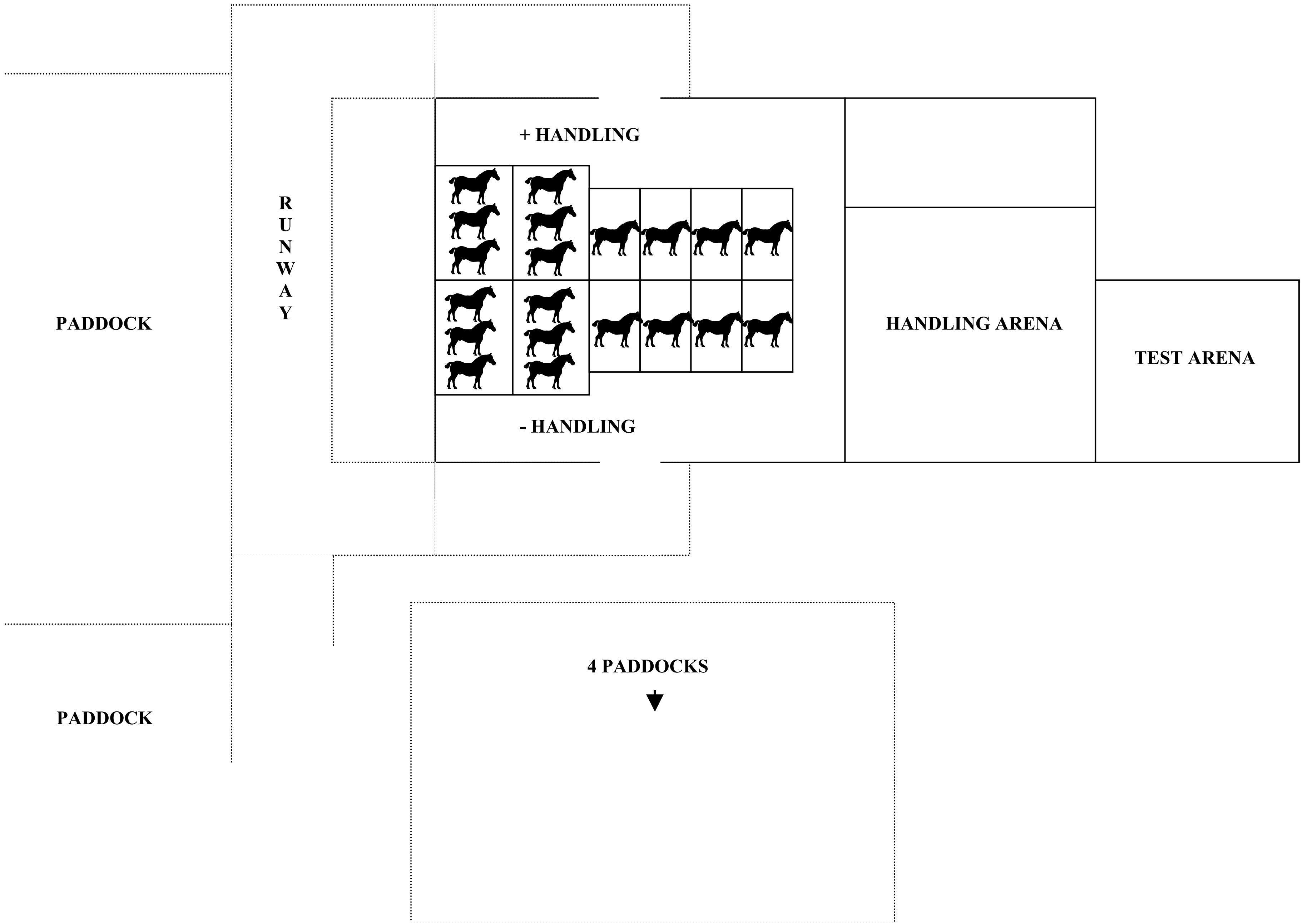

Photo by Malene Jakobsen

4. Effects of social environment

The social environment of young horses is often a matter of being raised alone or with young horses of the same age (Chapter 2.2.), which is far from the natural life of young horses (Chapter 2.1.). The social environment constitutes an important part of the housing environment of young horses but other parts of the housing such as spacing (e.g. Zeitler-Feicht and Prantner, 2000) or access to exercise (e.g. Bell at al., 2001) have attracted more focus in scientific studies. The present work is the largest project so far on the specific effect of two different social environments on the development of young horses.

This chapter will discuss the results and the literature on effects of the social environment on both the behavioural and physical development of young horses and the consequences for their later use.

4.1. Behavioural measures

Social environment early in life is likely to affect not only social skills but also other types of behaviour like feeding behaviour, fear reactions etc. (Le Neindre et al., 1992).

4.1.1. General activity and behavioural development

Group housed horses exercise more when in a paddock compared to singly housed horses (**Paper I**) and the lack of exercise for young foals has been shown to alter their locomotive behaviour (Barneveld et al., 1999). In addition, the lack of exercise retards the development of the musculo-skeletal system (Chapter 4.2.). The exercise in group housed horses does not only consist of forward locomotion but also e.g. rearing, bucking and play fighting, and it is therefore very likely that group housed horses develop a better co-ordination of movements than singly housed horses. This may be essential for their later use as sport horses as Back et al. (1995) showed that the kinetics of locomotion observed in foals were predictive of their locomotion as adult horses. On the other hand Kusunose et al. (1986) found that horses that were alone on pasture travelled longer than horses pastured in groups. However, in their study the horses pastured alone were without horses in neighbouring paddocks and the increased exercise is likely to be a reaction to being isolated rather than an effect of the social environment per se. Kusunose et al. (1986) found that group size influenced the activities of the horses. Grazing time and duration of grazing bouts were shorter when only one horse was pastured and increased linearly as the group size increased up to four horses.

Even though the horses in the present study were only in paddocks for approx. 3 hours per day there was a significant difference in the behaviour shown by single housed and group housed horses (**Paper I**). This is in accordance with Heleski et al. (2002) who found that time-budgets of horses pastured in groups of three horses resembled a feral horse time budget whereas single housed horses spent more time lying and less time moving. Single housed horses spent significantly more time licking or chewing walls, kicking at the walls, pawing and bucking/rearing bouts (Heleski et al., 2002) indicating that there was a motivation for activity that was not fulfilled. This is confirmed in a study by Hughes et al. (2002) who found that solitary foals manipulated objects more than socially raised foals.

When horses were exposed to a novel environment and isolation at one year of age group housed horses vocalised more than single housed horses (**Paper II**) indicating that they were more distressed. At two years of age there was no difference, possibly due to the horses being more used to be taken away from the other horses e.g. in connection with weightings, veterinary treatments and behaviour tests. Likewise, group housed horses defecated more often when in the training arena than single housed horses (**Paper III**). On the other hand single housed horses ran loose for longer periods in the arena than group housed horses before the training sessions started (**Paper III**). However, the latter result may reflect the fact that the single housed horses are motivated for exercise when in company. These results are not in accordance with studies on calves where individually housed calves were more fearful when isolated in a novel arena than group housed calves (Jensen et al., 1997).

Glade (1984) studied the social sleeping behaviour in young horses and found that when space allowance was not a limiting factor, group housed young horses had fewer but longer periods of recumbency than young horses housed singly. In general, young horses spend more time lying than older animals and for all age groups recumbency is influenced by space allowance (Zeitler-Feicht and Prantner, 2000). Young horses housed singly in stalls spent about one third of the day in a recumbent position, which may be a reflection of the more quiet environment in the stalls or due to the fact that the restriction of the environment limited the possibility to perform other behaviour patterns compared to young horses in outdoor pens, which had the opportunity of interacting with neighbours in the adjoining pens (Glade, 1984). Within a group high-ranking animals will be lying more than lower-ranking animals (Zeitler-Feicht and Prantner, 2000). In the present experiment lying behaviour was recorded in the first replicate for the first two weeks, i.e. right after weaning (Matthiesen, 1999). On the first day after weaning single housed foals rested in lateral recumbency more often than group housed horses, but by the end of the observation period there was no difference in resting behaviour between single housed and group housed horses.

Feeding activity of individual horses was not assessed in the present study but it is likely that there was a variation between the horses within the groups (**Paper I**). Matthiesen (1999) observed feeding activity at treatment level in the first two weeks of the experiment in the first replicate, i.e. right after weaning. Single housed horses had more eating bouts on day 1, day 4 and day 7, and ate longer on day 4. On day 14 after weaning there was no difference in neither eating frequency nor eating time (Matthiesen, 1999). Kolter (1984) showed that not only rank but also the tolerance of individuals in a group determine the feeding activity. Low-ranking animals get less access to feed than higher ranking animals. However, the tolerance of individuals, which may be different from the rank order, was even more important. In groups, which are not fully integrated e.g. due to new animals being introduced, some animals may be prevented from feeding to an extent that impairs their welfare (Kolter, 1984). In practice, however, this problem may be solved by head partitions (Holmes et al., 1987) allowing subordinate animals to feed. In an experiment where horses were kept together according to their emotionality, i.e. a "nervous" group and a "normal" group, the "normal" yearlings tended to consume feed in a more regular manner throughout the daylight hours than the "nervous" yearlings (McCann et al., 1988a). It is also likely that the feeding behaviour differed between horses housed singly and horses housed in groups as it has been shown in pigs (Bornett et al., 2001), although no difference in feed intake between housing treatments was found (Chapter 4.2.2).

4.1.2. Horse-horse interactions

Although horses are social by nature their social skills still have to be refined and practised. In the present experiment the social behaviour of group housed horses seemed better developed than that of single housed horses as shown by the lower frequency of aggressive behaviour and the higher frequency of subtle agonistic interactions such as displacement and submissive behaviour (Christensen et al., 2002a). These differences imply that by housing young horses singly and thus not giving them the opportunity to practice their social skills they may be more prone to the risk of injuries when later on being in contact with other horses. In a survey on race farms most injuries were attributed to the young horses playing too hard (Gibbs and Cohen, 2001), but how the horses were managed and housed were not clear. Individually housed calves were observed to express fear of unfamiliar calves (Jensen et al., 1997) potentially leading to inappropriate behaviour when introduced in a group. Previously group housed colts frequently had a former group mate as their nearest neighbour whereas previously single housed colts did not associate more with their former box neighbours, when they were pastured in groups (Christensen et al., 2002a). This result indicates that physical contact may be necessary in order to establish bonds between animals, and that full physical contact is an important part of the social behaviour. This was confirmed in calves as measured by operant conditioning. The calves were more motivated to get access to full contact than to head contact (Holm et al., 2002), indicating that limited social contact is not enough to fulfil the animals' social motivation. Additionally, previously single housed horses stayed closer together than group housed horses (Christensen et al., 2002a) perhaps indicating a higher level of social motivation, perhaps due to nervousness as the same was seen for "nervous" horses compared to "normal" horses in the study by McCann et al. (1988a). Also, Kusunose et al. (1986) found that the mean individual distance increased from 5 m when two horses were pastured together up to 30-50 m when 12 horses were pastured together. This may indicate that horses are more comfortable when in a large group but as the mean distance to nearest neighbour was constant irrespective of group size it may also reflect the fact that when the group gets too large sub-groups will occur.

Singly housed horses spent more time performing social grooming and play behaviour than group housed horses when they were given the opportunity (Christensen et al., 2002a) indicating that the motivation to perform these behaviours had been present also during confinement. This is confirmed in the observations made when the horses were in the paddocks (**Paper I**). Although the single housed horses had very limited access to social contact through the fence they still had some contacts indicating a strong motivation.

4.1.3. Horse-human interactions

In the present work singly housed horses showed more interest in contacting humans and were more easily approached by humans in their home environment (**Paper II**). This result corresponds with observations by Hughes et al. (2002) who found that foals kept without contact with other foals interacted more readily and spent more time with an observer than foals kept on pasture with other foals. Also in calves, single housed animals interacted sooner and more often with the test person than calves housed in pairs (Lensink et al., 2001). When the horses were tested on their reactions to an unfamiliar person in an unfamiliar environment no effect of social environment was found (**Paper II**), which may reflect that the effect of isolation masks other effects. Isolation is a stressful event for a horse, and the presence of a human may have no calming effect as indicated in a study by Jezierski and Górecka (1999). When horses were isolated in a stable due to the other horses leaving the stable the presence of a human gave a further rise in heart rate although this may be a conditioning effect, i.e. expectation of being untied and joining the other horses (Jezierski and Górecka, 1999).

In the present experiment singly housed horses also interacted more with a trainer during weekly training sessions than group housed horses (**Paper III**). The interaction consisted mainly of non-aggressive biting indicating that singly housed horses were motivated for physical interaction. This result was confirmed by observations during summer when horses from both treatment groups were kept on pasture in groups. Singly housed horses spent more time performing social grooming than group housed horses (Christensen et al., 2002a).

In an experiment by Rivera et al. (2002) it was found that singly housed horses needed more time for initial training than group housed horses. Since the singly housed horses were kept in stalls, whereas the group housed horses were kept on pasture, environmental enrichment and stimulation could be part of the difference in their results. In the present experiment, however, similar results were found. Singly housed horses completed fewer stages in the training program and they bit and kicked more during training sessions than group housed horses (**Paper III**). There was a large variation between horses in relation to the number of sessions they needed to complete a stage but this could not be contributed to the social environment. Whether the performance in the training program was related to tractability or learning ability is unclear. Also, there may be an effect of the social environment e.g. hierarchy within the groups although Haag et al. (1980) found no correlation between the rank in the hierarchy and performance in two different learning tests in 10 ponies. In a study in calves (Lensink et al., 2001) the contrary result was found, it took more time and effort to load pair housed calves than singly housed calves. The difference may be due to the fact that the calves were loaded individually and were not used to being isolated as opposed to the horses in the present study and in the study by Rivera et al. (2002).

4.2. Measures related to the physical development

In the present work only few differences were found between single and group housed horses concerning physiological measures (**Paper I**). Both treatment groups followed a normal development pattern for young horses concerning feed intake, growth and bone development.

4.2.1. Bone development

Group housed horses were more active than single housed horses when in paddocks and it was expected that the higher energy expenditure would give a difference in feed intake and/or growth and thus also in bone development. However, this was not the case. Activity or exercise has been shown to have beneficial effects on bone development in horses (Barneveld and van Weeren, 1999) and thus also a difference in bone quality as assessed by radiology was expected but not confirmed in the present work (**Paper I**). However, group housed horses showed higher levels of calcium, magnesium and the enzyme alkaline phosphatase in plasma, which indicate a higher activity level in bone development. Still, levels for single housed horses were within the normal range, and thereby not considered to affect the bone development negatively. The reason for the lack of effect may be that both treatment groups actually exercised too little in order to achieve the beneficial effects of a higher physical activity. In most studies on bone development young horses have either been exercised or the time spent on pasture has been much longer than in the present work. Bell et al. (2001) found that pasture rearing or 12-h daily turnout was beneficial to maintain and increase the bone mineral content in comparison to horses kept in stalls. In their study horses were housed singly in stalls whereas the pastured horses were in a group. The differences found by Bell et al. (2001) was not an effect of the social environment but of the level of activity which, as indicated in the present work (**Paper I**), might be a secondary effect of the social environment. Bell et al. (2001) did not record behaviour but reported that horses on pasture were engaged in running, chasing and play-fighting. The same types of behaviour were observed in the present work and at a much higher level for group housed than for single housed horses (**Paper I**).

4.2.2. Feed intake and growth

In the present work no difference was found in feed intake despite the higher level of activity for group housed horses (**Paper I**). Size differed between housing treatments but contradicting for the two replicates, and there was no difference in daily gain or body condition scores. As the feed intake was not recorded on an individual level for horses housed in groups it is possible that there were large variations within the groups even though the overall mean did not differ from the horses housed singly. Even in groups of three horses as in the present study a hierarchy will exist and this is likely to influence the feeding behaviour and perhaps the feed intake of individuals in the group. For instance, Houpt and Wolski (1980) found that subordinate ponies spent less time eating when in the same paddock as a dominant pony compared to when the ponies were separated by a fence. Also, the dominant pony was less aggressive when the pony-pair was separated by a fence than when they were in one paddock. Feeding behaviour may be influenced not only by the rank but also by the tolerance between animals in a group meaning that some horses might be prevented from feeding (Kolter, 1984). In the study by Kolter (1984) two horses in a group of 6 horses had a lower feed intake and had access to forage of lower quality because they were not tolerated by the other horses. In the present study horses were fed ad libitum and the quality of the Total Mixed Ration supposedly remained the same throughout the day; thus no horses were prevented from consuming the feed they needed/wanted.

4.2.3. Physiological measures

Heart rate – when measured before and in an arena test – was not affected by social environment in the present study (**Paper II**). This is in accordance with Kusunose et al. (1986) who found that there was no relationship between heart rate measures and group size. Also Heleski et al. (2002) measured faecal glucocorticoid metabolite concentration in weanling horses but found no differences between horses housed singly in stalls and horses pastured in groups. Lensink et al. (2001) found no difference between calves housed singly or in pairs before and during loading onto a truck but during transport pair housed calves had a lower heart rate than single housed calves. Pair housed calves were transported together which may have had a calming effect. Isolation in an unfamiliar environment gave a rise in heart rate independent of the social environment (**Paper II**), which implies that in relation to the later use of horses it is essential that horses learn to be on their own. It requires only a little training as indicated in the study by Jezierski and Górecka (1999) who also found an increased heart rate when isolating horses but the horses habituated to the situation within a few days.

Photo by Eva Søndergaard

5. Effects of handling

Handling is here used as a broad term for any human interaction with horses from grooming via handling and training tasks to actual physical training. When generalising on the effects of handling several factors have to be considered such as the age at which the horses were handled, the type of handling as stated above, the frequency and duration of handling sessions and finally the time from handling was performed until the effect of handling was evaluated. Although this thesis focuses on the young horses from weaning onwards, the effects of early handling, i.e. handling before weaning, will also be discussed as this handling is claimed to have a long term effect (Miller, 1989; 1991).

In terms of handling and training of the young horse it is important to realise that there may be different reasons why training is more effective during particular periods. One reason is related to neuronal development, particularly the establishment of synaptic connections between neurones in the central nervous system. This development has been described in other species (e.g. cats: Blakemore and Cooper, 1970, and chickens: Gunnarsson et al., 2000) but not in horses. A second reason is related to the fact that in terms of habituation to potentially threatening stimuli, desensitisation occurs faster in naïve animals than in animals that have already developed fear of the stimuli (Bateson, 1979). In other words, it is easier to habituate a horse to something before it has become afraid of it, i.e. at a young age.

In this chapter, results from the present work and from the literature on effects of handling on the development of young horses will be discussed with special emphasis on the consequences for their later use.

5.1. Behavioural measures

Since handling is performed by humans it is natural to expect effects on several aspects of the human-animal relationship, namely how does the horse react to humans in various situations (Chapter 5.1.1.), how does the horse react in general (Chapter 5.1.2.), how easy is it to handle the horse (Chapter 5.1.3.), did the horse learn how to learn? (Chapter 5.1.4).

