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What impact does stall architecture have on horses’ behaviour?

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Abstract

Box housing remains predominant in horse industry despite of the spatial and social restrictions it causes to the horse, leading to the emergence of abnormal behaviours such as stereotypies, which can arise very soon after the first box housing. In the present study, we have investigated the impact of openings in the boxes, in terms of possibilities of vision, on the normal and abnormal behaviours of box housed horses. Two complementary studies were performed: one observational study on 32 sport horses, all living in the same place, being of the same breed and sex, which aim was to compare the behaviours of horses maintained for a long time in two types of boxes that differed mostly in the possibilities of contact with close neighbours versus watching outdoor activities; the second experimental test consisted in moving purebred Arab broodmares from one to another type of box randomly every day for 66 days, the two types of boxes differing only by the possibility or not to put the head outside above the open top half door. The results show a clear statistical relation between box architecture and horses’ behaviour, especially stereotypic behaviours. Their prevalence and type differed according to the type of box in both studies. Overall the access to outdoor vision, and its degree (head out or not) had a major effect on the horses’ behaviours, which was the same in both studies, despite of the differences between populations in terms of breed, sex, occupation. The experimental study reveals that changes in behaviours can be rapid after a change of housing.

Keywords: stereotypies, time budget, housing, welfare, horse

Introduction

Single box housing is predominant in sport horses but remains also very frequent in riding schools. Such housing imposes different types of restrictions on horses, mostly spatial (hence locomotory) and social. Single box housing has thus been associated with the prevalence of abnormal behaviours such as stereotypies in questionnaire based epidemiological studies (e.g. [1]). The lack of close social contact seems to be one major problem as the presence of side windows enabling at least visual or naso nasal contact enables the reduction of abnormal repetitive behaviours, and especially weaving [2]. Visser et al ([3]) found that young warmblood horses developed stereotypies in the two first weeks after their first box housing if they were in single boxes while pair housed animals did not. Benhajali et al ([4]) showed that broodmares with foals were less stereotypic than their non foaling neighbours housed in the same conditions, the foal being a source of social interactions. In fact, being at least able to see closely a neighbor seems crucial as the presence of a horse picture or of a mirror reduces considerably the expression of such behaviours, even in horses that had been known to be stereotypic for several years ([2], [5]).

In the present study, we have investigated the impact of boxes’ architecture, and especially the opportunity for social visual contact on the behaviour of adult horses housed in singe boxes, with a special emphasis on stereotypic behaviours. Two complementary studies were performed: one based on the observation of 32 horses of same breed (SF), sex (geldings) and discipline (dressage) living on a same site (hence under the same management conditions) in two different types of boxes: (1) front half door open on outside and small side window with grid, (2) internal boxes with 2 side windows with grid and a front (corridor) half door closed with a grid, enabling to see close neighbours but no outside view; the second based on an experimentation performed on 42 Arab
purebred broodmares (non pregnant) housed in the site for more than three weeks in single boxes, the experimentation consisted in changing their housing randomly everyday between two types of boxes: type 1: front half door open on the courtyard and small opening near the ceiling enabling mostly olfactory contact with neighbor, type 2 boxes were similar but a grid on the door prevented the horse to have the head outside.

I. Study 1 (Hausberger et al, subm)

A. Material and methods

Subjects and housing conditions

Thirty-two horses (French Saddlebred) were observed at the “Ecole Nationale d’Equitation” (ENE) at Saumur in August 1994. They were all kept under the same conditions (housing and feeding practices): straw bedded single boxes, they were fed pellets (3 times a day) and hay (only once, in the morning), had water ad-libitum, and were ridden for one hour every day. Their type of work was dressage (competition and high school). They were all geldings and were 6 to 19 years old (µ = 10.03 ± 3.8).

Thus, all horses shared the same living conditions, were of the same sex and breed but differed only in the type of box they were living in (Fig 1a): 17 horses were housed in type 1 (surface: 9.75 m2; openings: 3.32m2) boxes consisting in two full walls, a side window with grid that allowed to see one neighbour and the front half door was open, enabling the horse to have the head outside. This opening gave a view over the riding arena and horses being led from their box to the working areas and back; 15 lived in the internal stable in boxes of type 2 (Fig. 1b) where they had no window or opening on the outside but had side windows with grids on each side wall, enabling sight and nose to nose contact with their neighbours as well as a grid above their door, enabling sight of neighbours across the corridor: they could see therefore more than 5 neighbours (1 on each side and 3 in front at least). Type 2 boxes were 9 m2 and had 11.76 m2 openings. Type 1 boxes favoured a vision of the outside world while type 2 boxes favoured social visual contact at close range only. Horses were kept in the same box for longer periods and all of them had been in this same type of box for more than 6 months.

Data collection and statistical analyses

Each horse was observed during 10 to 11 5min sessions distributed in the morning (8 to 11 a.m), in the afternoon (1 to 4 p.m. and 5 to 7 p.m) and before meals, yielding 50 to 55 minute observation per horse (mean: 54.22 ± 1.84min per horse). The same observer (EG) recorded all the observations through a voice recorder. The time of observation of a given horse changed every day following a rotation schedule (thus if one horse was observed from 05:00 p.m. to 05:05 p.m. on day 1, it was observed between 05:05 p.m. to 05:10 p.m. on day 2, etc).

All behaviours were noted. Abnormal repetitive behaviours were identified according to Mills ([6]) (see Appendix 1).

Non parametric statistics were used: Chi square tests to compare the number of horses performing a behaviour or activity according to the type of box; Mann Whitney U tests to compare the frequency of occurrences of behaviours between horses living in different types of boxes.
B. Results

Overall, the horses living in type 1 boxes spent less time sleeping (U=197, p=0.007) while no difference was found in activities such as eating (type 1: 0.703±0.276; type 2: 0.732±0.268; U=133, p=0.85) or drinking (type 1: 0.027±0.029; type 2: 0.022±0.028; U=114, p=0.606). All horses performed at least one type of abnormal repetitive behavior (ARB including stereotypies) during the observation period. However the type of ARB performed depended on housing (type of box).

Thus, weaving was observed in almost half of the horses with external view and less than 10% of the horses living indoors (X²= 8.07, p<0.005) (Fig.2). while about 80 % of the horses living indoors performed repetitive grid licking for less than 10% of the horses with external opening (X²= 12.5, p<0.001).

Figure 2 : Proportion of horses performing weaving according to the type of box.

II. Study 2: Experimental approach (Benhajali et al subm)

A. Material and methods

Subjects and housing conditions

Forty two purebred Arab broodmares aged 4–22 years (µ = 9.23 ± 5.37) were observed at the national stallion breeding facility of Sidi Thabet, located 20km from Tunis. They were housed in individual stalls where they received barley grains (4 kg/day) and hay every morning. Roughage was therefore available most of the day time. They were released every day from 9 a.m. to 3 p.m. in a paddock where free access to water and limited shelter (5 trees) were provided. No food was available then but some freshly cut grass was left on the ground around 12 a.m. every day. None of the mares was pregnant at that time. Mares came from 75 breeding farms (x = 1.48 ± 0.89 mares/stud) and had been in the facility for at least 3 weeks before the start of observations. Thus, all horses were of the same sex, breed and overall living conditions.