5.1.1. Human-animal relationship

The human-animal relationship was not influenced by handling in the present study when assessed by approach tests in the home environment but in the first replicate handled horses approached the test person sooner than non-handles horses when tested in an unfamiliar environment (**Paper II**). This is in accordance with Mal et al. (1994) who found no significant effect of handling in a forced human approach test although the flight distance was shorter for foals handled extensively compared to foals handled intermediately which again had a shorter flight distance than non-handled foals. In the present study the chance of a horse approaching and the chance of approaching a horse was increasing with age independent of the level of handling (**Paper II**). These results indicate that handling does not affect the horses' interest in or fear of humans when they are in a calm situation but that this may change when the horses are in a novel situation, and that the age of the horses may have an influence as well. In calves effects of handling have been more pronounced (e.g. Lensink et al., 2001), which may be due to the fact that it is easier to have totally non-handled calves than totally non-handled horses when normal management procedures for the two species are followed.

5.1.2. Emotionality

In the present study there was no effect of handling in the way horses behaved in an arena and human-encounter test (**Paper II**), although there was an effect on heart rate (Chapter 5.2.). This is in accordance with a study by Heird et al. (1981) were foals were given a score for emotionality when performing a maze test and no effect of handling was found. In contrast, Heird et al. (1986) found that horses handled for 18 months reacted less emotionally to novel stimuli, as compared to horses handled for one to three weeks. Additionally, Visser et al. (2001) found that flightiness was the only trait that showed consistency over time when horses were tested at 9 and 10 months of age and at 21 and 22 months of age, indicating that flightiness is a trait of the horse.

Handling may be as little as having gentle contacts with humans and still have an effect on the animals' reaction to challenging stimuli as shown in calves by Lensink et al. (2000). Veal calves that had received gentle human contact around meals for 21 weeks were less agitated than calves that had minimal contact with humans.

5.1.3. Tractability

In the present experiment handled horses were caught sooner after an arena test than non-handled horses when tested as one-year olds but not when tested as two-year olds (**Paper II**). There was no correlation between the number of training sessions needed to fulfil the various stages in the training scheme. This indicates that each training session was perceived as a new situation and that there is no overall level of tractability (**Paper III**), although it is unclear whether the performance in the training program was related to tractability or learning ability (Chapter 5.1.4.). In cattle a consistency in the reaction to types of handling was found (Grignard et al., 2001) but similar studies in young horses has not been found. In the present study trainers differed in their rate of successful training sessions (**Paper III**), which may reflect that the tractability is influenced by the relationship and interactions between the horse and the trainer (see also 5.2.1.).

Exposing a new-born foal to ten sessions of handling during the first 14 days of life, the first session starting immediately after birth, has been claimed to have a permanent effect on the foal's acceptance to handling later in life. The practice has been termed 'imprint training' (Miller, 1989; 1991), the term 'imprint' suggesting that a critical period for handling exists in the horse. Considering that horses are obviously able to learn to accept handling also during later stages in life, the term 'imprint training' is somewhat misleading. But whether foals are more sensitive to handling early in life, i.e. that a certain handling procedure has a greater or longer lasting effect when performed early in life, has been analysed in several studies. Early handling had minor effects when the foals were tested 4 months later but it seemed that there was an effect of the temperament of the dam (Sigurjonsdottir and Gunnarsson, 2002). Whereas no major effect of early handling was found in several studies (Mal et al., 1994; Søndergaard and Jago, 2001; Williams et al., 2002), a greater effect of early handling was found in other studies (Mal and McCall, 1996; Larose and Hausberger, 1998; Simpson, 2002). In the case of Mal and McCall (1996) handling from 1 to 42 days of age was compared with handling from 43 to 84 days of age and the foals were tested at 85 days of age. The early handled foals were reported to submit more readily than foals handled later but this may be an effect of lack of confidence rather than the fact that they have learned to accept the handling. Likewise, it was reported that during the handling it was easier to handle the younger foals due to their smaller size meaning that the foals handled later were struggling more during handling sessions. This may imply that foals had a very different experience from the handling and thus learnt something different. This emphasises the difficulties of assessing the effects of early handling against effects of handling at other times. It is not possible to handle the foals in the same manner due to the difference in size. Also, in a study by Diehl et al. (2002) the young foals actually resisted the handling procedure and the restraints. Additionally, mares of handled foals sniffed more and ate less hay than mares of control foals, and handled foals took longer to first stand indicating that the early handling may disturb the mare-foal relationship.

One recent study, which compared the effect of handling during the postnatal period and the post weaning period, concluded that handling after weaning had a greater effect than postnatal handling (Lansade et al., 2002), a difference that has also been observed in cattle (Boivin et al., 1991). The most interesting result of the study was that the effect of both types of treatment decreased over a 10-month period. In other words, it seems that handling must be repeated in order to have a permanent effect.

Jezierski et al. (1999) found that horses handled for 14 or 24 months (5 days per week) were easier to manage when tested at 12, 18 or 24 months of age. Interestingly, they tended to be less manageable at 24 months than at 18 months indicating that too much handling may have some negative effects. This was also observed in pigs where handled pigs were more difficult to move than non-handled pigs (Day et al., 2002).

Long term effects of handling have only been investigated in few studies. Visser et al. (2003a) found only minor and non-significant differences in reaction to the bit, lunging and transport between horses trained twice per week from 5 months of age and untrained horses when they were broken in at 3 years of age.

5.1.4. Learning ability

In a training situation it may be difficult to distinguish learning ability from tractability. In the present study there were only few correlations between the number of training sessions needed to fulfil the various stages in the training scheme as stated previously (Chapter 5.1.3.; **Paper III**). This result may reflect the fact that each training session was perceived as a new situation and that there is no overall level of tractability, or it may reflect learning ability. Likewise, when trainers differed in their rate of successful training sessions it may reflect that the learning ability and/or the tractability is influenced by the relationship and interactions between the horse and the trainer. Le Scolan et al. (1997) argue for one or more underlying behavioural dispositions that are stable across situations, but also in their study only few correlations were found between the horses' reactions in various situations concerning emotionality and learning ability. For instance, there was no correlation between performance in an instrumental learning test and a spatial learning test. Nicol (2002) has recently reviewed several studies on learning ability and concludes that it does not seem to be a trait in the horse but rather seem to depend on the context, i.e. age of the horse, previous handling, type of learning etc.

Learning ability as a direct effect of the level of handling was not assessed in the present study but has been addressed in several other studies. For example, Mal et al. (1994) found no effects of handling in a learning test performed on days 1, 3 and 15 after weaning where the foals had been handled at 3 different levels before weaning. The effects may have been overruled by the effect of the stress around weaning (Chapter 2.2.), as many foals did not complete the test at all and as performance in the test increased significantly on day 15 after weaning compared to days 1 or 3 after weaning. Heird et al. (1981) found that intermediately handled foals performed better in a maze test than extensively handled or non-handled foals but reported that the reasons for poor performance for the two groups seemed to be different. Non-handled foals showed fear and reacted to novelty by choosing the same side each day, i.e. no learning occurred whereas extensively handled foals explored the maze before choosing, thus being noted for an error. Foals were given a score for "trainability" before the test, which had no correlation to the number of trials needed to reach the criterion in the maze test.

Learning may be affected by the length and distribution of training sessions. In the present study horses were trained 3 times per week, i.e. with one day between sessions, each session lasting 10 minutes, and the schedule was not varied (**Paper III**). Rubin et al. (1980) found that horses trained once a week achieved a high level of performance in an avoidance learning test in fewer sessions than those trained 2 or 7 times per week. However, time from start of training to completion was shorter for the horses trained 7 times per week. McCall et al. (1993) found that the number of trials within a session affected the number of sessions needed to learn an avoidance learning test. In their study 16.2 trials per training session were found to be the optimum. The optimum training scheme may depend on the task trained as indicated by results from Kusunose and Yamanobe (2002). They found that 30 minutes of daily training, i.e. 7 days per week, was more efficient than training for 4 days followed by 3 days of rest. Training in this case was lunging, driving from the ground, being ridden etc and both groups were trained for 17 days in total.

5.2. Physiological measures

In the present study the heart rates of handled horses were lower than those of non-handled horses prior to exposure to a novel environment and the rise in heart rate when exposed to the novel environment was lower as well (**Paper II**). This is in accordance with McCann et al. (1988b), Jezierski et al. (1999) and Visser et al. (2002) who found that handled horses had lower heart rates than non-handled horses in a range of test situations. Similar results were found in calves by Lensink et al. (2001). However, when the horses in the study by Visser et al. (2002) were broken in at 3 years of age there was no difference in heart rate between previously handled and non-handled horses (Visser et al., 2003a). Visser et al. (2002) found that the increase in heart rate when horses were exposed to a novel stimuli could not be explained by physical activity. They suggested that the increase together with a decrease in heart rate variability indicated a shift of the balance of the autonomic nervous system towards a sympathetic dominance indicating a higher level of emotionality.

Even in horses that are not handled daily, handling may be a positive event as indicated by Feh and Mazières (1993) who showed that if horses were groomed at a preferred site of the body, which is usually around the withers, their heart rates were lower than the resting heart rate. Grooming at a non-preferred site gave no change in heart rate. These results have later been confirmed and expanded by Normando et al. (2002) who found that grooming reduces the heart rate of horses independent of the place of grooming although grooming at the withers has a larger effect than grooming mane, shoulder or hip. These results are very important in terms of discussing reinforcement and rewards in horse training. Patting the horse is generally considered a secondary reinforcer, which has to be learnt in connection with a primary reinforcer like food before it can be used as a reward in training. These results indicate that if patting is performed like grooming, i.e. scratching rather than patting, this may be a primary reinforcer and does not need to be associated with food in order to have a rewarding effect on the horse. However, who the handler is may affect the horse as well since riding horses showed higher heart rates when they were handled by an unknown person rather than a known person (Baragli et al., 2003).

In the present study the baseline heart rate of one-year old horses was lower than that of two-year old horses whereas the increase in heart rate when exposed to a novel environment was higher for two-year-old horses than for one-year old horses (**Paper II**). Correlations were not calculated in the present study but Visser et al. (2002) found consistency over time in heart rate and heart rate variability suggesting it to be measures related to the temperament of the horse.

In accordance with the results on heart rate Simpson (2002) found lower cortisol concentrations in handled foals than in non-handled foals. Foals were handled daily for the first 5 days of life and tested at 4 months of age. In addition, handling may affect other physiological measures indirectly related to measurements of stress. For instance Lensink et al. (2000) found that veal calves that had gentle contact with humans around meals for 21 weeks had fewer abomasal lesions than calves that had minimal contact with humans.

Handling does not seem to have an effect on the physical development, although in the present study a few effects of handling were found. For instance, handled horses were heavier than non-handled horses (**Paper I**). There is no apparent explanation for this result as feed intake and activity in paddocks did not differ. Day et al. (2002) found that handled pigs ate more than non-handled pigs but they also lacked an explanation. Additionally, handled horses showed lower levels of haemoglobin than non-handled horses, but both treatment groups were within the normal range for young horses (**Paper I**) and the difference is not considered to be important in relation to handling.

Photo and manipulation by Eva Søndergaard

6. Conclusion and perspectives

The behavioural development of a horse from birth till adulthood is a continuous process that needs the presence of certain environmental features, as well as the absence of others, to occur optimally. For some behaviour patterns (e.g. maternal bonding) exposure must occur during specific periods in order to exert an effect, but for other behaviour patterns (e.g. socialisation on conspecifics or humans) repeated exposure over an extended period appears be to necessary in order for learning to be permanent. Since these ontogenetic mechanisms seem to operate similarly under natural as well as husbandry conditions, optimal housing and management of the young developing horse is necessary in order to obtain an adult horse that reacts the way we expect it to react.

6.1. Conclusion

Group housing and handling exert a positive effect on the social behaviour and emotionality of young horses.

6.1.1. Effects of social environment

- Group housed horses exercised more than single housed horses, which may be beneficial for the development of the musculo-skeletal system.
- Group housed horses were less aggressive and their social behaviour seemed better developed that the social behaviour of single housed horses.
- Single housed horses approached sooner and can be approached more closely by people when tested in their home environment than group housed horses.
- Group housed horses tended to reach more stages in the training program than single housed horses.
- Single housed horses kicked and bit more during training than group housed horses.
- There were no effects of social environment on feed intake or growth.

6.1.2. Effects of handling

- In general no effect of handling on the reactions towards humans in approach tests.
- Handled horses are less emotional when assessed by behaviour and physiological measures than non-handled horses.
- Effects on tractability seem to depend on details of the handling, like age at handling, type of handling, duration of handling etc.
- Handling does not affect learning ability directly, but effects due to less emotionality and better tractability are observed.
- Handled horses show a lower rise in heart rate than non-handled horses when exposed to novelty.
- Handling may have a positive effect on measures such as heart rate and cortisol secretion that are known to be related to stress and immunology.

6.2. Perspectives

From the present study it appears that there is no doubt that group housing is essential for young horses in relation to their social behaviour and also beneficial in relation to their reactions in training situations. However, it is still an open question whether young horses have to stay in groups all day all year round, or if part-time group housing may have the same positive effects. Another question is how to achieve the best composition of the group. Most young horses are housed in semi-natural groups, i.e. homogenous groups where a clear leadership may be missing. It is evident that foals learn many things from the dam, e.g. food selection but it is unclear in which way a missing obvious leadership may affect the behavioural development of young horses after weaning. Another aspect of the homogenous groups is the fact that the highest ranking animal may not be psychologically capable of being a “leader”, a fact which may potentially result in a tyrannical leader. This problem has been recognised in practice but remains to be investigated in an experimental study. The use of horses in leisure and sport often requires that the horse will meet or even be housed with unknown horses. How horses are best prepared for that situation is not known. Perhaps some regrouping during the socialisation period is beneficial. Additionally, adult horses will often be on their own and therefore it may be useful for young horses to learn to be separated from other horses in various situations.

Likewise, there is no doubt that handling of young horses has a positive effect in relation to their later life as companions in leisure or sport. However, there are still some open questions in relation to the long term effects of handling and details of the handling scheme. Focus in many experiments has been concentrated on the time at which handling is conducted, but it may be that it is not so much the specific time at which handling takes place but rather that handling is repeated with certain intervals over an extended period that is essential in order to achieve a permanent effect. Unfortunately, no systematic studies have been conducted to evaluate how often handling must be repeated, how long the intervals between training sessions should be, and whether the extended period should last from weaning till adulthood or whether a shorter period is sufficient. As shown in this study only 20 hours of handling during a two-year period are enough to exert some positive effects but details about the handling scheme are still unclear.

Apart from concerns about the time at which handling should be carried out and how often it should be repeated, an equally important question is what the young horse should learn in order to function satisfactorily as an adult. Obviously, socialisation in relation to humans, i.e. learning the ability to obey commands to stand still, to lift a leg, to be led etc. is only part of what is required of a horse. Other skills such as remaining calm in traffic or when separated from its conspecifics, are equally important. Unfortunately, also in this aspect our knowledge is based primarily on practical experience rather than systematic investigation. There is little doubt, however, that in order to produce horses that fulfil the demands of future riders, we need a much better understanding of what kind of training a young horse should receive before its education as a riding horse starts.

Despite the holes in our knowledge there is no doubt from the results of the present study and other studies that group housing of young horses and probably of older horses too, should be promoted. Likewise, despite the holes in our knowledge on handling and training of horses, introducing foals to handling is far more safe than introducing an adult horse to handling; thus any positive human-animal interaction at a young age will be better than no interaction.

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Photos by Janne Winther Christensen and Eva Søndergaard

Paper I

Activity, feed intake and physical development of young Danish Warmblood horses in relation to the social environment

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Livestock Production Science (submitted)

Abstract

Appropriate feeding and housing are necessary to keep horses physically and mentally healthy. Keeping young horses in groups may be more like their natural social environment than keeping them individually but it makes individual feeding more difficult. This problem was addressed in a larger project on the effects of rearing environment on the social and physical development of young horses. Forty Danish Warmblood colts in two replicates were housed either singly (n=16) or in groups of three horses (n=24) from weaning until 2½ years of age. They were fed a Total Mixed Ration *ad libitum* and feed intake was recorded on a daily basis. Live weight and height at withers were assessed monthly, and blood parameters, radiology and activity annually.

Group housed horses travelled longer and were more active when in paddocks than single housed horses. Live weight and size were affected by social environment but contrasting for the two replicates. There were no effects of social environment on daily gain or body condition score. Activity of skeletal and muscle enzymes (aspartate aminotransferase and alkaline phosphatase) was affected by social environment but contradicting for the two replicates. A higher concentration of calcium and magnesium and a lower concentration of inorganic phosphorus was measured in group housed horses than single housed horses. All values obtained were within the normal range for growing horses. There was no effect of social environment on radiological results or other blood parameters.

In conclusion, social environment affected the level of activity, and group housed horses were exercising more than single housed horses, a difference that is assumed to be beneficial for the physical development. Feed intake, growth and variables related to the physical development were not affected by the social environment outside the normal range.

Introduction

Young horses are the competition or leisure horses of the future, thus we aim at providing them with a good start in life. A good start involves appropriate feeding and housing to keep the horses physically and mentally healthy. Keeping young horses in groups is closer to the natural life of horses than keeping them individually but may make feeding individual rations more difficult. For a correct musculo-skeletal development individual feeding may be advantageous, and this requires individual housing or that horses are tied during feeding. Since young horses require a high amount of forage in the diet, individual feeding is usually practised for concentrate feeding whereas forage is fed *ad libitum* on group level. Feeding a Total Mixed Ration (TMR) to horses would make group housing advantageous to individual housing in terms of work load, provided that the feeding has no negative effects on the development of the horses. In order to be able to determine the energy density of the TMR it is necessary to be able to predict the voluntary feed intake of the ration.

Differences between single and group housed animals in feed intake and/or growth rate can often be attributed to differences in activity, access to feed etc. (Morgan et al., 1999) leading to a higher feed intake in single housed animals than in group housed animals. Effects of the social environment itself, i.e. being housed alone or in a group are difficult to assess. It is assumed that an animal whether growing, lactating or merely maintaining itself given free access to a balanced, non-constraining food has a desired level of daily food intake. Whether a given level of daily food intake is a mean to achieve a desired performance or is a goal in itself is open to discussion (Nielsen, 1999). Experiments on pigs and cattle have shown that, in general, individually fed animals eat more than group fed animals (pigs: Gonyou et al., 1992; cattle: Harb et al., 1985) although contrasting results have been reported (calves: Warnick et al., 1977; Chua et al., 2002; pigs: Petersen, 1976). Even without a higher feed intake daily gain is often higher in individually housed pigs than in group housed pigs (Petersen, 1976; Spicer and Aherne, 1987), possibly because more energy is retained in individually housed pigs. The energy retention may be caused by less activity or a reduced metabolic heat production in individually housed pigs (Patterson, 1985). In contrast Barnett et al. (1981) found that individual penning of pigs resulted in a chronic stress response which would be expected to affect the feed conversion rate negatively.