Two types of straw bedded boxes (all 5x3 m) were available: type 1 with 3 almost full walls and an opening on the top half door enabling to have the head outside; type 2 which were similar except that a grid on the top half door prevented the horse to have the head outside, limiting the visual horizon. In both cases, very small openings near the ceiling (above the horses’ head) at the upper level of the side walls could provide a minimal contact (nasal mostly, not visual) between neighbours.

Data collection and statistical analysis

Observations were made by two observers everyday from the 21th March to the 26th of May 2011 (66 days) using instantaneous scan sampling (8 scans / mare / day). Twice a day (once in the morning before feeding and once in the evening after feeding), each observer walked throughout the stable 2 times and noted the behaviour of each of the mares at the instantaneous time of each passage. The total number of scans was 11684 (278.2 ± 79.3 per mare). The time budget for each behaviour was determined as the recorded numbers of each behaviour divided by the total recorded number of all behaviours in each horse.

The same mares were observed in the two different types of boxes and therefore the behaviours of the mares were compared according to the box in which they were when observed, using a Wilcoxon test.

B. Results (Fig 3)

Twenty seven percent of the mares were observed performing an abnormal repetitive behaviour. Those that did performed them more when they were in the type 1 boxes (Z= 4.38, p<0.01). This is
true for weaving that diminishes fourfold when the mares were in the type 2 boxes ($Z=3.41, p<0.01$) and crib biting ($Z=3.51, p<0.01$). Overall the horses were quieter in the type 2 boxes as compared to type 1 boxes with more resting ($Z=5.38, p<0.01$), lying down ($Z=2.02, p=0.04$) and feeding ($Z=5.59, p<0.01$) and less alert standing ($Z=5.57, p<0.01$).

Figure 3: Time spent (proportion of scans) performing the different types of stereotypies according to the type of box

III. Discussion

The results obtained through these two studies confirm of course the inappropriateness of single box housing for horses, especially when they have no opportunity of going out at some stage. Thus, the first population observed had a higher prevalence of stereotypic behaviours than the second: reasons are in particular that the mares were in paddocks part time, but also the differences in occupation (see also [7]).

Nevertheless even in this restricted type of housing, some conditions may be still less appropriate than others. Here we show that having close (visual/olfactory) contact with neighbours diminishes the risk of major stereotypies such as weaving (less when two side windows) (study 1) which just confirms earlier findings ([2], [5]) although increasing repetitive grid licking, which may reflect some frustration not to be able to have proper contact. We also show that changes in housing induce immediate behavioural changes (study 2). More intriguing and interesting however is the major finding that distant visual contact is an aggravating factor for stereotypic behaviours and especially weaving, considered as reflecting frustration of social contact [8].

Thus, in both studies, being able to have the head outside to watch distant neighbours and above all, horses that were led to the arena or to other activities, seem to increase the risk of weaving in both populations. This is especially remarkable in the broodmare population where it was the only difference between the two types of boxes: mares that had grids on the half door performed less weaving than those who could have the head outside and watch conspecifics and human walking around. As stereotypies are considered a sign of frustration ([9], [10]), this seems to reveal that horses experience more frustration in these conditions, due to either being unable to join the distant horses, or to being unable to move out of the box as do the other horses (ex in the riding arena or walking along the boxes). In monkeys, it has been shown that it is much more frustrating to watch a conspecific eating an (unreachable) appetitive food than seeing simply being denied access to the same visible food [11].

This is once more the demonstration that “only animals can tell”. Humans would tend to think that being able to watch outside and see activities would reduce boredom and hence stereotypies while obviously this situation creates much more frustration as suggested also by Cooper et al ([8]) study.

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References


Appendix : terminology

The stereotypic behaviours noted corresponded to those described in a variety of studies and had the common feature of consisting of repetitive movements performed without any specific goal [6].

Weaving: obvious lateral swaying, movement of head, neck, forequarters and sometimes hindquarters [6].

Stall-walking: the pacing of a fixed route around the stall ([12]).

Head nodding: repetitive bobbing of the head up and down [6].

Door kicking: repetitive kicking of the door [13].

Wind-sucking: was defined as when a horse bends the neck, tenses the muscle on the underside of its neck while opening the mouth and with the neck muscles forces air in the oesophagus without supporting the teeth on any solid material [14].

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Pathologies of employees in the horse industry: what is the relationship with their professional environment?

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Abstract

Employees in the horse industry are exposed to many risks, accidents or occupational diseases. This is the sector that has the highest rates of accidents in frequency and severity. ¾ are related to the contact with horses, and current thinking is based on the improvement of the human/animal relationship to improve safety. The analysis of all stakeholders interviewed remains “we work with the living” or “it is fate.” There is no research of co-factors leading to the accident, for example the method of causal tree that works around the 4 main factors (individual, task, equipment, environment) that come into the genesis of an accident.

Prolonged exposure is responsible for diseases of the musculoskeletal system and the respiratory system. Studies on working conditions show the importance of physical work in this sector, trips, carrying of weights, unfavorable postures, with ergonomics often perfectible positions. Respiratory diseases are common, surveys on aerosols encountered in the stables show in their composition the presence of molecules known for their allergenic or irritant nature. They highlight the role of ventilation in reducing their concentration.

Keywords: health, safety, ergonomics, occupational accidents, occupational diseases

Introduction

The MSA (Agricultural Mutual Assistance Association) is the organization that manages benefits in the agricultural sector (health care, retirement, family, accidents/occupational illnesses), a single-access point for facilitating the administrative procedures for its members. It has a “Health and Safety at Work” service that brings together prevention counselors and occupational physicians who aim to preserve the health of employees and operators in any activity, whether professional or not, which may have an impact on the body during an accident (occupational/AT), or through prolonged exposure in the form of an illness (professional/MP). The activity of the prevention counselors providing aid and advice to employers, the monitoring of employee’s health by occupational physicians, and the statistics provided by the AT/MP service help identify risks in the sector. The MSA appears to be the only organization that provides an analysis with large amounts of data.

I. Accidents at work

In 2012, the horse industry had the highest rate of work-related accidents for all agricultural domains (1), and even among all professional sectors (2). Representing 1.3% of agricultural workers, the horse industry is the source of 4.7% of accidents leading to work stoppage, 4.6% of serious, non-fatal accidents and 4% of fatal accidents (1). The frequency of accidents and the severity rates are among the highest, as are the severity levels, which reflect the aftereffects of the accident.