For horses these comparisons have not been made. In the present experiment I hypothesise that group housed horses will be more active and therefore have a higher feed intake than single housed horses but that the physical development of the horses will not be affected. A Total Mixed Ration was fed and feed intake, growth, activity and musculo-skeletal development were assessed and related to the social environment of the horses.

2. Materials and Methods

The experiment was conducted at Research Centre Foulum, Denmark as part of a larger project on the effect of rearing environment on the social and physical development of young horses.

2.1. Animals, housing and management

Twenty Danish Warmblood (DW) male foals were purchased from 19 private farms in 1997 (replicate 1) and 20 DW male foals were purchased from 19 farms in 1999 (replicate 2), and brought to the experimental station at weaning at an age of 4.3 (+/- 0.5) and 5.0 (+/- 0.5) months of age, respectively. All foals were born in April and May and raised with their dams mainly on pasture with no access to additional feed. The foals were offspring from 6 sires, 4 in each replicate. From the time of purchasing at the age of 2-3 months until weaning the foals were handled minimally.

At Research Centre Foulum all foals were housed in the same building during the experimental period of two years. For each replicate 8 foals were housed singly and 12 foals were housed in 4 groups of 3 foals. The individually housed horses were in visual, olfactory and auditory contact but could not physically interact with other horses. The space allowance for all horses regardless of treatment was 9m^2 per horse. Half of the single housed horses and half of the group-housed horses were handled for 10 minutes three times per week. The remaining ‘non-handled’ horses were handled only for monthly weighings, farrier and veterinary treatments.

All foals were in paddocks for approximately 3 hours per day, half of the horses in the morning, the other half in the afternoon, where they were kept in the same way as in the stable, i.e. individually housed horses were alone in their paddocks and group housed horses were in groups in the paddocks. The size of the paddocks was 20 x 40 m^2 for single housed horses and 45 x 90 m^2 for group housed horses. When housed, all foals had free access to a Total Mixed Ration (Table 1), which was fed every morning.

Table 1. Content of Total Mixed Ration and concentrate

Total Mixed Ration	Mean content (range), % of dry matter	
	1st replicate	2nd replicate
Grass silage	22.5 (17.0-31.4)	21.9 (11.9-36.1)
Barley straw	23.1 (5.0-29.9)	35.8 (22.9-42.6)
Hay	20.0 (16.4-29.0)	16.6 (0[1]-27.3)
Concentrates	32.8 (17.2-50.0)	22.6 (14.7-34.6)
Molasses	1.6 (0-3.7)	2.3 (0-2.6)
Energy content Sc.FU[2] / kg DM	0.66 (0.59-0.81)	0.55 (0.33-0.60)
Digest. crude protein g / kg DM	134.3 (119.0-156.4)	106.7 (82.6-121.0)
Concentrates		
Oats	46.0	
Barley	11.8	
Wheat bran	12.0	
Molasses	4.0	
Soya oil	5.0	
Soya cakes	11.5	
Bone meal[3]	4.0	
Sun seed cakes	4.0	
Salt	0.5	
Chalk	0.5	
Dicalciumphosphate	0.3	
Dry yeast[4]	0.2	
Avitren vitamin mixture[3]	0.2	
Content in kg. dry matter of concentrate		
Energy, Sc. FU[1]	1.0	
Digest. Crude protein, g	133	
Lysine, g	6.2	
Calcium, g	7.4	
Phosphorous, g	6.3	
Magnesium, g	1.5	
Manganese, mg	72	
Copper, mg	22	
Zinc, mg	79	
Selenium, mg	0.23	

[1] From the end of February in the second winter period in the second replicate onwards hay was not included in the ration due to lack of good quality hay at the experimental station.
[2] 1 Sc. FU=7,890 kJ NE
[3] Omitted from the concentrate from November 16, 2000 due to changed regulations concerning the use of bone meal in animal feed
[4] LEO Pharma A/S, Ballerup, Denmark

Within each replicate the Total Mixed Ration was adjusted during the experiment according to the body condition of the horses changing the ratio between forage and concentrate (Table 1). Due to a technical error the ration in the second replicate differed slightly from the one used in the first replicate (Table 1). In order to account for this replicate was included in all interactions in the initial models used in the analysis (see statistical methods).

The front of each box consisted of vertical bars with a distance of approximately 30 cm allowing the horses to feed from the floor in front of each box. All pens were straw bedded and equipped with an automatic drinker. All horses spent their first summer (mid May to September) on pasture in one big group with free access to a mineral mixture. In the second summer period singly housed horses were on pasture in one group and group housed horses in another group for six weeks due to studies on social behaviour before the groups were joined for another 4 weeks. In August after the second summer period all horses were housed and handled until the end of the experiment in the middle of September.

In the first replicate one horse from the single housed, handled treatment was culled due to injury at 6 months of age. In the second replicate one horse from the group housed, handled treatment was culled due to health problems at 18 months of age.

2.2. Data

Feed intake was recorded on a daily basis for each pen. Feed was weighed out for each pen in the morning and the following morning left over feed was weighed and discarded. An estimated left over of at least 1 kg feed per horse per day was attempted to ensure *ad libitum* intake.

The foals were weighed and measured at the withers when entering the station and at 4-week intervals during each winter period. Additionally, for the second replicate body condition was scored on a scale from 1 to 9 with 1 being extremely thin, 5 being average and 9 being extremely fat.

Data on feed intake, body weight, height at withers and body condition were blocked in three age periods during each winter period, in total 6 periods. Periods were defined as I: 4.7 to 6 months, II: 6 to 9 months, III: 9 to 12.5 months, IV: 16.5 to 18 months, V: 18 to 21 months, and VI: 21 to 24.5 months of age. For each period feed intake capacity of the singly housed horses was estimated as daily intake in kg dry matter in percentage of mean live weight.

Each year in September, i.e. three times for each replicate the horses were X-rayed and blood samples were taken. For each horse 10 X-ray pictures were taken of toes in lateral medial projection, hocks in two oblique projections, and stifle in lateral medial projection. Radiological results were categorised in 4 groups (Table 2) in relation to the significance for the longevity of the horse for reactions in growth lines, fragments, osteochondric (OCD) related defects with or without fragments and new bone formations in a total of 14 scores.

Table 2. Radiographic classification

Group	Description
0	No deviation or minor deviations considered to be within normal variation
1	Small deviations from normal variation. Clinical significance unclear or unknown but considered to be unlikely to affect the performance of the horse.
2	Deviations from normal variation. Negative effects on performance are unclear.
3	Deviations from normal variation. Negative effects on performance are very likely.

Whole blood was anticoagulated with potassium-EDTA (potassium-ethylenediamine-tetraacetate). For the first two years of sampling in the first replicate the number of leukocytes (LEU) was counted electronically (Linson counter 431A, control blood EQUINOX (haematology reference control)). Haemoglobin content was determined by the cyanomethaemoglobin method. Haematocrit (HCT) was determined by centrifugation in a haematocrit centrifuge (Heraens Haemofuge) at 12000 g. The number of leukocytes (LEU) and haemoglobin (HGB) was counted electronically (CELL-DYN™ 3500, ABBOTT Diagnostics Division). Furthermore, whole blood was collected in sodium heparin and centrifuged at 1370 *g* for 15 min. The blood plasma was separated from the blood corpuscles and stored at -20°C until analysis. ASAT (aspartate aminotransferase) and ALP (alkaline phosphatase) activity was quantified using standard colorimetric methods performed on autoanalyzer (OpeRA™, Technicon, Bayer). ASAT is a muscle enzyme and is used as an indicator of over-exertion in the muscles (Snow and Vogel, 1987). ALP is a skeleton enzyme, which in young horses, can be used as an indicator of the activity level in bone development (Nitzschke and Fürll, 1996).

Analysis of total calcium (Ca) in plasma was based on initial acidic liberation of protein bound calcium and subsequent complexation with cresolphtalein in alkaline medium. The complex was determined using 550 nm spectrophotometry. The method is standardised by Technicon RA® Systems (1994). Plasma magnesium (Mg) was determined spectrophotometrically using the colour shift due to chelation by xylidyl blue, the reaction was read directly at 500 nm, as practised by Technicon RA® Systems (1994). Inorganic phosphorus (IP) was measured as increased absorption due to complexation with ammonium molybdate in an acid environment. The method is standardised by Technicon RA® Systems (1994).

Each year at the end of April, i.e. twice in each replicate the horses were observed for two hours in three days while in the paddocks. During observations distance travelled and frequency of trot/gallop bouts, rearing/bucking/rolling bouts and social contact bouts were recorded for 0-15 minutes, 15-30 minutes, 30-60 minutes, 60-90 minutes and 90-120 minutes from entering the paddocks. All observations were made from a car or camper van placed next to the paddocks.

Four observers covering either one group of horses or two single housed horses were observing simultaneously. Distance travelled was calculated from drawings of each horse's movements in the paddock. Bouts of trot/gallop or rearing/bucking/rolling were defined as ending when the horse changed behaviour. Social contact was anything from touching to play fighting where touching was the only possible social contact for single housed horses.

2.3. Statistical methods

Feed intake was analysed as kg feed, kg DM and Scandinavian Feed Units (Sc. FU) (1 Sc.FU=7.890kJ NE) per day, feed intake capacity as % intake of live weight, live weight as kg, height as height at withers in cm, growth as daily gain in kg, and body condition as scores and changes in scores in the six age periods. ASAT and ALP were analysed separately for each replicate due to a potential loss in enzyme activity due to a longer storage of the samples in the second replicate. Radiological results were analysed as total score for characteristics related to OCD (OCD) and total score for characteristics not related to OCD (XRAY). All variables relating to radiological results and exercise in paddocks were log-transformed to obtain normally distributed variables. Values given are least square means and standard errors of means. For transformed variables values are back-transformed to the original scale and given as least square means and 95%-confidence intervals.

Several models with the same structure were used. Replicate (1,2), sire (1-6), age of horse (½, 1½ or 2½ years) or age period (I-VI), housing (single, group) and handling (+, -) were fitted as fixed effects in all models. For variables concerning exercise in paddocks also the observation day was included as a fixed effect. All two-, and three-way interactions between replicate, age/age period and housing were included in the start model for each variable but excluded hierarchically from the model if they were not significant at the 5%-level.

For feed intake pen within replicate, and for other variables additionally, foal within pen and replicate were fitted as random effects. For ASAT and ALP foal within pen was fitted as a random effect.

For variables concerning exercise in paddocks correlations between the measurements taken over three successive observation days were modelled as first order autocorrelation for each horse within replicate and age.

The data analysis for this experiment was generated using the procedure SAS/MIXED of SAS/STAT software version 8. (SAS, 2000).

Results

Activity

Results for variables concerning observations in paddocks are shown in figures 1 and 2. There was an interaction between the effects of replicate, housing and age for distance travelled (Figure 1a) and frequency of trot/gallop (Figure 1b). In general, group housed horses travelled longer and had a higher frequency of trot/gallop bouts than single housed horses (Figures 1a and 1b).

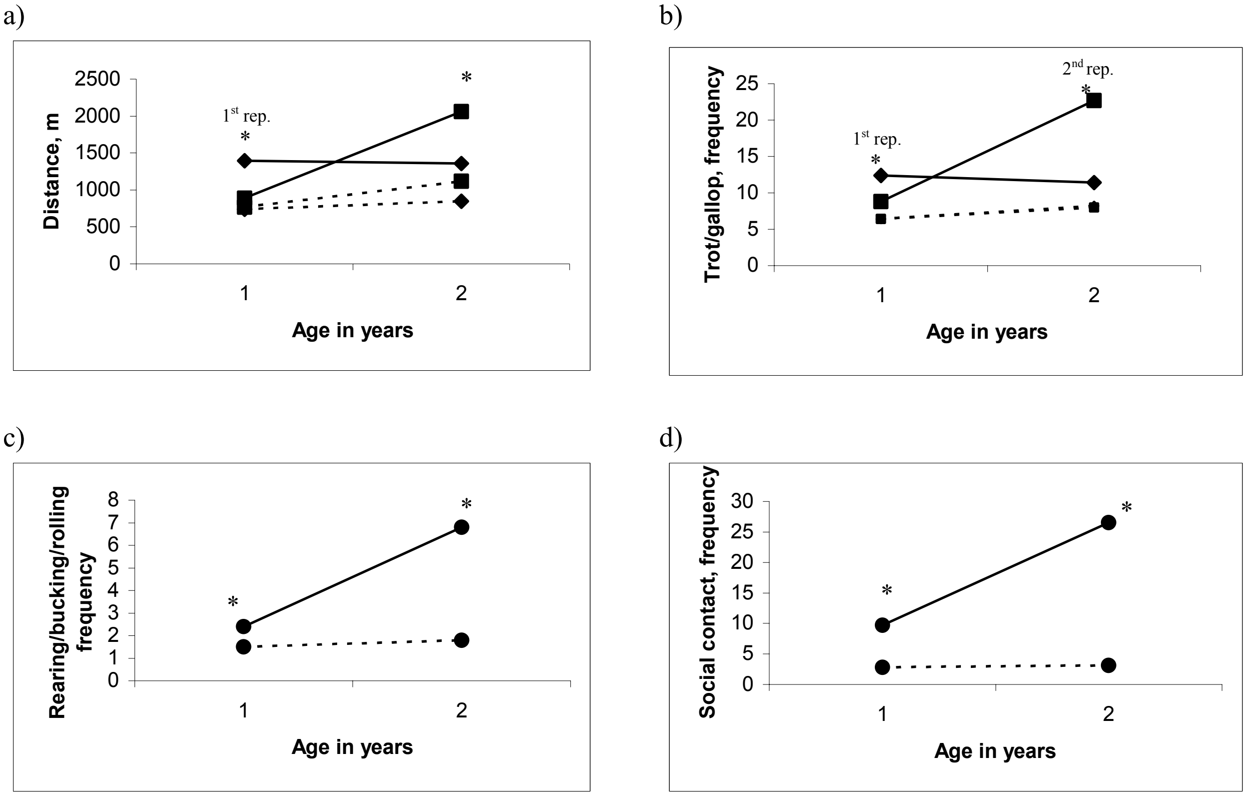


Figure 1. LS mean at the original scale for distance travelled in m (a), frequency of trot/gallop (b), frequency of rearing/bucking/rolling (c) and frequency of social contact (d) for single housed horses ----, and group housed horses — in the first replicate ♦ and the second replicate ■. * indicates a difference between housing treatments within replicate and age periods at the 5% level. Lower confidence intervals were within 65% to 81% of the mean and upper confidence intervals were within 123% to 152% of the mean.

In the second replicate distance travelled and frequency of trot/gallop were higher for two-year old horses than for one-year old horses. For all observation periods within the 2-hour observation period group housed horses covered a longer distance than single housed horses (Figure 2).

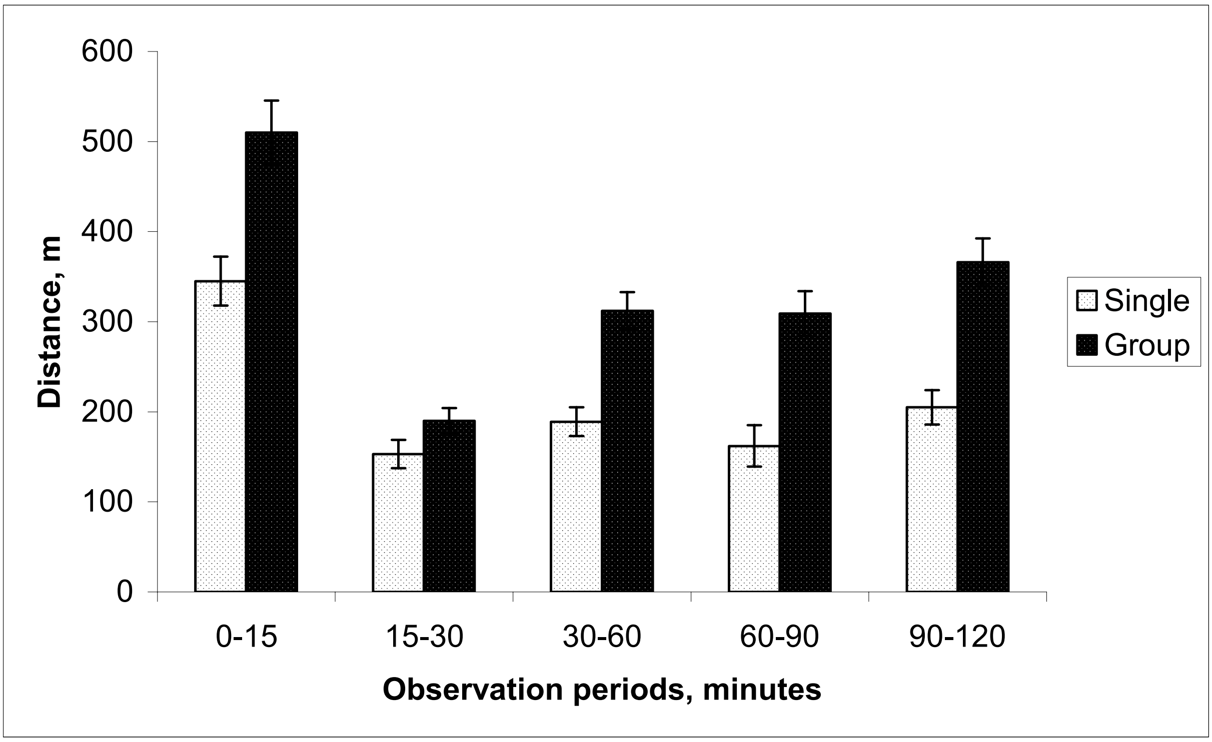


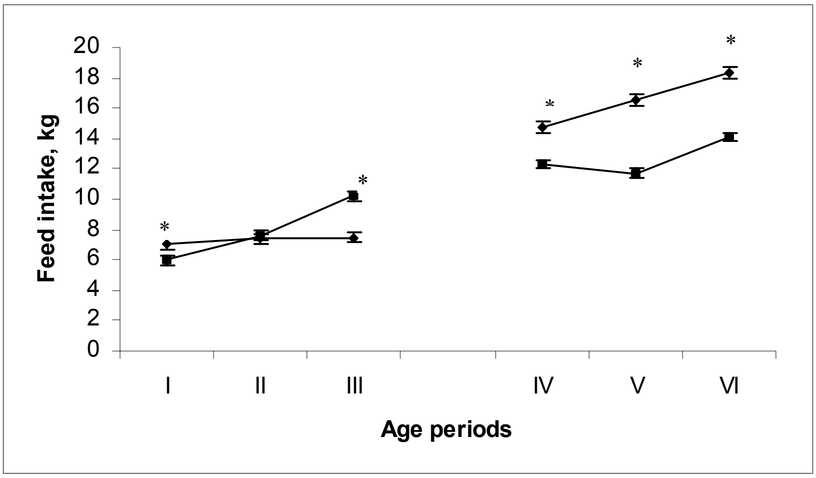
Figure 2. Mean and standard error for distance travelled in paddocks in relation to social environment within each observation period.