3 out of 4 accidents are related to direct contact with the animal (on top of or next to), half involving a fall from the horse and the other half next to the animal (national statistics), with
variations depending on the specific regions. This proportion is 75% in the Orne, but this is due to it being a breeding region, two-thirds of accidents occurring next to the horse and one-third due to a fall from, or the fall of the horse (the same proportions in 3 studies in 2000, 2006 (3) and in 2013). The 2000 study (4) highlighted that fractures are more often caused by pushes (33%) than by kicks (20%), with work stoppages being longer (29 days instead of 13).

When interviewing employees, 2 replies invariably come up: “we work with animals” or “that’s how it is, that’s just fate.”

Currently, many studies deal with the human/animal relationship (environment, breeding practices, training, etc.) in order to determine what improvements could be made in this relationship to increase safety (4). “It seems that day-to-day experience with humans could play a major role in horse’s reactions” (5). This line of investigation has a certain interest and the MSA has helped fund a study undertaken by the Human and Animal Ethology Laboratory of Rennes on the impact of the condition of the animal and the human-horse relationship. It has produced several publications (5) (6) (7) (8) but another approach, working higher up the chain, must be associated with it.

No thorough analysis of the “co-factors” (organizational, economic, environmental, human) currently exists. This has been underlined by H. Pasquet in his thesis (9) “The analysis of risk factors appears to be the essential step for the prevention of accidents.” He adds “According to the practitioners that were interviewed, 20% of accidents could not have been avoided,” does this mean that 80% could have been avoided? According to the INRS, “Workplace accidents never result from a single cause. They are the consequence of a combination of factors” (10). The cause of an accident may seem obvious; organizational (an employee who had to separate a herd of mares into 2 groups alone), material (horse held by an elastic sheet), human (an employee who wanted to catch a horse by approaching it from behind), and, of course, the animal itself.

However, it is necessary to identify the problem that created the accident. The causal tree method studies the 4 main factors involved in the genesis of the accident (individual, task, equipment, environment) and looks into the problem(s) that led to an accident. Lack of time and personnel are often mentioned. A study conducted in different stud farms (11) has shown organizational differences where some farms planned their tasks ahead of time while others worked in a piecemeal fashion. The human factor must also be explored in this domain, where the denial of risks appears to be quite high “they understand well that something is being done that they say at the same time shouldn’t be done” (12). Some practices are potential generators of accidents such as driving horses in group (25% of driving accidents in a 2013 study), and feeding at pasture (7 accidents).

The lack of research keeps us from identifying the exact role of the organizations. It is however possible to consider the influence of the facilities in the occurrence of certain accidents: the preparing of horses or veterinary care in unsuitable locations, or at the pasture under the supervision of a single person, inadequate local structures, work areas that mix horses and vehicular traffic for example.

II. Occupational Illnesses

The influence of the structures is certainly more prevalent in the development of occupational illnesses. The body reacts to prolonged exposures that lead to occupational illnesses, which are recognized when they fall within criteria that are set out in the tables.

In agriculture, the most common illnesses affect the musculoskeletal system: periarticular disorders (85% of declarations) and affectations of the lumbar spine (8%). No other category of occupational illnesses exceeds 1% of the reports.

In the horse industry, 2 points emerge: a postural component (increased lumbar spine disorders with 16% of the MP) and respiratory illnesses affecting the allergic mechanism: 4%.

A. Physical work

The physical nature of the work in the horse industry is not disputed, but it is unclear whether awareness exists of the actual workload.

At the request of the CPHSCT of Orne (3), the ANACT and the MSA have observed the actual work conditions, highlighting the importance of the physical loads with:

- multiple trips;
- poor postures, the “everything on the ground” policy; standing up-bent over posture adopted more than 500 times by a stable boy on a single observation day (washing equipment, crossing fences, filling buckets with pellets, pouring into the troughs, etc.).
- postural efforts for prehension or traction requiring a large amount of tension in the shoulders and spine;
- the carrying of weights (buckets of water, food, bags of grain, ...).

A study undertaken using cardiovascular frequency metering (13) confirms this physical load. One measurement has shown a cardiac cost for an employee that approaches the maximum allowed as defined in the French Decree of June 15, 1993 on manual work. During his or her workday, an employee undertakes light activity (<20% of energy expenditure) for half the time, and, for the other half, intense (30 to 50% of energy expenditure) or very intense activity (6% of the time from 50 to 75% of energy expenditure). These points mentioned above about movements, the carrying of loads and the postures were also highlighted, as well as the poor definitions of workspaces.

It is therefore essential to analyze, identify and treat these work activities. At the organizational level, areas for further reflection and recommendations have been identified (14) in order to facilitate the work tasks:
- design to reduce movements (locations of different “workshops”, saddlery, dung heap, feed, etc. in the organization);
- reduction of unfavorable postures and work on the ground (tables for cleaning leggings, mini silos instead of bags that allow buckets to be filled above the ground, ...);
- use of suitable equipment (wheelbarrows for pellets instead of buckets, replacing of trailers with edges that are too high during manual cleaning ...);
- working on uneven grounds in order to facilitate the rolling of equipment.

Many of these solutions are relatively simple, but are often difficult to change, because they are related to “habitual” behavior. More complex solutions also exist such as the mechanization of cleaning activities.

B. Respiratory illnesses

In the presence of an aerosol (dust, gas, steam), the respiratory system can respond with an “individual” reaction specific to the subject (allergic reaction), or in a non-specific manner, depending on the molecule, triggering an irritation or overload that provokes the same type of reaction in most individuals. The symptoms are common (cough, sputum, etc.) and can lead to COPD (chronic obstructive pulmonary disease). Some substances may evolve into more distinct illnesses (asbestosis and asbestos, silica and silicosis).

Occupational respiratory diseases are found in various categories, 45 (allergic mechanism), 22 (silica), 54 (inhalation of vegetable textile dust), but the majority of non-specific illnesses has no medical characteristic, few biological markers indicating exposure and little experimental data. They do not appear in these categories and are not recognized. It is therefore difficult to know the exact number of employees affected. Lamprecht finds an OR of 1.5% (IC 95% 1.1-2.0) for agricultural workers with obstructions of the bronchial airways (15). This same conclusion was reached in the 2011 scientific report of the RNV3P network (16) based on the results from 32 Consultation Centers for Professional Pathology (47,768 pathologies related to the work studied, of which 24% were respiratory diseases). It shows an overrepresentation of respiratory diseases in the agricultural sector (adjusted RR = 1.37, 95% CI = 1.17 - 1.55). Generally, the most dangerous recognized agents are physical silica dust, coal, cadmium and endotoxins. If the relationship between COPD/dust exposure is established, it is likely due to gasses and fumes (17).

In the horse industry, an increase in respiratory illnesses has been noted (4.8% of MP reported), mainly due to illnesses affecting the allergic mechanism. A recent study by the MSA of Côtes Normandes (18) confirms the increase in respiratory symptoms without being able to distinguish between allergy and irritation.

The existence of dust is obvious in the zone (handling of straw, hay, sweeping). The regulatory limits of concentrations of total and respirable dust (respectively 10 and 5 milligrams per cubic meter of air - Art. R4222-10 of the French Work Code) appears to be exceeded regularly and may cause breathing problems (19) (20).
In a stable, the constituents of the atmosphere are composed not only of vegetable dusts, but also many other substances such as animal allergens, bacteria, fungal spores, endotoxins, of β(1-3)-glucan (21). Ammonia is also found, as well as the residues of pesticides or biocides.

Allergic reactions – allergenics

Respiratory illnesses affecting the allergic mechanism are reported more frequently in this sector (4% MP) than in other agricultural sectors in terms of the General Regulatory Regime (0.5%). On the subject of asthma in the report cited above (16), the allergen families most frequently encountered are animal allergens (4th place out of 33) and biocides (3rd place out of 33), including the quaternary ammonium. However, these "products" are often encountered in the horse industry, coming not only from the animals but also from biocides for the disinfection of the premises. An inventory of the products approved for the disinfection of premises (22) counted 114 molecules, including many quaternary ammonium compounds.

It should not be surprising, therefore, that workers in this sector have a higher frequency of allergic illnesses.

Non-specific occurrences: the role of irritants

Ammonia: a horse produces an annual average of 7.3 kg of ammonia (23). Sanne Hansen Kiilerich (24) has found an average concentration of ammonia of 103 ppm at 5 cm from the ground in stables, with concentrations of 250 ppm in some boxes. The irritant effect of this compound on the respiratory system is known. In France, the permissible exposure limit values (ELV) and the average exposition values (AEV) are 50 and 25 ppm respectively.

Endotoxins: lipopolysaccharides are present in the outer membranes of Gram negative bacteria. Their role in the genesis of COPD has already been mentioned (17) and now seems well established (25). A threshold value of 100 UE/m3 is commonly allowed for acute effects, but does not lead to consequences during chronic exposure.

Their measurement is uncommon and is variable depending on the time and season (26). In this study, endotoxin levels of 310 UE/m3 in the morning in winter were measured, and returned to the 50 EU with the doors open. In autumn, with open doors, the average level was 150 EU.

β 1-3 glucan: like endotoxins, the role of β 1-3 glucan in irritative mechanisms has been demonstrated. In the same study (26), values of 0.02 to 0.3 ng/m3 were measured.

This data on the elements found in the atmosphere of the stables and their ability to provoke illnesses in the pulmonary system lead us to believe that the employees in the stable are most affected by this type of diseases.

Furthermore, it is easy not to notice that the tasks undertaken in these facilities are physical and are performed with a hyperventilation (an increase in the frequency and depth of breathing) to compensate for the increased demand for oxygen, increasing at the same time the input of pollutants.

In order to reverse this trend, the decrease in aerosols suspended in the air must be sought:

- By improving ventilation:
  - natural ventilation during the design of the building;
  - assisted ventilation (controlled ventilation), even if the results still need to be confirmed (27).
- By reducing dust emission (cleaning of bedding with vacuums, wetting of grounds before sweeping).

Areas for further research? Silica, new bedding

There is no specific study on this particular aspect of the work environment. Silica is one of the most well-known lung irritants. It enters into the composition of the sands for tracks or paths. In the Safety Data Sheet supplied by the manufacturer of silica sand X... (for sport and leisure purposes) it is stated: "In accordance with EC Directive 67/548, silica sand is not
classified as dangerous." But as a precautionary measure it is stated: "Alveolar dust may contain crystalline silica that may be released into the atmosphere. Prolonged or massive inhalation can cause pulmonary fibrosis (silicosis). In work environments, exposure to crystalline silica should be monitored and taken into account."

The new beddings that replace straw produce a dust that is recognized in other trades as being harmful. There is less exposure in this domain, but it is permissible to consider a possible transposition of effects.

Sawdust is responsible for cancers of the ethmoid in sawyers (MP 36) and flax and hemp dust are elements considered as COPD (MP 54).

Is the use of these new beddings the cause of an increase in respiratory diseases?

**C. One final point: zoonoses**

Zoonoses are infectious diseases transmissible from animals to humans and vice versa. Only 2 of these diseases have been reported but they are probably more common. Pest control, basic hygiene and adequate ventilation allow these infestations to be limited.

**Conclusion**

In this industry, workplace accidents are numerous and result from horse reactions. Current research focuses on the human/animal relationship. No studies exist on the influence of "co-factors" (organizational, environmental, human, etc.) which makes it difficult to understand their influence on the occurrence of accidents.

In terms of occupational illnesses, two types can be seen:
- pathologies related to the musculoskeletal system, due to the physical loads. Design of buildings, reduction of movements, use of appropriate equipment, organizational improvements, decreasing the "everything on the ground" policy, are elements that can improve the work environment. Often the only elements that prevent the reflection on the improvement of working conditions are experience, habits, routine and lack of time.
- pathologies related to the respiratory tract are common in this industry, and stem from dust emissions of all types. Ventilation is one of the factors that appear important for limiting exposure to aerosols.
- other risks related to the environment exist, such as zoonoses.

To conclude, the French Work Code stipulates (Article L4121-1) that the employer must ensure the safety and protect the physical and mental health of the employees. This same Work Code can be used to ascertain the various norms for dust, light and noise in the work environment, as well as regulations relating to load handling and other specific risks (chemical, biological, etc.).

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Characteristics of different types of equine housing, impact on working conditions

Abstract
As part of the national REFerences network (Economic Network of the Equine Industry) and the micro-economic evaluation group, the Equine Network conducted a survey of equine establishments in 2013. From the 126 structures that were evaluated, the survey allowed us to characterize the diversity of housing types for which the terminology has been refined. The analysis of the data, having produced a typology of the buildings, shows that despite the different sizes of interior boxes, approximately 10 m², they are the most frequently used box types in farming operations (42%). The number of working hours for routine tasks is related to the overall organizational structure and particularly to the buildings. The time required to lead the horses in and out of the building can double per horse per day, depending on the building type. Manure management (maintenance and cleaning of boxes) is even more strongly influenced by this parameter.

Introduction
The work requirements in equine systems are significantly higher than in other sectors, in particular because of the individual handling and the form of economic development of the animals (Madeline L., Pavia J, 2012). Recent work published by the equine network has shown a real lack of productivity in equine structures, already burdened by economic difficulties (Institut de l’Elevage, 2013). Under these conditions, the design of the buildings, in connection with the working conditions and the housing of the animals, can influence the internal organization of the operation (time per task) and the labor productivity.

Buildings must meet three basic needs of the horse, i) the need to eat regularly, ii) the need for space and iii) the need for contact with other horses (Boussely L., 2003). The national survey conducted in 2013 on the farms in the Equine Network, which investigated the different types of housing and the time spent on routine tasks, revealed significant differences between structures.