Group housed horses were rearing/bucking/rolling more and had a higher frequency of social contact than single housed horses across replicates and age (Figures 1c and 1d). For all behavioural variables except frequency of social contact there were significant differences between observation days ($P<0.05$). There was no effect of sire or handling for any of the variables related to exercise in paddocks.

Feed intake

For all variables on feed intake there was an interaction between replicate and age period ($P<0.0001$; Figure 3).

a)



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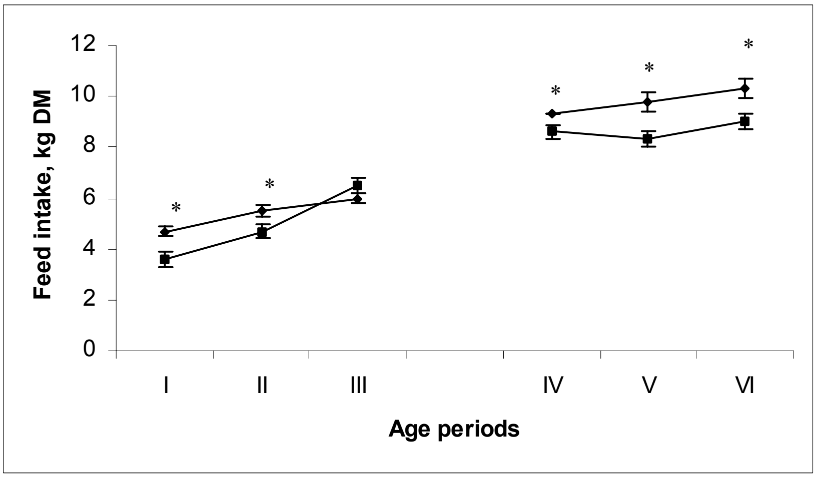

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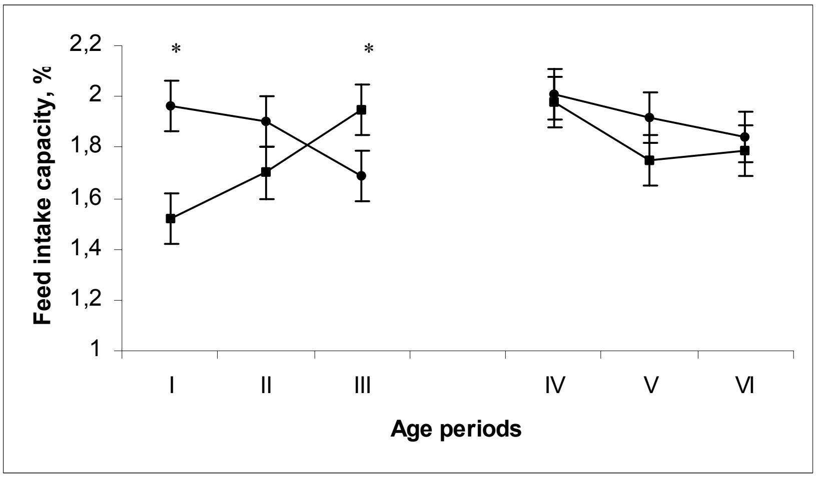

Figure 3. LS-means and standard error for feed intake in kg/d (a), feed intake in kg DM/d (b) and feed intake capacity in % (c) by age period for the first replicate ♦ and the second replicate ■ . * indicates a difference between housing treatments within replicate and age periods at the 5% level.

In general feed intake was lower in the second replicate than in the first replicate. A similar pattern was observed for energy intake (Sc. FU/d; data not shown). Social environment did not affect feed intake (Table 3).

Table 3. Effects of social environment on feed intake, daily live weight gain, Body Condition Score (BCS) and change in BCS presented as LS-means (standard error)

	Single (n=15)	**Group** (n=8 x 3)	**P-value**
Feed intake, kg/d	11.0 (0.3)	11.2 (0.2)	0.61
Feed intake, kg DM/d	7.1 (0.2)	7.3 (0.1)	0.57
Feed intake, Sc. FU/d	4.3 (0.1)	4.3 (0.1)	0.88
Daily gain, kg	.532 (0.027)	.485 (0.027)	0.22
BCS	6.7 (0.2)	6.8 (0.2)	0.79
Change in BCS	0.2 (0.1)	0.2 (0.1)	0.89

Feed intake capacity for single housed horses showed an interaction between replicate and age period, where feed intake capacity was similar in both replicates except for the 1st period in which it was higher in the first replicate and for the 3rd period in which it was higher in the second replicate (Figure 3c).

Growth

There was a significant interaction between replicate, housing and age period for live weight (P<0.01; Figure 4), and between replicate and age period for height at withers (P<0.0001) and daily gain (P<0.05) , and between replicate and housing for height at withers (P<0.01).

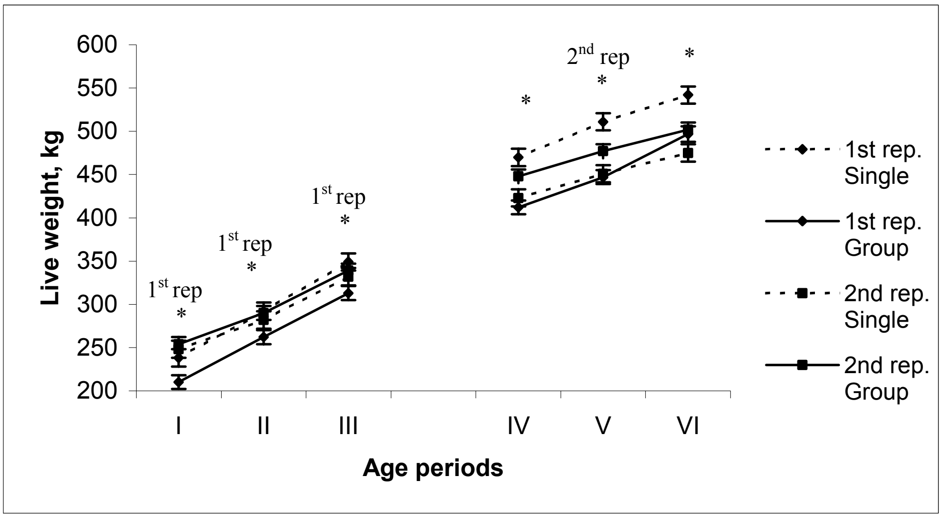

Figure 4. LS-means and standard error for live weight by housing, replicate and age periods. * indicates a difference between housing treatments within replicate and age periods at the 5% level.

In the first replicate single housed horses were heavier and taller than group housed horses whereas in the second replicate group housed horses were heavier but not taller than single housed horses. Horses in the second replicate were taller at the beginning of the experiment (138 cm ±1 vs. 134 cm ±1) but there was no difference by the end of the experiment (164 cm ±1 vs. 163 cm ± 1 cm). There was no significant difference in daily gain within age groups across replicates. Overall, handled horses were heavier than non-handled horses (Handled: BW 387kg ±6; Non-handled: BW 368kg ±5; P<0.05). In the second replicate body condition score differed between age periods with a higher BCS in the second winter and a higher increase in BCS in the 4th period than in other periods (Table 4). Social environment did not affect daily gain or BCS (Table 4). Progeny from different sires differed in height at withers (P<0.05).

Table 4. LS-means (standard error) for Body Condition Score (BCS) and change in BCS for the second replicate by age period. Different letters within rows indicate significant difference at P<0.05.

Age period	**I**	**II**	**III**	**IV**	**V**	**VI**	**P-value**
BCS	6.2^{c} (0.2)	6.8^{b} (0.2)	6.7^{b} (0.2)	6.4^{c} (0.2)	7.0^{ab} (0.2)	7.3^{a} (0.2)	<0.0001
Change in BCS	0.4^{ab} (0.2)	-0.2^{c} (0.2)	0.1^{bc} (0.2)	0.7^{a} (0.2)	0.1^{bc} (0.2)	0.4^{ab} (0.2)	0.0031

Radiological results and blood parameters

Results on radiology are shown in table 5. No difference was found between single and group housed horses (P>0.1). The score was decreasing with age for both non-osteochondrosis related characteristics (XRAY) and for OCD related characteristics. There was a highly significant effect of sire for characteristics related to OCD (P<0.0001).

Table 5. Total score for radiological results not related to osteochondrosis (XRAY) and osteocondrosis (OCD) by age presented as LS-means (95% confidence interval) on the original scale. Different letters within rows indicate significant difference at P<0.05.

Age	**½**	**1½**	**2½**	**P-value**
XRAY	1.2^{a} (0.8-1.6)	0.6^{b} (0.4-1.0)	0.3^{c} (0.1-0.6)	<0.0001
OCD	0.6^{a} (0.3-1.0)	0.4^{b} (0.1-0.7)	0.4^{b} (0.1-0.7)	0.0299

ALP was higher for group housed horses than for single housed horses at ½ year of age in the first replicate and across ages in the second replicate (Table 6). In the first replicate ALP values were lower at 1½ years of age than at ½ or 2½ years of age. In the second replicate ALP was decreasing with age. Progeny from different sires differed in ALP for the first replicate (P<0.05) but not for the second replicate (P>0.1).

Group housed horses tended to have a higher value of ASAT in the first replicate and a lower value in the second replicate (P<0.1; Table 6). In the first replicate the highest value of ASAT was found at 1½ years of age whereas in the second replicate it was at 2½ years of age. (Table 6). Progeny from sires differed in the ASAT values in both replicates (P<0.0001 in the first replicate and P<0.05 in the second replicate).

Table 6. LS-means (standard error) for ALP and ASAT by social environment and age interacting or separately. Different letters within rows indicate significant difference at P<0.05.

	Single			**Group**			**P-value**
Age	½	1½	2½	½	1½	2½	
ALP 1[1], U/l	392[b] (24)	262[c] (24)	368[b] (24)	501[a] (19)	271[c] (21)	381[b] (19)	0.0241
Housing/age	**Single**	**Group**	**P-value**	**½**	**1½**	**2½**	**P-value**
ALP 2[2], U/l	162[b] (6)	180[a] (5)	.0402	231[a] (6)	149[b] (6)	131[c] (6)	<0.0001
ASAT 1[1], U/l	293 (8)	311 (7)	.0738	286[b] (8)	380[a] (9)	240[c] (9)	<0.0001
ASAT 2[2], U/l	281 (6)	265 (5)	.0518	250[b] (7)	243[b] (7)	326[a] (7)	<0.0001

[1] 1st replicate
[2] 2nd replicate

Group housed horses had a higher level of Ca than single housed horses (3.23 mmol/l ±0.02 vs. 3.16 mmol/l ± 0.02; P<0.05) and for both treatments it was lower at ½ year of age than later (Figure 4). Ca levels were similar in the two replicates (P>0.05).

Levels of IP were higher at ½ year of age for both single and group housed horses (Figure 4), and decreased with age. At 2½ years of age the level was affected by housing; group housed horses having a lower value than single housed horses. Level of IP was higher in the first than in the second replicate (1.98 mmol/l ± 0.04 vs. 1.67 mmol/l ± 0.04; P<0.0001).

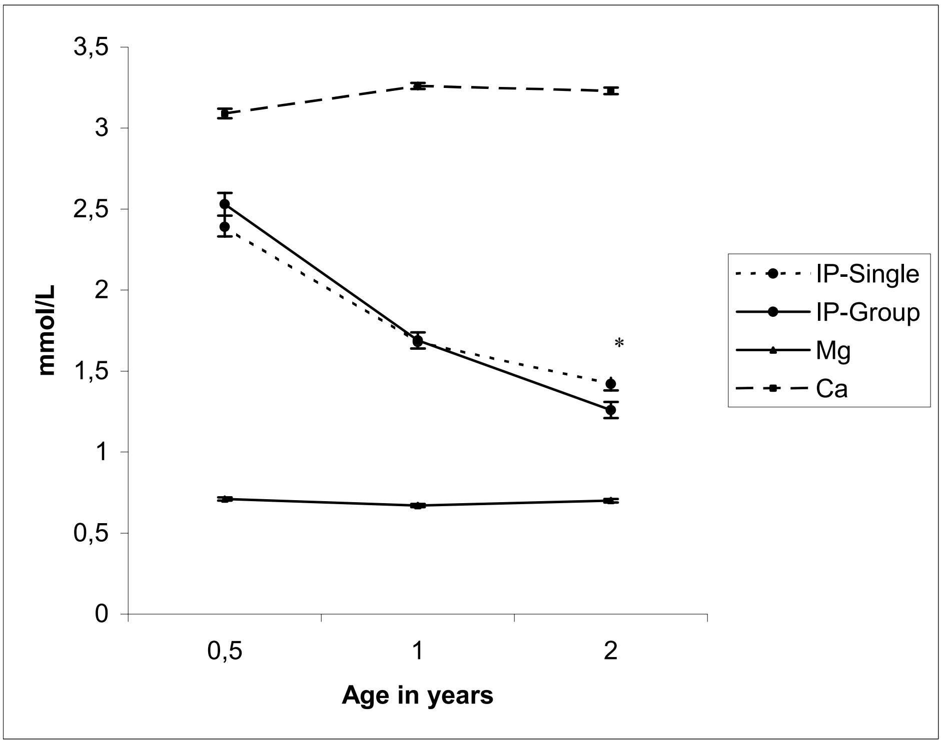

Figure 5. LS-mean and standard error for Mg and Ca by age and for IP by housing and age. * indicates a difference between housing treatments at the 5% level.

Group housed horses had a higher level of Mg than single housed horses (0.71 mmol/l ± 0.01 vs. 0.68 mmol/l ± 0.01; $P<0.05$). Across treatments the level of Mg was lowest at 1½ years of age (Figure 4). Level of Mg was higher in the second than in the first replicate (0.71 mmol/l ± 0.01 vs. 0.68 mmol/l ±0.01; $P<0.05$).

Horses in the first replicate had a higher HCT value at ½ year and 1½ years of age (Table 7). Horses in the second replicate had a higher LEU at 1½ years of age (Table 7). Handled horses had a lower level of HGB than non-handled horses (8.2 mmol/l ± 0.1 vs. 8.6 mmol/l ± 0.1; $P<0.05$).

Table 7. LS-means (standard error) for haematocrit value(HCT) and number of leucocytes (LEU) by replicate and age. Different letters within rows indicate significant difference at P<0.05.

Replicate	**1**			**2**			**P-value**
Age	**½**	**1½**	**2½**	**½**	**1½**	**2½**	
HCT, %	37.2^{ac} (.7)	38.0^{a} (.7)	34.7^{bd} (.7)	33.9^{b} (.7)	35.6^{cd} (.7)	35.8^{cd} (.7)	.0009
LEU, 10^9/l	10.9^{a} (.4)	8.2^{b} (.5)	8.3^{b} (.4)	10.5^{a} (.4)	10.5^{a} (.4)	9.3^{b} (.4)	.0003

Discussion

The social environment affected the activity of the horses as expected but did not affect feed intake or the majority of variables related to the physical development.

The travel distance for the group housed horses in the present study was comparable to the results from Kusunose et al. (1985, 1986 and 1987) although they found that horses pastured alone travelled longer and had a shorter grazing time than horses pastured in groups. The size of the exercise paddocks was confounded with the housing system in the present experiment and one reason for the differences found could be that the smaller paddocks for the single housed horses have limited the travel distance of the horses. However, paddocks were relatively big for one horse and differences were also found in the frequencies of the other activities, which were unlikely to be constrained by the space available. This might suggest that the social environment did influence the activities observed. If the size of the paddocks was the only influence the horses would be expected to have similar frequencies of trot/gallop given that the motivation to move would be the same, but the single housed horses would cover a shorter distance because of the space limitations. This was not the case. Also, Kusunose et al. (1985) found that field sizes from 0.2 ha to 4.2 ha did not affect the distance travelled. In the study by Kusunose et al. (1986) the horses pastured alone were unable to see other horses and they were not used to being alone so their observations may be a reaction to isolation stress whereas in the present study the single housed horses seemed to lack the motivation for activity.

It is interesting that single housed horses had a number of contacts even though their opportunities for having social contact were strongly limited. Additionally, where the other variables related to activity differed between observation days this was not the case for social contact, which remained frequent with little variation. This would indicate that there is a fairly strong and consistent need for the horses to have social contact. Housing horses alone may neglect this need as indicated by Christensen et al. (2002). Apart from benefiting the social welfare of horses, group housing leads to increased activity, which may benefit bone development (Bell et al., 2001) although this was not reflected in the radiological results in the present experiment.

Feed intake and daily live weight gain were lower in this study than in a previous experiment on the same research station with a similar feed where concentrate was fed separately (Staun et al., 1995). When feeding *ad libitum* with a Total Mixed Ration the horses were expected to use their feed intake capacity i.e. they would be limited by the bulk of the feed. However, this did not seem to be the case as feed intake in relation to live weight was somewhat lower than reported in other studies on young horses fed forage *ad libitum* (Ott & Asquith, 1986; Cymbaluk & Christison, 1989; Cymbaluk et al., 1989). These studies had daily gains similar to the present study. This result indicates that something else than the bulk must have been the limiting factor in the Total Mixed Ration. As caloric density was lower in the second than in the first replicate (Table 1) it would be expected that the horses would compensate by eating more which was not the case. Metabolic cues, which may have regulated the feed intake and/or feeding activity were not investigated in the present study and such cues have so far not been identified in horses (Ralston, 1986), but the lower protein content in the second replicate may have caused an inhibition of the feed intake (Schryver et al., 1987). It is likely that within the groups feeding behaviour and feed intake differed between individuals according to the social relationship within the group as shown by Kolter (1984). Subordinate animals may be reluctant to feed in the presence of dominant animals (Houpt and Wolski, 1980) thus not getting an adequate nutrition. In the present study feeding behaviour was not recorded but mostly all horses in the group were seen eating at the same time.

Although there were some effects of social environment on the blood parameters all values obtained in the present study were within the normal range for young horses (Staun et al., 1995; Kaneko et al., 1997), and therefore not expected to have detrimental effects on the physical development of the horses. ALP is decreasing with age in young horses in relation to the growth rate of bones but already from 12 months of age the curve is flattening (Nitzschke and Fürll, 1996) which may explain the apparent inconsistency in the results from the present experiment. Also IP is decreasing with age as seen in figure 5. This is in accordance with the study of Nitzschke and Fürll (1996). Levels of Ca and Mg in the present study are in accordance with the study by Cymbaluk and Christison (1989). Haematocrit and haemoglobin values are higher for trained than for non-trained horses (Snow and Vogel, 1987) and thus a difference between housing treatments due to the differences in activity could be expected but was not found.

There were no significant differences in radiological results between housing treatments but the score was decreasing with age of the horses. These observations are in accordance with results from a large Dutch experiment (Barneveld and van Weeren, 1999) in which they found that some radiological findings are related to the growth of the horses and tend to disappear when the horses are no longer in the growth phase. The effect of sire on the OCD scores are not surprising since heritability estimates of up 0.32 have been found for a variety of radiological scores (Veen et al., 1994). Exercise seems to be an important factor in the determination of the final make-up and hence biomechanical strength in the articular cartilage and tendons and is therefore a potentially powerful tool for the enhancement of injury resistance in young horses (Barneveld and van Weeren, 1999). On the other hand growth rate may be one of the most important factors that determine the occurrence of OCD (Barneveld and van Weeren, 1999) and should not be neglected when raising young horses, meaning that if young horses are fed a Total Mixed Ration as in this case it is important to monitor their growth rate in order to adjust the ration to have a moderate and constant growth rate.