From the 126 surveys that were evaluated, statistical analysis identified the elements that favored or that were detrimental to the workload. These elements, specific to the building type or to the type of housing, indicate possibilities for improvements in working conditions and productivity. Building design is a key element in the organization of work, the welfare of the horses and of those who care for them.

1. Materials and methods

1.1. Typology, samples, survey

Based on the national system of the Réseau d’Elevage Equin (Network of Equine Livestock), the investigations focused on the equine farms in the network, of which 126 were evaluated. Divided up according to the typology finalized in 2012, the farms are classified on the relative proportion of
equine gross proceeds in the total proceeds. When the equine proceeds are greater than 80% of the gross proceeds, the farms are classified as "specialized." Otherwise, they are considered "diversified" (e.g., cattle). The equine orientation stems from the proportion (+ 50%) of the proceeds of the main equine activity in the total equine proceeds, yielding the following categories: farms, equestrian facilities, mixed systems (Table 1). The database consists of 126 farms in operation and distributed throughout the territory, represented as blue dots (Figure 1). The surveys were conducted by interview using a guide, with the goal of collecting information about 1) general data about the farm, 2) data concerning the types of housing, 3) data related to infrastructure and 4) data related to on-call work time.

**Table 1**: Equine national typology (Institut de l’Elevage, 2012).

1.2. Data analysis

The first statistical analyzes were performed with using pivot tables and pivot charts in Excel. The data pertained mainly to general information from the farm that has been analyzed in this way. A Multiple Correspondence Analysis (MCA), used to investigate the relationship between two qualitative variables, helped highlight contingencies. An Ascending Hierarchical Classification (AHC) was used to bring together the individuals according to the variables analyzed by the MCA in order to offer the best possible partition, producing a typology of the buildings observed in the survey.

The Principal Component Analysis (PCA), which is used when we want to compare quantitative variables, was used to determine the correlation between the on-call activities in the surveyed farms.

2. Results

2.1 General data

2.1.1. Terminology of the types of housing

Stemming from the analysis of the data, the building typology distinguishes between outdoor systems, buildings with direct access to the outside, interior buildings (closed housing) and exterior buildings (housing with access to the exterior) (Table 2).

2.1.2. Workforce on the surveyed farms

The workforce is divided into three categories: operators, hired labor (which also includes apprentices) and the unpaid labor (family, students). Operator labor is slightly higher in a diversified system, in particular because of the size of the farms (cattle and horses). However, hired labor is higher in equine systems because of the highly individualized behavior of the animals (Figure 2).
2.2 Characteristics of the buildings

Boxes represent 85% of individual housing, two thirds of which are interior boxes (Figure 4). Stables, while employed less often, nevertheless represent 65% of collective housing. These are generally ponies A and B, housed in collective boxes large enough to accommodate 2 small-sized ponies. The surface area available for horses varies according to the type of housing. For individual boxes, it represents 10m² on average. In the stables, the surface area is much smaller and is typically closer to 4m². Collective interior boxes have, on average, a surface area of 33.5 m² but with a strong dispersion (Figure 5).

2.2.1. Typology of the housing in buildings

This typology is based on the ascending hierarchical classification after the regrouping of certain classes. The boxes declared to be collective have been reclassified as individual boxes, because of the similarity of the dimensions and use. It has been shown that these boxes are mainly used to house several small ponies. We will simply call them boxes, distinguishing whether they are internal or external (Table 3).

2.2.2. Types of horses housed

The interior individual boxes house mostly riding horses and large ponies (C and D) (Figure 6).
2.2.3. Distribution of fodder

Fodder is generally distributed on the ground, especially when the horses are in boxes and despite the waste caused and the possible ingestion of dust. The use of racks, while less frequent, can nevertheless be found, especially in buildings with stalls (Figure 7).

2.2.4 Manure management

When cleaning occurs frequently (at least once a week) it is typically done by hand. After more than one week of accumulation, the litter often needs to be cleaned by mechanical means (Figure 8). Manure is stored mainly in the field (44% of responses). On 20% of the farms, the effluents are managed using manure piles (and pits in diversified systems). The use of a temporary storage platform is often found in equine operations (18%) (Figure 9).

2.3 Work time by task according to buildings

The daily work time to lead horses indoors and outdoors varies from 2-5 minutes/day/horse, depending on the building type. However, these calculated times do not include the weekly outings which can greatly change the result. Operators using stables require less time. This is due to the collective behavior of the horses and to the access to the exterior area adjoining the barn. For others, the leading out of horses takes place individually, which requires more time per day (Table 4). Of the 137 respondents, only 19 have described this work as tedious. This essential activity can be delegated easily, even if it has the advantage, for the farmer, of allowing the horses to be observed.
adapted using existing structures. In the sample group, approximately two thirds of the operators
buildings used for housing and/or for specific infrastructures such as arenas or paths, built new or
Paradoxically, the respondents acknowledge that they have received little or no financial support
say that they have carried out extensive work to adapt or change their structure. Receiving little or no financial support for these projects (76% of responses), these operators have contributed personally (self-construction) to the
improvement of their operations.

Equestrian facilities require, especially during their construction, substantial investments for the
work times vary in the opposite sense: when one task is very time consuming, the other requires little
These differences are partly explained by the time spent in the building and
by the manner of cleaning. The building has a significant effect on the work time needed for the
housing or specific infrastructure (manège, courses, etc.). The buildings are constructed new or are

The PCA results have shown significant correlations between the working hours and the building.
In the context of RMT Buildings (Mixt Technologies Network).

The building has a significant effect on the work time: handling of horses, distribution of fodder and
housing maintenance.
The equestrian facilities require, especially during their construction, substantial investments for the
buildings used for housing and/or for specific infrastructures such as arenas or paths, built new or
adapted using existing structures. In the sample group, approximately two thirds of the operators
say that they have carried out extensive work to adapt or change their structure. Paradoxically, the respondents acknowledge that they have received little or no financial support for these projects (76% of responses). There are various means available to increase productivity and work comfort, and these must be developed in order to establish the long-term sustainability of the operations, particularly in the context of RMT Buildings (Mixt Technologies Network).

### Table 4

Average work time to perform the main tasks other than horse work (Institut de l’Elevage, 2014).

3. Discussion

Equestrian structures are constantly evolving structures and require a good deal of planning during
their construction and development phases. Investments are often required for the construction of
housing or specific infrastructure (manège, courses, etc.). The buildings are constructed new or are
adapted using existing structures. Approximately two thirds of operators say they have carried out
extensive work to adapt or change their structure. Receiving little or no financial support for these
projects (76% of responses), these operators have contributed personally (self-construction) to the
improvement of their operations.

The PCA results have shown significant correlations between the working hours and the building.
The distribution of fodder and the distribution of concentrates vary in the same way, that is to say
that when one of these tasks takes a long time, the other does as well, and vice versa. This is
explained by the fact that the same trajectories must be made to distribute the hay and the
concentrates to the animals. For the horse handling activities and the cleaning of the housing, the
work times vary in the opposite sense: when one task is very time consuming, the other requires little
time, and vice versa. These differences are partly explained by the time spent in the building and
by the manner of cleaning. The building has a significant effect on the work time needed for the
handling of horses, on the distribution of fodder as well as on the maintenance of the housing. A
mechanized system of fodder distribution will require an average of 1 fewer minute per horse per
day.

For open-air horses, the provision of the horses can take place with or without shelter. In the case of
open-air shelters, the time needed for the distribution of fodder (in winter) is 1.92 minutes/day/horse
in comparison with 3.78 for open-air horses without shelter.

Conclusion

The building has a significant effect on the work time: handling of horses, distribution of fodder and
housing maintenance.
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References


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Injuries in group kept horses

Lecturer: C. M. Mejdell

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Abstract

Group housing of horses is not very widespread, despite obvious advantages for their development and mental well-being. One often expressed rationale for this is that horse owners are worried about the risk of injuries due to kicks, bites or being chased into obstacles. To address this concern, we developed and validated a scoring system for external injuries in horses to be able to record the severity of a lesion in a standardized and simple way under field conditions. The scoring system has five categories from insignificant loss of hair to severe, life threatening injuries. It was used to categorize 1124 injuries in 478 horses. Most of these horses were allocated to groups to study the effect of group composition (i.e. same age or mixed, same gender or mixed, socially stable or unstable groups) on behaviour and injuries. The material included mainly riding and leisure purpose horses of different breeds, age and gender. Most injuries occurred the day after mixing.

Injuries of the more severe categories 4 and 5, which normally would necessitate veterinary care and/or loss of function for some time, were not observed at all. The minor injuries categorized as 1-2 counted for 99% of the total injuries. A few category 1 injuries were found on most horses, some horses had none injuries at all, and a few had many. Category 3 injuries (a minor laceration and/or contusion with obvious swelling) were only recorded in a baseline subset of 100 riding horses, there comprising 4% of the injuries. Whereas most of the injuries were found on the body, the category 3 injuries were mainly found on the limbs and head. The reason for this is probably that the skin there is tight and thus is more easily lacerated. Icelandic horses tended to have fewer and less severe injuries compared to other breeds. There was also a breed effect on location of the injuries.

We conclude that the risk for serious injuries when horses are kept in groups is generally low and fear of injuries should not be a reason to prevent horses from social interaction with other horses. However, we emphasize that most of our recordings were performed during the summer period, and many horses were unshod. The situation might have been different in winter, and special caution should be taken if mixing horses shod with ice studs.

Keywords: animal welfare, equine, scoring, group housing, health

I. Introduction

Group housing of horses, allowing them to interact socially, has obvious advantages for their development and wellbeing. In countries like Denmark, Sweden and Switzerland, group pasturing of young horses is therefore mandatory. Whereas loose housing systems have become widespread for many production animal species, the keeping of horses in single boxes indoors as well as single in outdoor paddocks is still very common. One often expressed rationale for this is that the owners are worried about the risk of injuries due to kicks, bites or being chased into obstacles. There is no doubt that such a risk exists but little information is available on the magnitude of the risk, severity of injuries, and preventive measures. This was addressed by the Nordic joint project “Group housing and managing horses under Nordic conditions: strategies to improve horse welfare and human safety” 2006-2010. The main aim of this research project was to identify general principles of how to keep horses in groups so that their welfare is maximized and the risk to humans is minimized. Among the objectives were studies on external injuries caused by horse-to-horse interactions, including the impact group composition might have on prevalence and severity of injuries. Results from these subprojects will be presented here.
II. Material and methods

A. Scoring system

To be able to categorize external injuries according to their severity in a systematic but yet simple way, a five point injury scoring system was developed and tested for observer reliability [5], see Table I. Both category and the exact body location of each injury were recorded. In practice this was done by using one paper sheet per horse showing a drawing of both sides of a horse. Injuries were marked with category directly on the sketch, using pens with different colour for different examination days. Any sign of lameness was evaluated visually by moving the horses at trot in the home enclosure.

<table>
<thead>
<tr>
<th>Cat.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lesion involving hair loss only, for example a superficial bite</td>
</tr>
<tr>
<td>2</td>
<td>Moderately sized contusion (bruise) with or without hair loss and/or an abrasion (scrape) in but not through the skin</td>
</tr>
<tr>
<td>3</td>
<td>Minor laceration (cut through the skin) and/or a larger contusion with obviously swollen parts</td>
</tr>
<tr>
<td>4</td>
<td>Laceration involving injury to deeper tissues, or laceration without such tissue damage but of a size that requires surgery</td>
</tr>
<tr>
<td>5</td>
<td>Severe and extensive injury which may lead to long lasting loss of function or even death/euthanasia</td>
</tr>
</tbody>
</table>

Table 1: Description of the categories within the scoring system (from mejdell et al. 2010 [5]).

B. Horses

A total of 478 horses in Norway, Denmark, Finland and Sweden were included in the study. Several breeds, both coldbloods and warmbloods, mainly riding and leisure horses, were represented. The horses were, with few exceptions, privately owned and the studies were usually performed on the home farm. Age ranged from yearlings to 26 years. 378 horses were allocated to 67 test groups established for the purpose of studying the effect of group composition [6]. 100 horses had been kept in socially stable groups at least during daytime for a minimum of 4 weeks prior to examination, resembling a baseline situation [5].

C. Experimental Design

In the baseline study, five horses were randomly selected from each of 20 groups from 14 different premises in Norway [5]. Inclusion criterion was that the group had been socially stable for at least four weeks before examination. All injuries found were recorded.

To study whether group composition influenced risk of injuries, horses were allocated to designed test groups. Thus, the study included the mixing situation which is considered especially risky when it comes to aggressive encounters. The studied group factors were age (horses of same age versus mixed age in the group) [7]; gender (horses of same gender versus mixed gender) [8]; and social stability (static versus dynamic groups) [9]. Even environmental enrichment was a factor studied in the project, however these results are not published and will not be further discussed. Horses were allocated to a test group in which all horses were unfamiliar to each other. In some cases full non-familiarity was not achievable, and horses were then grouped with horses they had been separated from for as long time as possible. Group size was set to a minimum of three horses and was typically 3-6 horses. Horses were clinically examined for any external injuries, scars, and lameness prior to mixing, to have a starting point record of each horse. This made it possible to record only new injuries. Horses were clinically examined at day one after mixing and new injuries and signs of lameness were reported, and again after 4-6 weeks.

For the age effect study, 10 pairs, that is five groups with 3-6 fillies and five groups with 3-6 colts/young geldings were paired with an equal group supplied with one extra, adult horse (at least two years older). For the gender effect study, six triplets consisting of one group with four mares,
one with four geldings, and one mixed group having two mares and two geldings, were studied. Groups were compared within farms in a matched case control design for farm, breed, and group size. Thus, a pair or triplet was always localized to the same farm and at the same time, and enclosure sizes and feeding regimes were similar.