Further studies on how group housing affects the individual horses with more detailed measures of development will be valuable especially in relation to the risk of creating “losers” in terms of both the physical and social development of young horses.

In conclusion, social environment affected the level of activity in such a way that group housed horses were exercising more than single housed horses. This is assumed to be beneficial for their physical development. Feed intake and variables related to the development were not affected by the social environment outside the normal range.

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Paper I

Photo by Eskild Keller Nielsen

Young horses' reactions to humans in relation to handling and the social environment

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Abstract

Forty Danish Warmblood colts in two replicates were used to investigate the effect of housing and handling in the rearing period on the reactions to humans. The horses entered the experiment after weaning and were housed either individually (n=16) or in groups of three (n=24). Half of the horses from each housing group were handled three times per week for a period of ten minutes. Approach tests were performed in the home environment when the horses were 6, 9, 12, 18, 21, and 24 months old, and an Arena and Human Encounter test was performed in a novel environment when the horses were 12 and 24 months old, respectively. In the home environment single housed horses approached sooner and were more easily approached by a human than group housed horses whereas no effect of handling was observed. Horses approached sooner and were more easily approached with increasing age. In the Arena and Human Encounter test single housed horses expressed less restless behaviour, more explorative behaviour, and less vocalisation than group housed horses. Handled horses showed lower increase in heart rate during the test than non-handled horses. There was no difference between the number of times single or group housed horses touched an unfamiliar person in the Arena and Human Encounter test but handled horses approached sooner than non-handled horses. It is concluded that the social environment affected the way horses reacted to humans when tested in the home environment but not in a novel environment. In contrast handling affected the reactions to humans when tested in the novel environment but not in the home environment. However, handled horses also reacted less to the novel environment in general, thus indicating that handling is a mean of avoiding potential dangerous situations.

1. Introduction

Horses are used for various activities in relationships with humans. Consequently, a successful human-animal relationship is important for horse husbandry. If horses are fearful of humans they are prone to be stressed whenever human contact is unavoidable. Performance is likely to be reduced if the horse is fearful and it may be dangerous to handle fearful animals. The behavioural response to humans may be influenced by environmental as well as genetic factors (Le Neindre et al., 1993). The response will depend on the nature of the previous behaviour of humans towards the animal and also by the amount of time the animals have spent with humans (Hemsworth and Barnett, 1987). Thus, positive handling of horses is assumed to have a positive effect on the human-animal relationship.

Group housed animals may show less interest in contact with humans, a fact, which may interfere with the human-animal relationship. Conversely, it is a general belief that young horses housed in groups are easier to handle due to an abreaction within peers. The latter was confirmed in a study by Rivera et al. (2002), where horses kept in groups on pasture required less time to become habituated with the activities occurring from the start of training to mounting than horses housed in single stalls. Also, the frequency of unwanted behaviour was lower for horses in groups than single housed horses. However, due to the confounding between space allowances, housing system and social environment it is impossible to determine what caused the difference.

If the rearing environment and the amount of time young horses spend with humans are essential to their general perception of humans, it will affect their welfare directly through their own reactions towards humans and indirectly through the reaction of humans towards them. A horse that has confidence in humans is more likely to behave well when handled and thus it is in less risk of being punished or mistreated. Most studies on the various aspects of the human-animal relationship in horses have focused on handling before weaning (Mal et al., 1994; Mal and McCall, 1996; Søndergaard and Jago, 2001; Williams et al., 2002), one on a combined schedule with handling both before and after weaning (Jezierski et al., 1999) and some on effects of either handling (Visser et al., 2001 and 2002) or housing (Rivera et al., 2002) but the separate and interactive effects of handling and housing during the rearing period have not been investigated previously.

The aim of this experiment was to investigate single and group housed horses' reactions to humans in relation to handling intensity from weaning and until 2 years of age.

2. Materials and methods

The experiment was conducted at Research Centre Foulum, Denmark as part of a larger project on the effect of rearing environment on the social and physical development of young horses.

2.1. Animals, Housing and Management

Forty Danish Warmblood colts entered the experiment after weaning. The experiment was performed as two replicates of 20 colts entering either in September 1997 or September 1999 at a mean age of 4.3 (+/- 0.5) and 5.0 (+/- 0.5) months, respectively. Six stallions sired the colts; four sires in each replicate. In each replicate, eight horses were housed singly in boxes of $9m^2$ and 12 horses were housed in 4 groups of 3 horses in boxes of $27m^2$ (Figure 1). Separation between boxes consisted of walls of plastic planks (DAN Egtved A/S, Denmark) up to 1.2m and vertical bars with a distance of 8cm from 1.2m to 2.5m allowing the horses to see, hear, smell and touch but not physically interact with neighbouring horses. There were two rows of boxes as shown in figure 1. The rows were separated by 3m closed walls of plastic planks. Each box was equipped with an automatic drinker. The front of each box consisted of vertical bars with a distance of approximately 30cm allowing the horses to feed from the floor in front of each box. Horses were fed *ad libitum* once a day with a total mixed ration of chopped grass silage, chopped hay, chopped straw and concentrate, molasses and minerals. During the housing period, horses were given 3h of daily exercise in paddocks according to their housing, i.e. single housed horses alone and group housed horses in groups of 3 (Figure 1). Paddocks for single housed horses were 20 x 40 m^2 and paddocks for group housed horses were 45 x 90 m^2. All horses were exercised in the same paddocks every day. Each paddock was used by two pens in the stable i.e. two single housed horses or two groups of horses in the morning and afternoon, respectively. The horses were housed from mid-September to mid-May. The summer period they spent grazing in one joined group whereupon they returned to their previous housing conditions during the following winter period. The experiment ended when the horses entered the second summer period i.e. when they were two years of age. Half of the horses in each replicate and in each housing system were handled three times per week for a period of 10 minutes during each housing period. Handling was performed in an arena in the same building as the stable (Figure 1). Five people (two males and three females) were involved in the handling during the four-year period, and one of the two main trainers (one male and one female) was always present during handling. Handling involved leading, tying up, touching, lifting feet etc. From the foals were purchased at an age of approximately 2 months until weaning owners were instructed not to handle their foals unless for necessary veterinary treatments. Non-handled horses were only handled for monthly weightings, farrier and necessary veterinary treatment. There was no physical contact between the caretaker and the horses when feeding or at any other times. When going to and from the paddocks horses were running loose in a runway and no handling of the horses was needed. Visitors to the stable were only allowed to enter the part of the stable where the handled horses were (Figure 1) and were kept at distance from the horses.

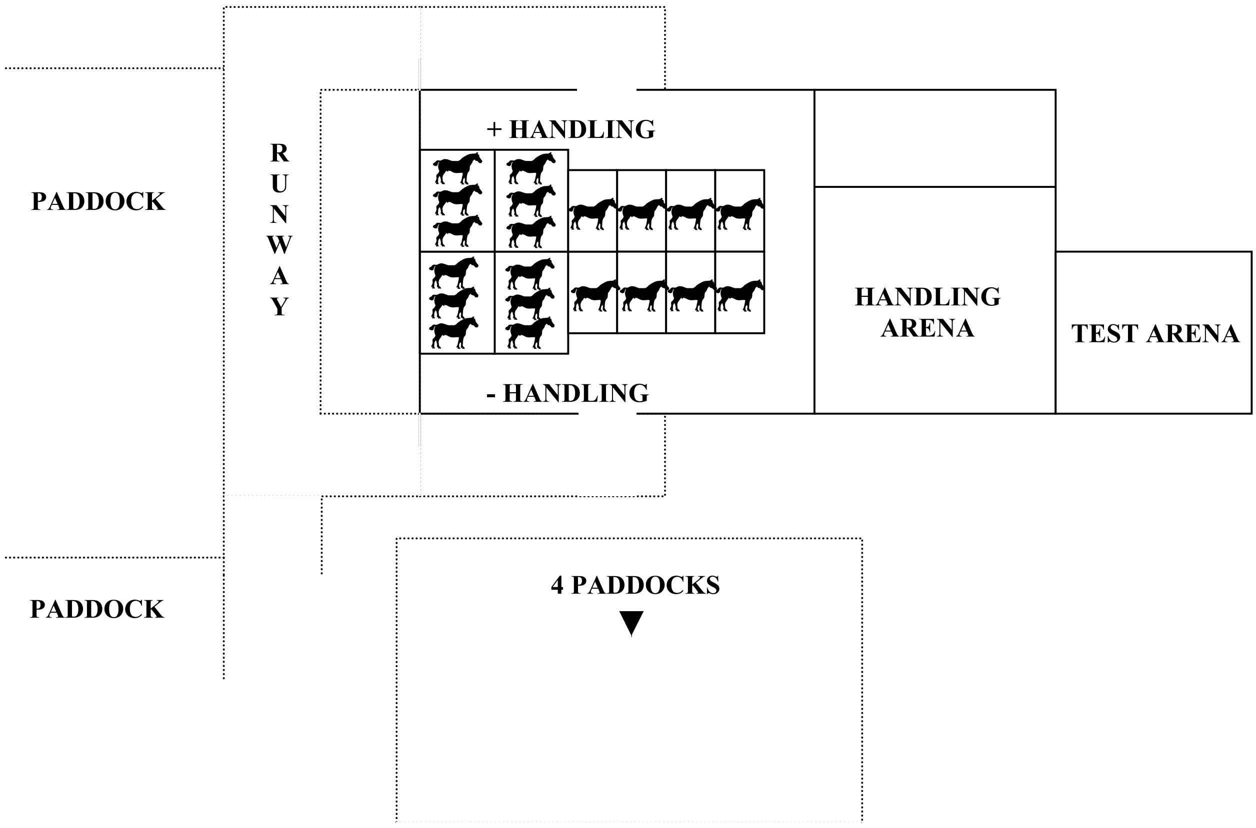

Fig. 1. Overview (not scaled) of stable, handling arena and test arena. The test arena was not permanent but only present during the Arena and Human Encounter Test. The test arena was situated outside the building. The Voluntary Animal Approach Test and the Forced Human Approach Test were performed in the exercise paddocks.

In the first replicate one horse from the single housed, handled treatment was culled due to injury at 6 months of age. In the second replicate one horse from the group housed, handled treatment was culled due to health problems at 18 months of age.

2.2. Tests and variables

To evaluate the human-animal relationship both in terms of age and environment three tests were performed several times. Two Approach Tests were performed in the home environment i.e. the exercise paddocks to simulate an unstressed situation, and an Arena and Human-encounter Test was performed in an unfamiliar and less spatial environment to create a slightly stressful situation in order to evaluate if reactions to humans are depending on the situation.

2.2.1. Voluntary Animal Approach Test (VAA test)

The test was performed 3 times during each winter period when the horses were 6, 9, 12, 18, 21 and 24 months old, respectively. It was performed in the paddocks approximately 2 hours after the horses were let out.

The test was adapted to horses from similar tests used on calves by Jago et al. 1999, Krohn et al. 2001 and Krohn et al. 2003. An unfamiliar person entered the paddock away from the horse/horses and walked to the middle of the paddock. Latency in seconds until a horse had its head within a distance of 1m and latency until the horse touched the person was recorded. The maximum test time was 3 minutes.

For the first replicate the test was performed by a different person each time i.e. in total 6 people whereas for the second replicate the same person performed all the 6 tests. Due to this change in procedure the two replicates were analysed separately.

For the statistical analyses only latency to touch the person was used as only a few horses came close to the test person without touching.

2.2.2. Forced Human Approach Test (FHA test)

The test was performed approximately 20 minutes after the Voluntary Animal Approach Test. The test was adapted to horses from a similar test used on heifers by Krohn et al. 1999. After finishing the Voluntary Animal Approach Test on all horses the same person entered the paddock away from the horse/horses and approached a horse slowly with approximately one step per second with hands hanging by the side. If the horse stood still when the person was within a 2m range (category 2 below) the person slowly raised the hand to let the horse sniff it. If the horse sniffed the hand the person slowly attempted to touch the neck of the horse. Horses within a group were approached one by one in a pre-determined order. A horse was scored from 1 to 4 on the following scale:

1: The horse moved away from the person before he/she got within a 2m range
2: The horse stood still when the person was within a 2m range
3: The horse sniffed the person's hand
4: The person could touch the horse on the neck

As for the Voluntary Animal Approach Test six people performed the test for the first replicate and for the second replicate the same person performed all the tests. Due to this change in procedure the two replicates were analysed separately.

2.2.3. Arena and Human Encounter Test

The test was performed at the end of each housing period when the horses were 12 and 24 months old respectively, in an outdoor test arena, which was unfamiliar to all horses. The arena was built of plywood upon asphalt ground. The arena measured 4.88m by 4.88m and the walls were 1.83m high. One side of the arena was next to the wall of the horse stable (Figure 1). On the side opposite the stable there was a double door in the wall of the arena. The test arena only existed during testing and apart from the duration of the Arena and Human Encounter Test horses were never on this side of the stable.

Each horse was equipped with a heart rate monitor (Polar ® Horse Tester) in the home pen and left there for at least 15 minutes with a person watching to avoid pen mates or the horse interfering with the equipment. One electrode was placed behind the scapula on the right withers; the other electrode was placed ventrally on the left side of the abdomen. The skin of the horse was moistened with water and the electrode smeared with gel to improve conductivity. Heart rate was calculated as averages at 5-sec intervals.

Each horse was led to the outdoor arena by the experimenter and then released (period 1). After three minutes an unfamiliar person entered the arena and stood next to the wall on the opposite side from the entrance for three minutes (period 2). Hereafter, the person left the arena and the horse was alone for three minutes (period 3). Regarding the test performed on the first replicate when they were 12 months old, period 3 was not included, and the test person caught the horse by the end of period 2. Otherwise, the experimenter entered the arena at the end of period 3, caught the horse and led it back to the stable.

The behaviour of the horse during all three periods was recorded using scan sampling with a 10 second interval. Behaviours recorded were standing, standing alert with elevated neck and intense orientation of the ears and eyes, pawing, sniffing floor/wall while standing or walking, sniffing person (period 2 only), walking, trotting and two tracking (Waring, 1983). Besides, all occurrences of rearing, defecation, blowing, nickering, and whinnying were recorded. In period 2, latency in seconds to first contact with the person and number of contacts with the person were recorded. Time taken to be caught after period 3 was recorded. Heart rate was measured throughout the test and variables were: Mean heart rate (beats per minute (bpm)) in period 1, 2 or 3 and when the horse was led to and from the arena as a deviation from the baseline heart rate (bpm), determined as the mean heart rate the last 5 minutes before the experimenter entered the pen to lead the horse to the arena. An increase in heart rate was assumed to reflect the level of emotionality as shown by Visser et al. (2002).

Behavioural variables in the Arena and Human Encounter Test were defined for analyses as follows:

Restlessness: All occurrences of rearing and defecating and number of scans with pawing, trotting, and pacing.

Exploration: Number of scans where the horse is sniffing floor or wall while standing or walking and number of scans where the horse is sniffing the person.

Vocalising: All occurrences of blowing, nickering and whinnying.

Standing alert was analysed as a single variable.

On three occasions the test ended before time because the horse escaped from the arena. This happened once in the first replicate when the horses were two years old. The horse was single housed and not handled. In the second replicate it happened once when the horses were one year old and the horse in question was group housed and not handled, and once when the horses were two years old and the horse was group housed and handled. For the first two horses the test was ended in the second period and for the last horse it was ended in the first period.

2.3. Statistics

The latencies to touch the test person in the VAA test were analysed with a Cox proportional hazard model (cf. Cox, 1972). The hazard rate $\lambda(t)$, i.e. the instantaneous probability to touch being conditional on not having touched until time t, was modelled as

$$\lambda(t) = \lambda_0(t)\exp(SIRE + AGE[months] + HOUSING + HANDLING)$$

for each replicate separately. $\lambda_0(t)$ stands for the baseline hazard rate. The correlation of the measurements within boxes was accounted for by an estimation of the variances of the estimates of the parameters with a grouped Jackknife estimate (Therneau and Grambsch, 2000).

For the FHA test the data were analysed via a continuation-ratio model (Fienberg, 1980). The four possible responses of a horse (cp, 2.2.2.) were considered describing discrete states for which it is plausible to assume that a horse has to pass a lower state in order to reach a higher one.

The continuation-ratio models the log-odds of the probability of attaining a higher state, given that a lower state has been attained.

$$\log\frac{P(Y > i \mid Y \geq i; X)}{P(Y = i \mid Y \geq i; X)} = \alpha_i + SIRE + AGE[months] + HOUSING + HANDLING, \text{ i} = 1, 2, 3$$

where the observations per horse are considered to be multinomial distributed. This model allows a direct expressing of the chance or odds-ratio of attaining a higher state. Correlation of measurements within pens was accounted for by calculating the variances of the estimates via the generalised estimation equation (GEE) approach of Zeger and Liang (1986).

Behaviour and heart rate variables measured throughout the Arena and Human Encounter test were analysed in a mixed model

Y = REPLICATE + SIRE + AGE [years] + HOUSING + HANDLING + TEST PERIOD + HOUSING*HANDLING +AGE*HOUSING + AGE*HANDLING + AGE*TEST PERIOD + AGE*HOUSING*TEST PERIOD + AGE*HANDLING*TEST PERIOD

where pen within replicate and horse within replicate and pen were included as random effects. The correlations between the measurements taken over three successive test periods were modelled as first order autocorrelation for each horse. Non-main-effect-terms were excluded hierarchically from the model if they were not significant at the 10%-level.

For the following factors: baseline heart rate, heart rate when led to and from the arena, time to be caught and number of times touching the person, the effect of the test period was not included. The variables vocalising, time to be caught, and number of times touching the person were log transformed [log (variable+1)] to obtain normally distributed variables. Results are presented as least square means transformed to the original scale of the variables.

Latencies to touch the test person were analysed with a Cox proportional hazard model. The hazard rate $\lambda(t)$ was modelled as

$$\lambda(t) = \lambda_0(t)\exp(REPLICATE + SIRE + AGE[years] + HOUSING + HANDLING * REPLICATE)$$

As with the data from the VAA test, the correlation of the measurements within boxes was accounted for by using a grouped Jackknife variance-estimate (Therneau and Grambsch, 2000).

The data analysis for this paper was generated using the procedures SAS/GENMOD and SAS/MIXED of SAS/STAT software version 8. (SAS, 2000).

3. Results

3.1. Effects of handling

There was no effect of handling in the VAA test or in the FHA test in any of the replicates (Tables 1-4).

Table 1. Estimates from Voluntary Animal Approach Test 1st replicate. The hazard rate ratios are calculated with respect to the level of the hazard of the reference level. A hazard ratio larger than 1 means that the horses under the 'Level' treatment approach the test person faster than those under the 'Reference Level' treatment. Where 1 is not included in the 95% conf. interval there is a significant difference to the reference level.