For the social stability study the experimental design was a bit different: all horses were young, Danish warmblood mares and the study was performed on one location, and all horses were pastured. Group size was three. In seven of the groups the horses remained in the same group (static groups) throughout the period, whereas in eight groups, one horse was moved to another group every week (unstable groups), for seven weeks. Injuries were scored at the end of the experimental period.

**D. Statistics**

The validation of the injury scoring system was done by attribute agreement analysis using Kendall’s coefficient of concordance, Kendall’s correlation coefficient and Fleiss’ kappa [5]. Frequency of injuries was analysed for effect of group composition using non parametric comparisons: Mann Whitney if comparing two categories and Kruskall Wallis if there were three categories of groups to compare [6,8,9], and in one study the observations were modelled in a generalized linear model assuming a normal distribution [7].

**III. Results**

The scoring system showed generally good intra- and inter observer reliability (Kendall’s W 0.94-0.99 and 0.91, and mean kappa 0.72 and 0.59, respectively), and good agreement with the “golden standard” (Kendall’s tau 0.88 and mean kappa 0.66) and could safely be used to assess injuries in the practical trials [5].

A total of 1124 injuries were recorded in 478 horses. None of the injuries were severe (category 4-5). Actually, category 1 and 2 counted for 99% of the injuries, and within these, 85% were category 1. No horses were found to be lame.

In the base line study of 100 horses, 308 injuries were recorded [5]. Median number of injuries was 1 for category 1, and 0 for categories 2-3. 28 horses had no injuries at all, and some horses had many. One young stallion had as many as 28 category 1 injuries. Among the horses recorded with at least one injury of the category in question, mean numbers were 3.5, 1.8, and 1.3 for category 1, 2, and 3, respectively. Body location and injury category of the 308 recorded injuries in this study is given in Table II. Whereas category 1 injuries were far more commonly reported than categories 2-3, the category 3 was over represented on the head and legs.

<table>
<thead>
<tr>
<th>Body part</th>
<th>Injury category</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Head</td>
<td>10.3</td>
</tr>
<tr>
<td>Neck</td>
<td>15.3</td>
</tr>
<tr>
<td>Chest</td>
<td>11.2</td>
</tr>
<tr>
<td>Barrel</td>
<td>21.9</td>
</tr>
<tr>
<td>Rump</td>
<td>27.7</td>
</tr>
<tr>
<td>Inguinal</td>
<td>0.8</td>
</tr>
<tr>
<td>Front leg carpus and above</td>
<td>2.5</td>
</tr>
<tr>
<td>Front leg below carpus</td>
<td>0.4</td>
</tr>
<tr>
<td>Front leg, coronet</td>
<td>0.4</td>
</tr>
<tr>
<td>Hind leg hock and above</td>
<td>4.1</td>
</tr>
<tr>
<td>Hind leg below hock</td>
<td>5.0</td>
</tr>
<tr>
<td>Hind leg coronet</td>
<td>0.4</td>
</tr>
<tr>
<td>SUM</td>
<td>100</td>
</tr>
<tr>
<td>% of all injuries</td>
<td>78.6</td>
</tr>
</tbody>
</table>

Table 2 : Body location of injuries (%) found in baseline study shown per injury category
In the studies of effect of group composition, most injuries were recorded the day after mixing. All recorded injuries were minor, that is category 1-2. In general, no effect of group composition on injuries was found [6]. However, some interesting differences in aggressive interactions, which are a risk factor for injuries, were found.

Groups consisting of young horses supplied with an adult horse showed fewer aggressive behaviours with physical contact (P=0.018) and tended to show fewer threat behaviours (P=0.063) compared to groups consisting of young horses only [7]. Few injuries were found; 56 were in category 1, three in category 2 and none in categories 3-5. Young geldings and colts had a higher frequency of injuries at the day after mixing (P<0.05) compared to fillies. Young geldings and colts tended to show more play behaviour than fillies (P=0.070) but there were no gender differences regarding agonistic behaviours.

In the study which was designed to look at gender effects, more but still minor injuries were found: 136 in category 1, 19 in category 2, and none in the categories 3-5 [8]. The gender groups did not differ significantly regarding frequency of injuries, although mares in pure mare groups tended to have fewer recordings. Groups with geldings as well as mixed gender groups showed more play behaviours compared to mare only groups. In this study, a negative correlation between enclosure size and aggressive interactions was found; horses in groups with the smallest space allowance showed the highest mean number of aggressive interactions [8].

In the study on effect of social (un)stability only minor injuries, a total of 97 in category 1, and 9 in category 2, were recorded altogether, and there was no significant differences between the treatment group [9]. However, the number of injuries tended to be higher in unstable groups, and they tended to have more recordings of agonistic behaviours. Further, the occurrence of play behaviour varied to a larger extent in unstable groups. There was an effect of horse, meaning that some individuals were more aggressive than others. Aggression levels did not increase or decrease in the unstable groups during the test period, indicating that horses neither habituated nor were sensitized by repeated regrouping [9].

There was an overall effect of breed on injuries, as Icelandic horses had fewer and less severe injuries compared to other breeds [6]. Furthermore, injuries on Icelandic horse were more likely to be located on the rump (28.3 %) compared to warmbloods (19.2%) and all other breeds (16.7 %) (P<0.001) [6].

IV. Discussion

Severe injuries or lameness were not recorded during the studies. In fact, only category 1-2 injuries were found in the group composition studies, in which we recorded new injuries occurring after mixing and during the following 4-6 weeks (incidence). Actually, the most severe score recorded at all was category 3, constituting 4% of the injuries found among the baseline horses (prevalence data) and 0% in the group composition studies (incidence of new injuries). Category 3 equals a contusion or minor cut through the skin, not necessitating veterinary care or influencing on function. The category 3 injuries were only found on the head and legs, places where the skin is rather tight. This leads us to suggest that the reason for category 3 being overrepresented on head and legs, is that a kick, strike or bite that hits a tight skin more easily leads to a laceration compared to hitting the more flexible skin on a body part with soft subcutaneous tissues.

Icelandic horses had fewer injuries compared to other breeds [6]. This may be explained by the fact that Icelandic horses commonly are raised in groups and therefore have become more tolerant to other horses or are better at reading the intention of other horses, so that threats are sufficient in agonistic encounters. A few of the horse groups were run during late autumn and winter, so another reason may be that Icelandic horses develop a thick winter coat which protects the skin against injuries (no horses wore blankets). The fact that distribution of injuries varied among breeds may also reflect breed differences in the way horses interact aggressively [10].

We found that colts and geldings displayed more play behaviours than mares [7,8]. This can explain the finding that males sometimes were found to have a higher number of low category injuries than mares, as these superficial injuries may stem from play or playfighting and may actually indicate positive animal welfare [11].