Factor	**Level**	**Reference level**	**Hazard rate ratio**	**95% conf. interval**	
				Lower	**Upper**
Housing	Single	Group	2.96	1.21	7.22
Handling	Non-handled	Handled	0.88	0.38	2.01
Age (months)	6	24	0.12	0.03	0.40
Age (months)	9	24	0.67	0.22	2.04
Age (months)	12	24	0.46	0.15	1.47
Age (months)	18	24	0.31	0.08	1.26
Age (months)	21	24	1.36	0.53	3.48

Table 2. Estimates from Voluntary Animal Approach Test 2nd replicate. The hazard rate ratios are calculated with respect to the level of the hazard of the reference level. A hazard ratio larger than 1 means that the horses under the 'Level' treatment approach the test person faster than those under the 'Reference Level' treatment. Where 1 is not included in the 95% conf. interval there is a significant difference to the reference level.

Factor	**Level**	**Reference level**	**Hazard rate ratio**	**95% conf. interval**	
				Lower	**Upper**
Housing	Single	Group	3.65	1.42	9.37
Handling	Non-handled	Handled	0.62	0.25	1.52
Age (months)	6	24	0.03	0.00	0.18
Age (months)	9	24	0.12	0.04	0.32
Age (months)	12	24	0.25	0.13	0.48
Age (months)	18	24	0.18	0.06	0.54
Age (months)	21	24	0.68	0.38	1.22

Table 3. Estimates from Forced Human Approach Test 1st replicate. Odds ratios are calculated with respect to the level of the hazard of the reference level. An odds ratio larger than 1 means that the horses under the 'Level' treatment are more likely to be approached by the test person than those under the 'Reference Level' treatment. Where 1 is not included in the 95% conf. interval there is a significant difference to the reference level.

Factor	**Level**	**Reference level**	**Odds ratio**	**95% conf. interval**	
				Lower	**Upper**
Housing	Single	Group	3.68	1.64	8.23
Handling	Non-handled	Handled	0.51	0.25	1.05
Age in months	6	24	0.11	0.05	0.26
Age in months	9	24	0.10	0.04	0.25
Age in months	12	24	0.18	0.07	0.44
Age in months	18	24	0.25	0.15	0.44
Age in months	21	24	4.29	0.77	23.89

Table 4. Estimates from Forced Human Approach Test 2nd replicate. Odds ratios are calculated with respect to the level of the hazard of the reference level. An odds ratio larger than 1 means that the horses under the 'Level' treatment are more likely to be approached by the test person than those under the 'Reference Level' treatment. Where 1 is not included in the 95% conf. interval there is a significant difference to the reference level.

Factor	Level	Reference level	Odds ratio	95% conf. interval	
				Lower	**Upper**
Housing	Single	Group	5.83	2.39	14.27
Handling	Non-handled	Handled	0.87	0.33	2.32
Age in months	6	24	0.03	0.01	0.11
Age in months	9	24	0.16	0.07	0.40
Age in months	12	24	0.17	0.08	0.38
Age in months	18	24	0.42	0.21	0.82
Age in months	21	24	0.65	0.26	1.62

Table 5. Estimates for latency to touch the test person in the second test period in the Arena and Human Encounter Test. The hazard rate ratios are calculated with respect to the level of the hazard of the reference level. A hazard ratio larger than 1 means that the horses under the 'Level' treatment approach the test person faster than those under the 'Reference Level' treatment. Where 1 is not included in the 95% conf. interval there is a significant difference to the reference level.

Factor	Level	Reference level	Hazard rate ratio	95% conf. interval	
				Lower	**Upper**
Replicate	1	2	0.63	0.44	0.90
Housing	Single	Group	0.91	0.61	1.36
Handling 97	Non-handled	Handled	0.34	0.17	0.69
Handling 99	Non-handled	Handled	1.33	0.39	1.44
Age (years)	1	2	1.34	0.69	2.59

In the Arena and Human Encounter test there was a significant three-way-interaction between age, handling and test period for the variable standing alert (P=0.05). There was no difference in the second and the third test period but in the first period one-year old non-handled horses stood less alert than two-year old non-handled horses (6.2 scans vs. 7.7 scans). One-year old handled horses were standing alert for 8.5 scans vs. 7.7 scans for two-year-old handled horses. Baseline heart rate was slightly lower (47 bpm) for handled horses than for non-handled horses (50 bpm; P<0.05). There was a significant (P<0.05) interaction between the level of handling and the test period for heart rate as shown in figure 2.

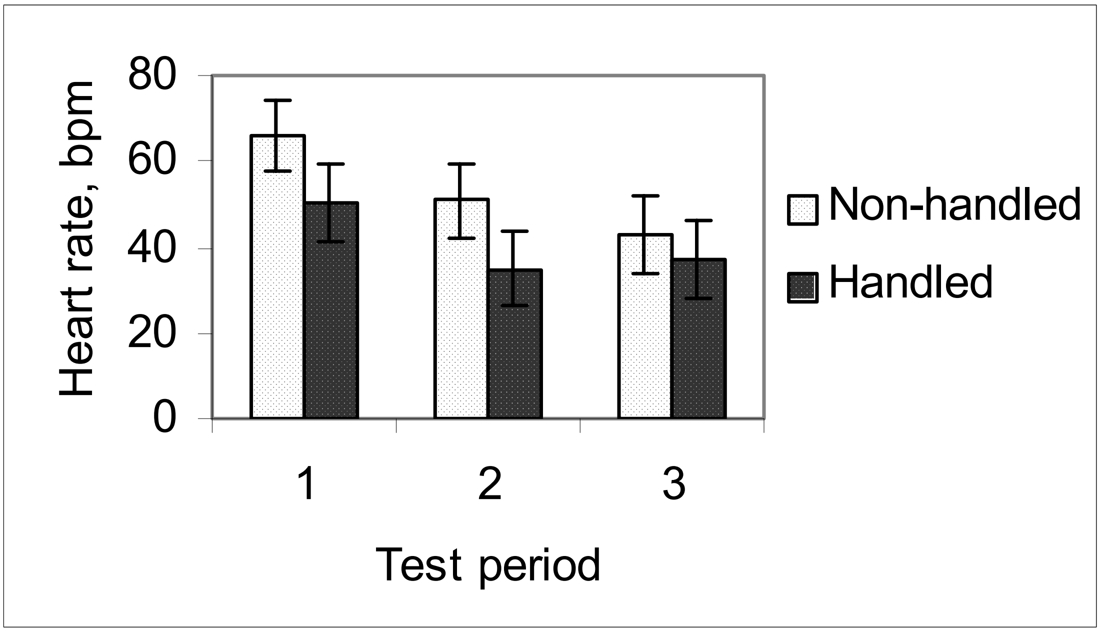

Fig. 2. Least square means and 95%-confidence intervals of heart rate (bpm) in the three test periods by level of handling

In all test periods non-handled horses had a higher heart rate than handled horses but the difference was decreasing with test period. Handled horses approached the test person sooner in the first replicate but not in the second replicate (Table 5).

At the age of one year handled horses were caught sooner than non-handled horses, while there was no difference at two years of age as shown in figure 3 (the interaction between handling and age was significant; P<0.01).

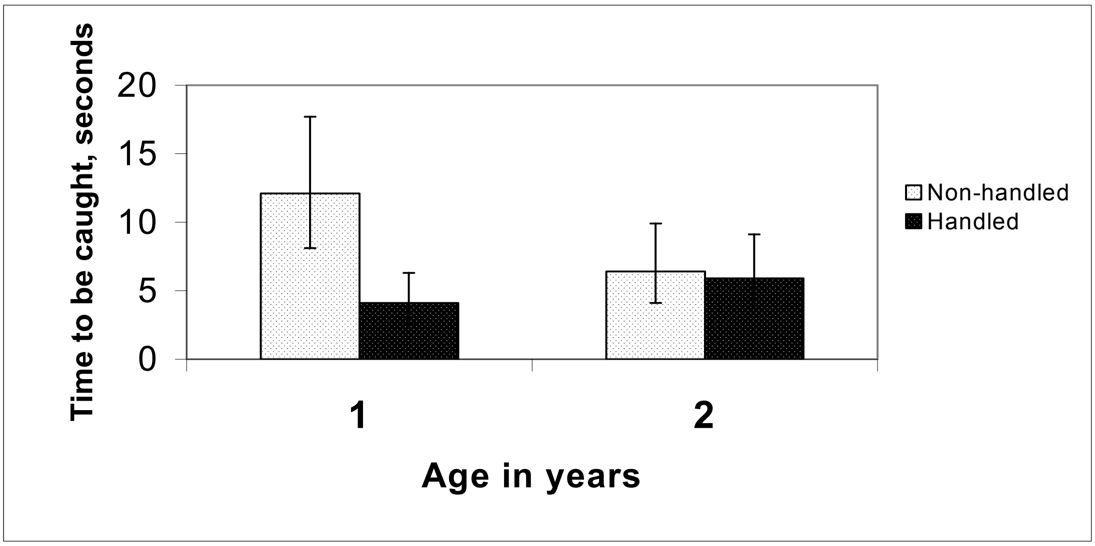

Fig. 3. Least square means and 95%-confidence intervals of time to be caught (seconds) after the test by age and level of handling

3.2. Effects of housing

The hazard of a horse touching in the VAA test was 3.0 and 3.7 times higher for single housed horses than for grouped housed horses, respectively. (Tables 1 and 2).

The chance of reaching a higher score in the FHA test was 3.7 and 5.8 times higher for single housed horses than for group housed horses in the first and the second replicate (Tables 3 and 4) ($P<0.05$ in both replicates).

In the Arena and Human Encounter test the interaction between housing and test period was not significant for the variable exploring ($P=0.07$). There was no difference in the first and the third test period but single housed horses tended to explore more in the second period than group housed horses (7.5 scans vs. 5.8 scans). The interaction between housing and test period was also not significant for the variable restlessness ($P=0.07$). There was no difference in the first and the third test period but single housed horses tended to be less restless in the second period than group house horses (7.1 counts vs. 8.8 counts). For vocalising there was a significant interaction ($P<0.01$) between the effects of age, housing and test period as shown in figure 4. One-year old group housed horses were vocalising more than one-year old single housed horses and two-year old horses.

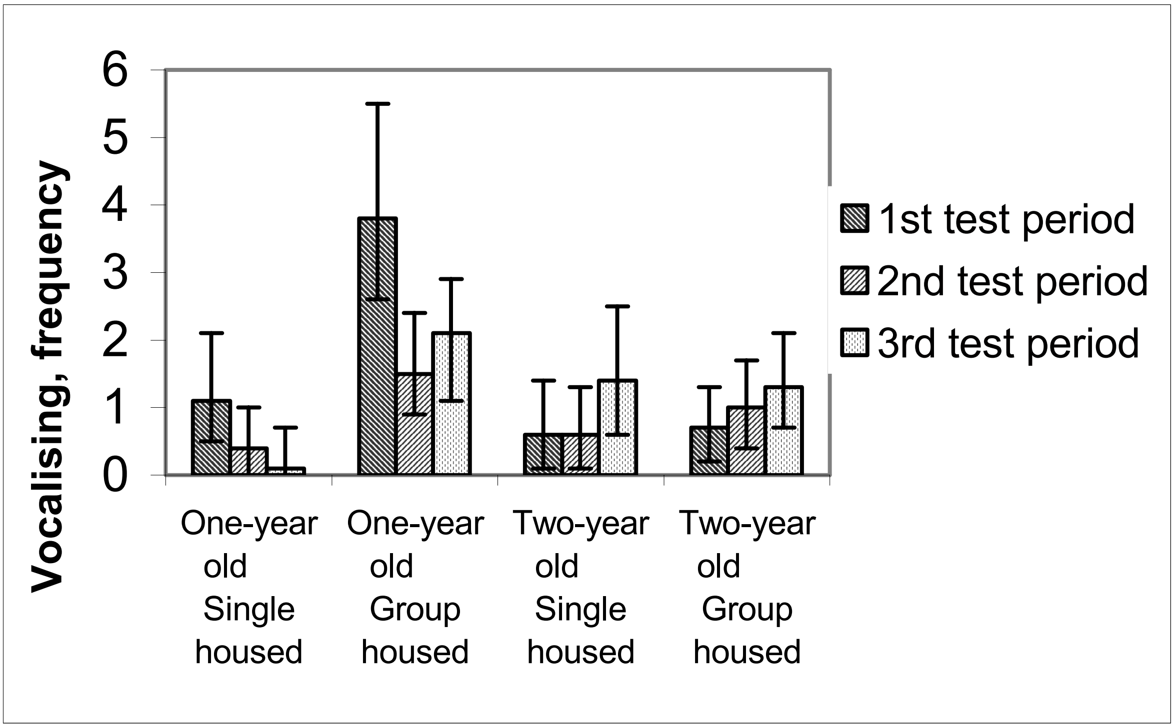

Fig. 4. Least square means and 95%-confidence intervals of number of vocalisations in the three test periods by housing and age.

3.3. Effects of age

The hazard of a horse touching in the VAA test was much lower at 6 months of age than at 24 months of age in the first replicate (Table 1) but from 12 months of age and onwards it was not different from the hazard of 24 months of age. In the second replicate the hazard of a horse touching was increasing with age except for a decline between 12 and 18 months of age (Table 2). In the FHA test the overall evidence that age is related to getting close to a horse is stronger for the first replicate (P=0.08) than for the second (P=0.17). The effect was not linear but overall increasing with age, the level at 6, 9, 12 and 18 months being significantly lower than at 24 months of age (Table 3 and 4).

In the Arena and Human Encounter test an interaction between the effects of age and test period for the variable exploring was not significant (P=0.08). There was no difference in the first two test periods but one-year old horses explored more than two-year old horses in the third period (7.5 scans vs. 5.5 scans). A three-way-interaction between age, handling and test period for the variable standing alert was observed as stated previously (P=0.05). As to vocalising there was a significant interaction (P<0.01) between the effects of age, housing and test period as stated previously.

Baseline heart rate was higher for one-year old horses than for two-year old horses (54 bpm vs. 43 bpm; P>0.0001), but it increased more for two-year old horses (39 bpm) than for one-year old horses (25 bpm) when they were led to the test arena (P<0.0001). There was a significant interaction (P<0.05) between the effects of age and test period for heart rate as shown in figure 5, although there was no difference between the age groups within each test period. The heart rate after the test was higher for two-year old horses (61 bpm) than for one-year old horses (46 bpm; P<0.0001).

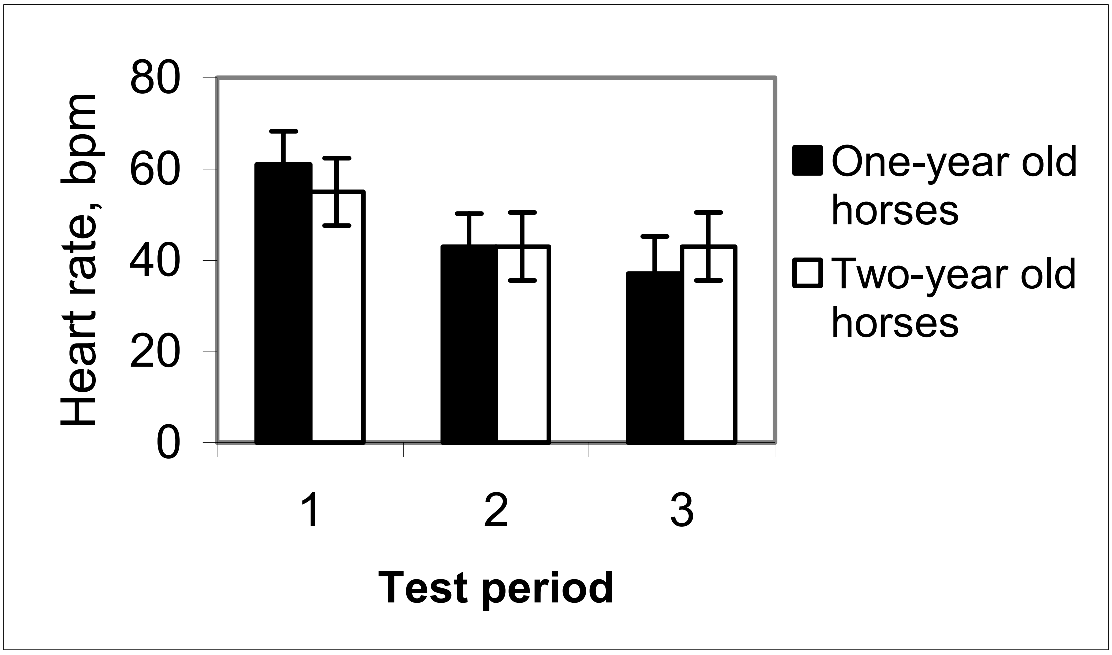

Fig. 5. Least square means and 95%-confidence intervals of heart rate (bpm) in the three test periods by age

Regarding the time taken to catch the horse after the test there was a significant interaction ($P<0.01$) between the age of the horses and the level of handling as stated previously.

3.4. Other effects

There was no effect of sire in the VAA test or the FHA-test in any of the replicates, although there was a low P-value ($P=0.06$) in the FHA-test for the second replicate. The effect of sire was significant for heart rate and for restlessness ($P<0.05$) but was not significant for vocalising ($P=0.09$).

In the first replicate the horses explored slightly less (5.1 scans vs. 7.9 scans) and stood alert more (8.3 scans vs. 6.2 scans) than in the second replicate ($P<0.05$). There was a tendency for horses in the first replicate to show a more restless behaviour than for horses in the second replicate (9.7 counts vs. 7.8 counts; $P=0.07$). The baseline heart rate was slightly higher in the first replicate (50 bpm vs. 46 bpm; $P<0.05$) and the heart rate increased more during the test (55 bpm vs. 39 bpm; $P<0.05$). The heart rate after the test tended to be higher (60 bpm) in the first replicate than in the second replicate (47 bpm; $P=0.07$).
As to number of contacts with the person in test period 2 there were no significant factors at all.

4. Discussion

In the tests performed in the home environment (VAA-test and FHA-teat) there was no effect of handling but an effect of age and housing. Single housed horses approached sooner and were more easily approached by a human than group housed horses. In general the hazard of a horse approaching and the chance of approaching a horse were increasing with age. In the test in the unfamiliar environment single housed horses tended to be less affected by the situation as they showed less restless behaviour, explored more and vocalised less. Handled horses had a lower increase of heart rate, approached the test person sooner and were caught sooner after the test than non-handled horses. One-year old horses had a higher baseline heart rate, a higher increase of heart rate, vocalised more, but also explored more in the Arena and Human Encounter test than two-year old horses.

Our tests were chosen in order to reflect some practical situations. In the home environment it is desirable to have horses that either approach or are easy to approach whereas in the novel environment the most important factor might be how aroused they are. If horses are aroused they might be more prone to react by fleeing which may create a dangerous situation. In this sense our results are contrasting. For the situation in the home environment housing seems to be the most important factor while in the novel environment the level of handling seems more important.

With the amount of handling applied we expected an effect on the horses' reaction towards humans. Non-handled horses were only led or touched by humans at monthly weightings or at treatments by the farrier and veterinarian. Apparently those few contacts with people have not resulted in a negative effect on the way in which they perceive humans as shown by their reactions in the FHA-test i.e. not fleeing. Rather it seems that the non-handled horses have preserved some curiosity towards people which the handled horses have lost as shown by their reactions in the VAA-test. In the tests in the home environment the challenge for the horses is very small. It is very easy for the horses not to have contact with people whereas the test in the novel environment requires handling in order to equip the horses with the heart rate monitor. Besides, in the arena the horses could not get as far away from the test person as they could in the home environment. So, in the slightly stressed situation in the novel environment handled horses react less to the situation in general and seem to find comfort in the presence of a human. This may be very important as Marchant et al. (2001) found that response in heart rate in a novel object test correlated positively to a score of anxiety in the horses, i.e. horses with a higher increase of heart rate were more anxious.

In accordance with our results, Hemsworth et al. (1996) found that handling of pigs and cattle shortened their latency to approach a test person, in an arena test situation, and handled pigs interacted more with the test person than non-handled pigs, whereas handled cattle spent more time with the test person than non-handled cattle. Also, Bertenshaw and Rowlinson (2001) found that handled heifers had a shorter latency to approach a person in a test arena than non-handled animals. Visser et al. (2002) tested 41 Dutch Warmblood horses in a novel object test and a handling test when they were 9, 10, 21 and 22 months old, respectively. Like in our Arena and Human Encounter test, they found that in the novel object test the trained horses had a lower increase in heart rate than the non-trained horses even when the change was corrected for the physical activities of the horses, whereas in the handling test there was no difference in heart rate between trained and non-trained horses. Also, Jezierski et al. (1999) found that handled horses had a lower heart rate and had a higher score for manageability than non-handled horses. It seems that handling horses affect their reactions towards a novel environment and to humans when the situation is slightly stressful.

The hazard of a single housed horse touching in the VAA test was higher than for a group housed horse, a fact indicating that single housed horses are more curious and more interested in contact with humans than group housed horses. Similar results have been seen in calves housed singly or in pairs (Lensink et al., 2001). Although the VAA test is often termed as a test of fear it may be more related to the motivation for investigatory behaviour as shown by Marchant et al. (1997). Also, for the horses tested in a group there may be an affect of how the other horses in the group react to the person i.e. social learning. This has been shown in cattle by Munksgaard et al. (2001).

For group housed horses the Arena and Human Encounter Test implies both a novel environment and an isolation from group mates which may be a greater challenge to them than it is to single housed horses to which only the novel environment is a new challenge, assuming that single housed horses do not feel part of a group although they are stabled next to other horses. This assumption is supported by the greater number of vocalisations for group housed horses when they are one year old, and by the fact that single housed horses tended to be less restless than group housed horses. Additionally, single housed horses were exploring more in the second test period than group housed horses. It is assumed that exploration is characterised by approach and direct investigation, and that fear is characterised by avoidance. On the same horses Christensen et al. (2002) showed that the bond between neighbouring single housed horses is weaker than the bond between group mates, an observation, which is supported by our observations in the Arena and Human Encounter test. Group housed calves were more distressed than single housed calves as shown by more bawling, attempts to escape and prancing when isolated in a novel environment but after just three days of habituation there was no difference (Purcell and Arave, 1991). A similar habituation was seen in relation to the horses in the way that there was no difference in number of vocalisations when they were two years old. Rivera et al. (2002) found that horses housed singly in stalls reacted more to initial training in a round pen than horses reared on pasture in groups but in this case the effect of social environment is confounded with the effect of indoor-outdoor environment which may be the reason for our contrasting results.

The chance of a horse approaching in the VAA test was increasing with age in both replicates (Tables 1 and 2) but with a less clear picture in the first than in the second replicate. This could be due to the different test procedures as described previously. In the second replicate there was a slight decline between the ages 12 and 18 months where there was a release of treatments indicating that the daily exposure to humans in the winter season is important in the human-horse relationship.

The younger the horses are, the more they react, both in their home environment and in the novel environment. This is reflected in their reactions towards humans, their behaviour and vocalisation, and their heart rate. The effect of age in the human and animal approach tests may be an effect of habituation to humans due to the daily feeding by humans but it can also be an effect of the psychological development that horses undergo with age. These results are in accordance with the results from Visser et al. (2001) who found that there was a higher increase in heart rate for horses tested at 9 and 10 months of age than for horses tested at 21 and 22 months of age. Levels of baseline heart rate were similar to the ones found in our study. Visser et al. (2002) had a larger difference between baseline heart rate and heart rate measured in the test than we did (approx. 85 vs. approx. 50), which may be due to the fact that there were more opportunities for physical activity in their test situations. They estimated that physical activity accounted for 23.3 up to 42.3 percent of the increase in heart rate. As the horses in our study were limited by space i.e. they could not canter and only trot for few steps, it is likely that most of the increase in heart rate is a non-motor effect i.e an indication of emotionality.

The models included sire and replicate because they were a part of the set-up for the experiment. The effect of sire was significant in a few cases indicating that behaviour in test situations may involve genetic factors as shown by Wolff and Hausberger (1994) on foals before weaning and on riding horses (Wolff and Hausberger, 1996). In the present experiment the horses were from 4 sires within each replicate in order to account for any genetic effects rather than to analyse them specifically.

Single housing seems to improve the human-animal relationship as evaluated in these tests, at least in the home environment. On the other hand group housing has a huge beneficial effect on the social behaviour of young horses (Christensen et al., 2002) so our results might be more useful as an explanation for some behavioural reactions rather than as a reason to keep horses isolated. In the Arena and Human Encounter test group housed horses reacted slightly more to the isolation than single housed horses showing that it might be important to habituate horses to isolation when they are reared in groups.

5. Conclusion

It is concluded that the social environment affected the horses' reactions to humans, when tested in their home environment but not in a novel environment. Single housed horses sought contact sooner and were more easily approached than group housed horses. In the novel environment handled horses had a lower heart rate and sought contact to a test person sooner than non-handled horses.

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Photo by Eskild Keller Nielsen

Group housing exerts a positive effect on the behaviour of young horses during training

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Applied Animal Behaviour (submitted)

Abstract

In an experiment on the effects of social environment and training on the human-animal relationship, 20 horses were handled according to a defined schedule. Eight horses were housed singly and 12 horses were housed in 4 groups of 3 horses. Horses were handled 3 times per week in 10-minute sessions from an age of 6 months until 2 years of age during two winter periods. A total of 50 and 70 sessions were given in the first and second period, respectively. Five randomly allocated people performed the training. The training schedule consisted of 43 stages, in which the horse had to fulfil the performance criteria of each stage in order to get to the next stage. In the first winter period, horses were led to the stable when they had "passed" a stage or after 10 minutes of training. In the second winter period, horses would start off at stage 1 again, and when they "passed" a stage they went on to the next stage within the same training session. Because of the change in training procedure results were analysed separately for the two winter periods. There was a significant difference between trainers in the number of times they made a horse "pass" a stage within each winter period. (χ^2_3, P<0.05; χ^2_3 ,P<0.001) for the first and the second winter period, respectively. Group housed horses "passed" more stages than single housed horses (17 vs. 14; 27 vs. 18 in the first and second winter period, respectively; P<0.05 for the interaction). Singly housed horses bit the trainer more frequently than did group housed horses (P<0.01). The responses of group housed horses to training clearly demonstrate the benefits of raising young horses in groups.

1. Introduction

Whether horses are to be used as companion animals, leisure, or competition horses it is essential that they behave in a manner that is safe for both the person and the horse. Consequently, handling involving teaching the horses “good manners” is essential. Many non-scientific books and articles have been written about training horses, but it is often difficult to separate fact from opinion in this literature. Most scientific studies have focused on the effects of early handling (Søndergaard and Jago, 2001; Sigurjónsdottir and Gunnarsson, 2002; Williams et al., 2002) or the time of handling (Heird et al., 1986; Mal et al., 1994; Mal and McCall, 1996; Larose and Hausberger, 1998), whereas only few studies have focused on the training schedule (Kusunose and Yamanobe, 2002), the learning method (McCall and Burgin; 2002; Visser et al., 2003b) or effects of the environment on tractability (Jezierski et al., 1999; Rivera et al., 2002). In contrast, horse learning has received considerable interest as recently reviewed by Nicol (2002). Learning studies, however, have mostly been conducted as laboratory studies in which horses had to perform a task out of a common context, e.g. maze tests or discrimination learning tests, i.e. tasks which are not common in practical horse training.

In practice, training of horses also involves an interaction between the trainer and the horse but most scientific studies have had another focus. The fact that horses and humans interact has been addressed in one recent study (Morgan et al., 2000), in which the personality and performance of both riders and horses were compared in a test situation. The interaction between the trainer and the horse in a training situation and its relation to the reactivity of the horse and environmental factors in a long-term training scheme has not been investigated so far.

The present experiment was therefore undertaken as part of a larger project on the effect of rearing environment on the social and physical development of young horses. The aim of the study was to evaluate the training scheme in relation to the social environment of horses.

2. Materials and methods

The experiment was conducted at Research Centre Foulum, Denmark as part of a larger project on the effect of rearing environment on the social and physical development of young horses.

2.1. Animals, Housing and Management

Twenty Danish Warmblood colts were handled as part of a larger experiment described by Søndergaard (2003) and Søndergaard and Halekoh (2003). The colts entered the experiment after weaning either in September 1997 (replicate 1) or September 1999 (replicate 2) at a mean age of 4.3 ± 0.5 and 5.0 ± 0.5 months, respectively. From the foals were purchased at an age of approximately 2 months until weaning owners were instructed not to handle their foals unless necessary for veterinary treatment. At an age of 3.0 ±0.5 months a test of the foals’ reactivity was performed as described by Søndergaard (1998). Foals were given a score of reactivity from 1 (quiet) to 3 (agitated).

In each replicate, four horses were housed singly in boxes of $9m^2$ and 6 horses were housed in 2 groups of 3 horses in boxes of $27m^2$. Separation between boxes allowed the horses to see, hear, smell and touch but not physically interact with neighbouring horses. There was no physical contact between the caretaker and the horses when feeding and besides training sessions handling was limited to monthly weightings, farrier and necessary veterinary treatment.

During the housing period, horses were given 3h of daily exercise in paddocks according to their housing, i.e. single housed horses alone and group housed horses in groups of 3. When going to and from the paddocks horses were running loose in a runway and had no contact with humans. The horses were housed from mid-September to mid-May. The summer period was spent on pasture in one joined group whereupon they returned to their previous housing conditions during the following winter period. The experiment ended when the horses entered the second summer period, i.e. when they were two years of age.

In the first replicate one singly housed horse was culled due to injury at 6 months of age. In the second replicate one group housed horse was culled due to health problems at 18 months of age.

2.2. Training

The horses were trained three times per week for a period of 10 minutes during each housing period. In the first winter period there were 50 training sessions and in the second winter period there were 70 training sessions for each replicate, adding to a total of 20 hours of training per horse. Training was performed in a rectangular 10m x 11m arena in the same building as the stable but separated by a wall. Five people (two males and three females) were involved in the training sessions during the four-year period, and one of the two main trainers (one male and one female) was always present during handling. The training scheme involved leading, tying up, touching, lifting feet etc. in 43 stages according to table 1.

Table 1. Training programme

Stage	**Description**
All stages	Each horse was led from its stable to the training arena. It was allowed to run loose. After it had calmed down the horse was handled for 10 minutes.
Stage 1	The horse was allowed to run free. When it had calmed down, it was caught and returned to its stable.
Stage 2	The trainer led the horse along the sides of the training arena; first in a right volt and then in a left volt. Thereafter, the horse was led in two figures of eight. The stage was completed when the horse no longer tried to stop or to free itself from the trainer.

Stage 3	Stage 2 was repeated. The horse was then tied to the railing in the training area and had to stand still for 5 min without trying to free itself. The trainer was allowed to stroke the horse and speak gently to it.
Stage 4	The horse was led along the sides of the training arena in a left volt. It was then tied to the railing and touched with stroking hands all over its body. The stage was completed when the horse showed no reaction to the touch.
Stage 5	The horse was led in a left volt round the training arena. The horse was then tied and its legs lifted as when cleaning its hoofs. The stage was completed when all four legs could be lifted without using force.
Stage 6	The horse was led in a left volt and was then taken to the centre of the arena. Here it had to stand still for one minute without the trainer touching it.
Stage 7	Stage 4 was repeated but the horse was not tied to the railing. This stage was completed when the horse was able to stand still without moving its legs when touched.
Stage 8	The horse was led in a left volt and taken to the centre. The halter was taken off and put back on. This stage was completed when the procedure could be done 3 times in succession without the horse trying to escape.
Stage 9	The horse was led in a left volt, tied to the railing and a thermometer was introduced into its rectum. This stage was completed when the horse accepted the introduction and removal of the thermometer, and was able to stand still for 2 min with the thermometer in its rectum.
Stage 10	The horse was led in a left volt and taken to the centre. It was held by the halter while the trainer touched the outside and the inside of the horse's nostrils. Thereafter its tongue was taken to the side as when inspecting the teeth.
Stage 11	Stage 5 was repeated, but this time the trainer hammered on the lifted hooves with a piece of metal.
Stage 12	The horse was led in a left volt and tied. It was then groomed all over its body, head, and legs with a medium-soft brush. This stage was completed when the horse accepted the brush.
Stage 13	The horse was led in a left volt and tied. It was then touched all over as when trimming it. This stage was completed when the horse accepted standing still when 'trimmed'.
Stage 14	The horse was led across 4 bars laid out with approximately 1m distance. This stage was completed when the horse crossed the bars without any hesitation or jumping.
Stage 15	The horse was led between 6 bars arranged as a L-shape with 2 m in between. The horse had to turn around between the bars and back out without touching the bars. This stage was completed when the horse had passed the bars once, had turned around between the bars twice, and had backed out once.
Stage 16	As stage 15, but this time the distance between bars was 1.4 m.

Stage 17 The horse was led in a left volt and then led in between the bars arranged as in stage 16. The horse had to back out of the angle.

Stage 18 The horse was led in a left volt and was stopped at the end of one of the bars with its forelegs on one side of the bar and its hind legs on the other side. The horse was then gently pushed sideways across the bar without its forelegs or hindlegs touching the bar. This stage was completed when the procedure could be done from both sides.

Stage 19 The horse was led in a left volt and across a wooden sheet placed in the centre of the arena. This stage was completed when the horse crossed the sheet from both sides without hesitation.

Stage 20 The horse was led in a left volt and across a wooden bridge (15cm) with ramps placed in the centre of the arena. This stage was completed when the horse crossed the bridge from both sides without hesitation.

Stage 21 As stage 20, but the ramps were removed from the bridge.

Stage 22 The horse was led in a left volt and up on the bridge with ramps. For 30 sec it had to stand still on the bridge without moving its legs. Afterwards it had to back down from the bridge.

Stage 23 The horse was led in a left volt and then in slalom between six tyres placed 0.6 m apart in the centre of the arena. This stage was completed when the horse passed the tyres without hesitation.

Stage 24 The horse was led in a left volt and to the centre of the arena. Stage 5 was repeated. The stage was completed when the horse no longer moved when its legs were lifted.

Stage 25 The horse was led in a left volt and let loose again. 4 bars were laid out as cavalettis and the horse had to cross the bars without being led. This stage was completed when the horse crossed the bars from both sides at a walking speed.

Stage 26 The horse was led in a left volt, let loose, and longed without a line. The commands 'walk' and 'trot' were practised. This stage was completed when the horse went willingly from walk to trot, maintained the speed for at least one lap, and then changed its speed to walk again when the relevant command was given.

Stage 27 As stage 26, but this time the command 'gallop' was included.

Stage 28 The horse was led in a left volt and to the centre. The trainer then let the rope hang loose while walking around the horse three times in succession. This stage was completed when the horse accepted the procedure without moving.

Stage 29 The horse was led in a left volt and taken to the centre of the area. The halter was removed and placed in front of the horse. The trainer walked round the horse, picked up the halter, and put it back on the horse. This stage was completed when the horse accepted the procedure without moving.

Stage 30 The horse was led in a left volt and then had to back across a bar placed in the centre. The stage was completed when the horse backed across the bar without being forced.

Stage 31 The horse was led in a left volt and taken to the centre. Stage 12 was repeated.

Stage 32	The horse was led in a left volt taken to the centre. Stage 11 was repeated.
Stage 33	The horse was led in a left volt and then tied to the railing with a 1 m long rope. The trainer placed himself 2 m away. The stage was completed when the horse was able to stand still for 3 min without tightening the rope.
Stage 34	The horse was led in a left volt and let loose. A bar was placed on the top of 2x2 tyres. The horse had to jump across the bar. The stage was completed when the horse jumped willingly across the bar from both sides.
Stage 35	The horse was led in a left volt and taken to the centre. Stage 13 was repeated.
Stage 36	The horse was led in a left volt. At a gentle pull of the rope under its chin it had to walk forward or stop. The trainer was always at the side of the horse. The stage was completed when the procedure was done 3 times in succession with a minimum of 10 steps between each 'walk' and 'stop'.
Stage 37	The horse was led in a left volt and taken to the centre. At the pull of the rope it had to learn to lower its head to the ground. The stage was completed when the horse lowered its head to the ground at a gentle pull.
Stage 38	The horse was led in a left volt and then to a wooden sheet in the centre. At the command 'walk' the horse had to cross the sheet. The trainer did not follow the horse. The stage was completed when the horse crossed the sheet from both sides without being driven.
Stage 39	As stage 38 but this time with a wooden bridge and a ramp. When on the bridge, the horse had to back down from it again (the trainer in front of the horse pushing it gently).
Stage 40	The horse was led in a left volt and taken to the centre. At a gentle swing of the rope the horse had to back. The stage was completed when the horse backed 3 times in succession.
Stage 41	As stage 36, but this time the horse had to move forward or stop whenever the trainer moved forward or stopped. As in stage 36, the trainer was at the side of the horse – not in front of it.
Stage 42	As stage 41, but this time the horse had to move 4 steps backwards at each stop. As in stage 36, the trainer was at the side of the horse.
Stage 43	As stage 42, but this time the horse had to move 10 steps in trot, too. As in stage 36, the trainer was at the side of the horse.

Prior to training the horse was caught in the box by the trainer and lead to the arena. The horse was let loose and allowed to run free until it approached the trainer; then it was caught and the training session started as described in table 1. If the horse did not approach the trainer it was approached when it stood still and caught. Training was performed with reinforcers like patting and a soft voice when the horse was performing well and a shout or a raised hand when the horse was misbehaving. Occasionally a whip was used for directing but never for slapping the horse. Food rewards were never used.

The horse had to fulfil the performance criteria of each stage in order to get to the next stage, e.g. a horse had to be able to stand still for one minute without moving a leg (stage 6 in table 1). Horses were led to the stable when they had “passed” a stage or after 10 minutes of training. During the second winter period, horses started off at stage 1 again, and when they “passed” a stage they went on to the next stage within the same training session. When the horses in the second winter period had reached the maximum stage from the first winter period they would from then on be led to the stable when they had “passed” a stage or after 10 minutes of training.

During training sessions two trainers were present. One trainer handled the horse in the arena, while the second trainer observed the training session from outside the arena. The observing trainer recorded the time the horse was running loose before the session started, the behaviour of the horse and the time for “passing” a stage. Recorded behaviours were defecation, biting the trainer or rope, kicking, rearing, or other behaviours where the horse was objecting the training.

Trainers changed horses from session to session to avoid training the same horse in two consecutive sessions.

2.3. Variables and statistics

The trainers were evaluated by the number of times they trained a horse to “pass” a stage in relation to the total number of training sessions by a χ^2 –test. Because of the difference in training procedure results were analysed separately for the two winter periods.

Variables in the training sessions were defined as shown in table 2. Several models with the same structure were used. Replicate (1, 2), winter period (1, 2) housing (single, group) and reactivity score (1-3) were fitted as fixed effects in all models and horse was fitted as a random effect. Two-way interactions were included in the start model but excluded hierarchically from the model if they were not significant at the 5%-level.

Table 2. Definition of variables used for the statistical analyses

Variable	**Definition**
Time loose	Mean time in seconds before the horse was caught before the training session for all training sessions within a winter period. Observations outside mean ± 3 x std. were omitted.
Biting	No. of sessions within a winter period where the horse bit at the trainer and/or rope
Kicking	No. of sessions within a winter period where the horse kicked with hind or forelegs or reared
Defaecation	No. of sessions within a winter period where the horse defaecated
Sessions per stage	No. of sessions to reach a stage for all stages where at least 16 horses performed the stage within each period. Stage 1 to stage 5 (1st period) or stage 1 to 7 (2nd period)
Max stage	The highest stage (Table 1) a horse reached within a winter period

'Time loose' was analysed in a mixed model with the interaction between winter period and housing included in the start model. 'Biting', 'kicking' and 'defecation' were recorded as count data i.e. number of sessions where the behaviour was recorded, and were analysed in a mixed model assuming a Poisson distribution and a logit link function with the interaction between winter period and housing included in the start model. 'Sessions per stage' was analysed in a mixed model assuming a gamma distribution with all two-way interactions between winter period, housing and stage included in the start model. 'Max stage' was analysed in a mixed model with the interaction between winter period and housing included in the start model.

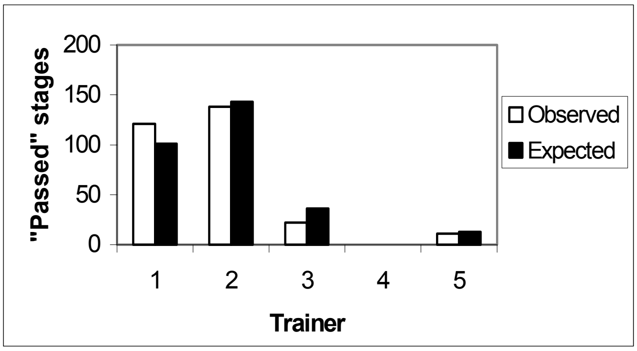
Correlations between stages 1 to 5 (n>17) within winter period 1, winter period 2 and winter period 1 and 2 in number of sessions needed to pass a stage were calculated using a Spearman correlation. Only correlations that occurred in two out of the three possible calculations were considered consistent and will be discussed.

The data analysis for this experiment was generated using the procedures SAS/MIXED, SAS/GLIMMIX and SAS/CORR of SAS/STAT software version 8. (SAS, 2000). Results are presented as least square means ±standard error or for transformed variables as least square means on the original scale with 95%-confidence intervals.

3. Results

There was a significant difference between trainers in the number of times they made a horse "pass" a stage within each winter period. (χ^2_3, $P<0.05$; χ^2_3, $P<0.001$) for the first and the second winter period, respectively (Fig. 1).

a)



b)

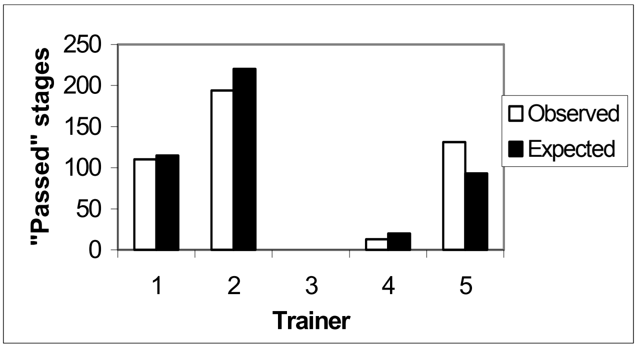
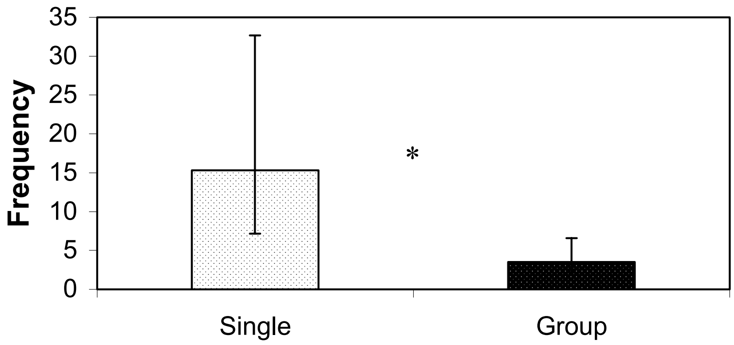
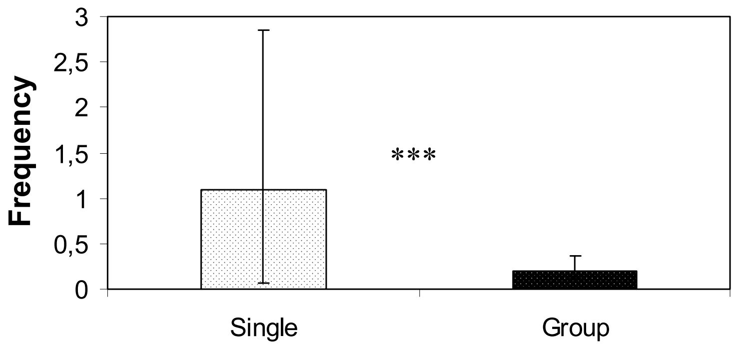


Figure 1. Observed and expected frequency of passed stages per trainer for the first winter period (a) and the second winter period (b). The probability of passing was p=0.32 in the first winter period and p=0.30 in the second winter period. Trainer no. 4 was not involved in the training in the first winter period. Trainer no. 3 was only involved in 7 training sessions in the second winter period and was omitted from the analysis.

a)



b)



c)

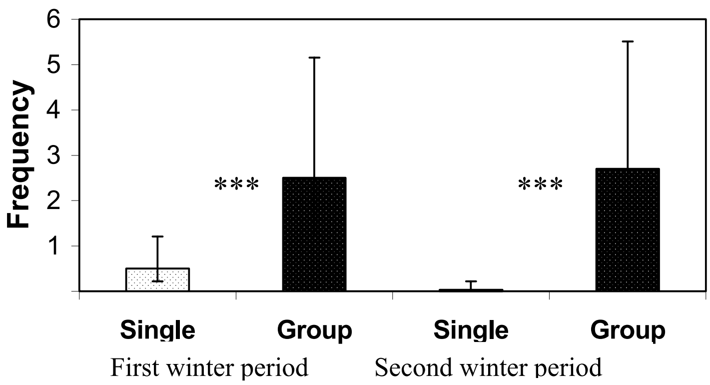


Figure 2. No. of sessions in which biting (a), kicking (b) or defecation (c) occurred. Bars represent least square means on the original scale and lines represent 95%-confidence intervals. * indicates significant differences between housing treatments.

Single housed horses ran loose for longer than group housed horses before training started ((78 ±12 seconds vs. 45 ±7 seconds, P<0.05). Singly housed horses bit (P<0.05) and kicked (P<0.001) in more sessions than group housed horses whereas group housed horses defecated more than single housed horses (P<0.001) (Figure 2).

No. of sessions per stage differed between winter periods (5.0 vs. 3.7 ‘sessions per stage’ in the first and second winter period, respectively, P<0.05) and stages (Figure 3, P<0.05). There was a large variation both between and within stages in the number of sessions the horses required to pass a stage. In the first winter period stages 3, 4 and 5 showed a large standard deviation (std>5), whereas several stages showed a small standard deviation (std<1). The stages 14, 17 and 20 showed a small standard deviation in both winter periods, whereas stage 13 showed a small standard deviation in the first winter period but a large standard deviation in the second winter period. For stages 22 and 23 in the first winter, 4 and 3 horses respectively passed the stages and all horses passed in only one session. In the second winter period all horses passed stage 1 in one session. Also, the stages 29 and 30 were passed in one session. In both cases 7 horses passed these stages.

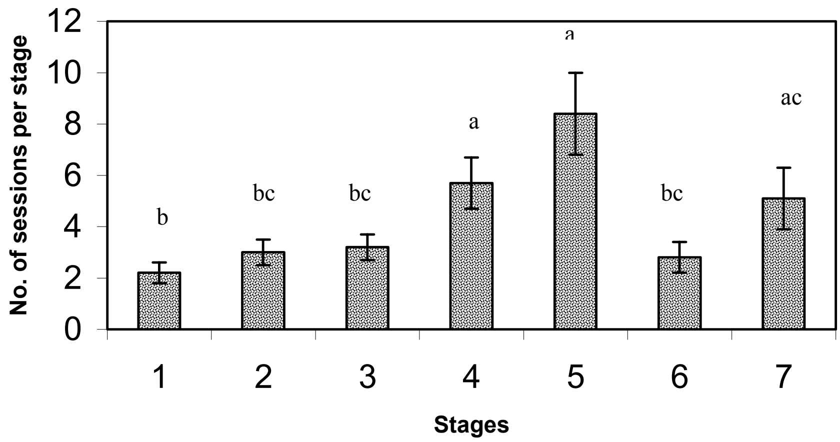


Figure 3. No. of sessions required to pass stages 1 to 7 presented as least square means (standard error). For stages 1 to 4 n=19, for stage 5 n=18 and for stage 6 and 7 n=16. Bars with different letters differ at P<0.05.

In the first winter period horses reached a ‘Max stage’ of 3 up to 25 stages. In the second winter period horses reached a ‘Max stage’ of 6 to 42 stages. There was a significant interaction between winter period and housing for ‘Max stage’ (P<0.05). Group housed horses “passed” more stages than single housed horses (Figure 4) but the difference between housing treatments was only significant in the second winter period.

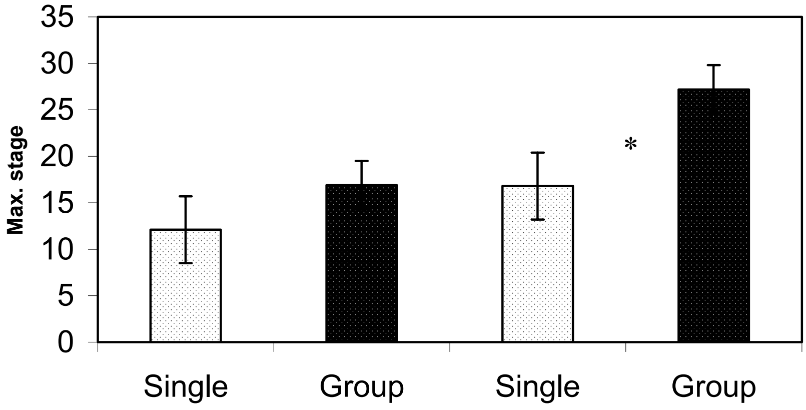


Figure 4. The maximal stage reached for single and group housed horses in the two winter periods presented as least square means (standard error). * indicates significant differences between housing treatments.

There was no effect of reactivity score for any of the variables (P>0.05).

No consistent correlations were found. Within the first winter period there was a negative correlation of –0.60 between number of sessions needed to pass stage 1 and 5 (P<0.01). No other correlations were found within the two winter periods but when the winter periods were pooled there were positive correlations between number of sessions required to pass stage 1 and the stages 2 and 4 (r=0.33 and P<0.05 in both cases). No correlations were found between the number of sessions required to pass a stage in the first winter period and the second winter period.

4. Discussion

Group housed horses passed more stages and showed less objectionable behaviour towards the trainer than single housed horses. Thus, horses kept in social groups were easier to handle and to train. Before training single housed horses ran loose for a longer time than group housed horses.

The result of the present study is in accordance with the result of a study by Rivera et al. (2002) who found that horses pastured in groups required less time to complete a training procedure than horses housed singly in stalls. Because of the design in their study, however, the difference could be attributed to the difference in access to exercise and environmental stimulation as well as the social environment. In our study we found that the difference can be attributed to the social environment although the effect of other factors like level of exercise cannot be excluded. The responses of group housed horses to training in addition to the beneficial effects of group housing on the development of social behaviour (Christensen et al., 2002) clearly demonstrate the importance of raising young horses in groups. The increased tractability of group housed horses was partly due to the fact that trainers had to spend less time avoiding objectionable behaviour like biting during training sessions. It seems that housing horses in groups, firstly, fulfils their motivation for social behaviour so that they do not have the same need for interaction as singly housed horses and, secondly, teaches them to react to another individual so that it is easier for them to understand the signals from the trainer. When the same horses were tested on their reactions to humans in approach tests (Søndergaard and Halekoh, 2003) single housed horses showed more interest in contact with humans than group housed horses but as stated in this study the kind of contact they are motivated for is not desirable when training the horses.

All horses were allowed to run loose for an unlimited time before the actual training started but in most cases they did not run at all. Instead, the horses often stopped in front of the trainer, were easily caught and were, in general, very attentive to the trainer. Because of the duration of the experiment several people were involved in the training. Differences in their rate of success with the training meant that some trainers had more horses pass the different stages than others. But because trainers did not train the same horses on successive training days, and because the criteria for passing a stage was well defined, this difference is not likely to have affected the results. The degree to which trainers differed when interacting with the horses was not investigated but could be an interesting issue for a future study. It is likely that experience with horse training could be one reason for the difference but also the personality of the trainer may have an influence, as indicated by Morgan et al. (2000). In stages where horses had to stand still (e.g. stage 6, 8, 28 and 29), calm behaviour usually was enough to induce the desired behaviour. Based on the low number of sessions required and a small standard deviation, the task of these stages generally seemed easy for the horses.

In the present training scheme several aspects of learning were included. Some of the stages (e.g. 4 and 5) involved a high degree of habituation, which seemed extremely difficult for some horses. Interestingly, there was no relation between the performance in these stages or overall performance and the reactivity score, indicating that the trainability of a foal may be hard to predict. This is not in accordance with Visser et al. (2003a) who found that it is possible to predict a substantial part of the show-jumping performance of an individual horse by measuring personality traits earlier in life. Their personality tests were performed after weaning though, whereas in our test it was while the mare was present (Sønderggard, 1998) which may have affected the results. Besides, in the study by Visser et al. (2003a) a range of tests and scores were quantified whereas we used a single score, indicating that the personality of a horse is too complex to be described with one score only. Wolff and Hausberger (1994) observed that behaviour of foals before weaning may be heritable indicating that it should be possible to predict later performance or tractability by observing the behaviour of foals. Further studies are needed to establish the fact.

The indication that there is no general trainability trait in horses is confirmed by the fact that no consistent correlations were found between stages. Other studies on this issue show similar results. Wolff and Hausberger (1996) found no correlation between the performance of horses in an instrumental task and a spatial task. Likewise, Visser et al. (2003b) found no correlation between performance in an avoidance learning test and a reward learning test, although individual learning abilities were found to be consistent over a short time interval within the two tests. Although a few studies have shown low correlations between performance in different learning tests, Nicol (2002) in her review concludes that performance in learning tests seem to be very task specific.

The aim of the present study was solely to evaluate the effect of the social environment on learning. The aim was not to optimise training but only to give the horses the same opportunities to perform. As a consequence, no other factors were varied although they may be of importance in horse training, e.g. the schedule of training sessions consisting of 3 sessions per week may not be the most efficient in terms of learning. The training schedule was slightly changed in the second winter as horses were allowed to proceed to the following stage after passing a stage that was a repetition from the previous winter. This was done in order to save time and to give the "best" horses the opportunity of completing more stages. Stages in the program cannot be considered to have an increasing level of difficulty as it was impossible to predict beforehand which tasks the horses would find difficult. For instance, as shown in figure 3, stage 6 seemed less difficult than stage 4 and 5. Many sequences of the stages were repeated in later stages and in most cases were then easier for the horses to comprehend e.g. stage 7 was a repetition of stage 4 without the horse being tied up (Figure 3). The fact that the number of sessions required to pass stage 7 was lower than for stage 4 demonstrates that our criteria for passing the stages was based on actual learning and not coincidental. Considering that some horses only managed to pass 3 to 6 stages during a whole winter period training may seem rather inefficient. In addition, providing a set time of 10 minutes per training session may actually have inhibited learning to some degree, since it is not considered good training procedure to stop in the middle of an exercise or right after the animal has misbehaved because it can accidentally encourage bad behaviour. Since such incidents were distributed randomly on the two treatments it is not likely that they have affected the main results although they may have contributed to the large variation between horses. Whether the variation between horses is also an effect of differences in learning ability or tractability is not known.

Another issue is the context of the training situation. The group housed horses experienced a higher degree of separation than single housed horses which could have affected their learning negatively. Separation from other horses usually exerts an emotional reaction in horses (Jezierski and Górecka, 1999), a reaction that has been shown to have a negative influence on learning ability (Heird et al., 1986). As shown in calves (Purcell and Arave, 1991) and in horses (Jezierski and Górecka, 1999) animals are likely to habituate to the separation after just a few repetitions. In the present study separation occurred 50 times in the first winter and 70 times in the second winter. We therefore expected that the horses would habituate. Upon release in the test arena, group housed horses were found to defecate more often than single housed horses. As defecation may be a symptom of arousal, this finding may indicate that group housed horses were more affected by isolation than single housed horses. It is important to note, however, that the result was mainly due to one of the 4 social groups in which all 3 horses defecated almost every time they entered the arena. Considering that the horses in this group reached stage 42, 41 and 37, respectively, it is unlikely that the horses were so upset that it affected their tractability or learning ability. Besides, another sign of arousal is movement and group housed horses ran loose for shorter time than single housed horses confirming that defecation in this case may be a sign of e.g. marking behaviour rather than arousal.

5. Conclusion

The social environment affects the behaviour of horses both before and during the training sessions, in that group housing exerts a positive effect on the behaviour of young horses during training. When first released in the training arena, single housed horses ran loose for a longer period than group housed horses. During training group housed horses “passed” more stages of the training program than single housed horses. In addition, single housed horses bit the trainer more frequently during training than did group housed horses. The responses of group housed horses to training clearly demonstrate the benefits of raising young horses in groups.

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