The horses were of different breeds and age and were studied during different seasons. However, many of the horses were young, many were kept on pastures, many were unshod and none of the
horses had shoes with ice-studs. These circumstances may have positively influenced our results, and results may probably have been different if mixing unfamiliar horse shod with ice-studs. On the other hand, we studied horses in a situation where aggressive interactions often occur, that is after mixing unfamiliar individuals.

Therefore, we conclude that risk of injuries caused by horse-to-horse interactions of horses kept in groups is probably overestimated. Fear of injuries should not be a reason to keep horses in social isolation. Company is important to horses, and horses will work hard for access to another horse [12]. Care should be taken when introducing a new horse to a group, and some methods to reduce the risks was tested during the NKJ-project [13,14]. Aggression levels, and so the risk of injuries, were found to be negatively proportional with space allowance [8], which is in accordance with a study by Flauger and Kreuger [15]. Other important factors to prevent injuries are measures to avoid competition among horses by securing all individuals sufficient access to feed and other resources, and having management routines that do not elicit aggression [1,3,16].

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References


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Effects of feeding management and group composition on agonistic behaviour of adult horses in group housing systems

Abstract

Under natural conditions, horses spend 12 - 18 hours a day with synchronous feeding, whereas forage is usually rationed in stabled horses. In group housing systems, therefore, feeding is a situation in which agonistic behaviour is often increased due to the limited availability of the resource. The aim of this study was to evaluate how organisation and duration of the roughage provision as well as group composition influence agonistic behaviour of group housed adult horses. The study was conducted on 50 group housing systems in Switzerland. Groups consisted of 4 - 21 adult horses (n = 390). Each group was observed directly during two periods, 30 minutes directly before (pre-feed period) and during the first 30 minutes after a feeding time (feed period). All occurrences of agonistic behaviour were recorded continuously. The feeding management differed greatly between stables, feeding systems were “floor”, “fodder rack”, “feed fence”, ”net”, “feed stand” and “mixed”. Hay (or haylage) was mostly provided 2 - 3 times a day, but the duration of hay availability varied from 1.5 - 24 hours a day, while straw was mostly available ad libitum. The probability of threatening behaviour decreased in all feeding systems from the pre-feed to the feed period, with the steepest decrease in “feed stands”. The probability of aggressive behaviour was highest in the feeding systems “floor” and “mixed” and lowest in the feeding system “net”. Considering both aggressive and threatening behaviour, “feed stands” showed the lowest probability for agonistic behaviour, followed by “net”. In addition, with an increasing duration of daily hay availability, the probability of aggressive behaviour decreased substantially in the feed period. Consequently, to reduce agonistic behaviour, feeding systems for group housed horses should either offer feeding places separated through partitions that permit no or only limited contact between individuals or widely distributed feeding places. Furthermore, it is highly recommended to provide horses nearly ad libitum not only with straw but also with hay.

Keywords: horse, group housing, agonistic behavior, feeding system, feeding management

I. Introduction

The potential risk of injuries is a major concern of horse owners regarding group housing, although studies showed that levels of agonistic behaviour are generally low in free-ranging horses [1]. Under natural conditions, horses are socially lively steppe inhabitants with a highly synchronous feeding activity [2,3]. As grazers, their natural diet is generally poor in energy and rich in fibres, and thus horses usually spend 12 - 18 hours a day feeding [4,5,6]. Their digestive system is adapted to continuous feed intake, with the result that horses avoid fasting for longer than 3 - 5 hours [7,8]. Contrary to most mammals, the feeling of satiety is not achieved by a stimulation of the stretch receptors with a filled stomach but by a fatigue of the masticatory muscles [8,9].

Although domesticated horses have similar behavioural and physiological needs [8,10], the feeding regime of domesticated horses usually differs markedly from the wild. Under housing conditions, forage is generally higher in energy and consequently, to prevent overweight, often rationed. As a result, the duration of feed intake is restricted. These circumstances, in addition to limited space conditions, are likely to cause higher frequencies and intensities of agonistic behaviour [11,12]. Previous studies examining enrichment in group housing systems and their effects on the
occurrence agonistic behaviour showed that horses provided with continuous forage opportunities showed less agonistic and more socio-positive behaviour [13,14]. Further, also the design of the feeding system has an impact on agonistic behaviour. Studies showed problems with high-ranking horses which have priority access to feeding places and therefore lower-ranking horses might not get adequate access to feed [15,16]. Furthermore, if groups are heterogeneous with regard to age and exercise levels, the provisioning of individually calculated feed rations may be required [12]. Therefore, individually separated feeding places seem to be advantageous, but on the other hand, Kolter [17] found increased frequencies and intensities of agonistic behaviour in feeding systems that did not allow the horses to see their surroundings and to retreat from higher-ranking pen-mates.

Meanwhile, to our knowledge, no studies exist that simultaneously compared a variety of different feeding systems and investigated the influence of feeding management and group characteristics on agonistic behaviour in group housed adult horses. Therefore, the aim of this study was to evaluate how the organisation and duration of roughage provision as well as the group composition influence the agonistic behaviour of group housed adult horses in a large sample of stables. In principle, it is to be expected that the level of agonistic behaviour is lower in groups in which forage is offered widely distributed and available over a long period of time.

II. Animals and methods

The study was conducted at 50 group housing systems in the German-speaking part of Switzerland from April - October 2013. A total number of 390 horses (188 mares, 202 geldings) at the age of 2 - 32 (age: 13.3 ± 6.5 years), housed in groups of 4 - 21 individuals (group size: 7.8 ± 4.0), were observed. The sex ratio within the groups varied from same-sexed groups (only mares: 2 groups, only geldings: 6 groups) to equally mixed groups (12 groups); 16 groups had more mares than geldings and 14 groups had more geldings than mares. On average, horses were residents of the groups between 0.1 and 19 years. The group housing systems had at least two spatially separated areas, a run and a littered lying area. The feeding area was either an additional spatially separated area or feeding took place in the run. Hay (or haylage) was fed in a variation of different feeding systems:

- **Floor**: Hay is provided directly on the floor.
- **Fodder rack**: Hay is provided in a large manger. Feeding places are often divided by palisades, requiring an elevation of the head for lateral movement.
- **Feed fence**: Hay is provided in a large manger or a feed bunk. Feeding places are divided by vertical bars, requiring stepping backwards before lateral movement is possible.
- **Net**: Hay is provided in nets of different mesh sizes.
- **Feed stand**: Hay is provided in individual feeding places, separated through fence panels or solid wooden panels (with or without viewing slits):
  - with contact at front: allowing limited physical contact with the head.
  - without contact at front: panels preventing physical contact.

(Some groups were locked up in the feed stands during feeding times, in order to avoid displacing another horse from its stand.)

Each group was observed on one day. During observations, all horses were present and the management was carried out as usual, except that groups were not allowed to have access to pasture (including the night before). All groups were observed for 30 minutes before a feeding time (pre-feed period) and for the first 30 minutes after feed delivery (feed period). All occurrences of agonistic interactions were recorded continuously (all event sampling; [18]). Nine behaviours were distinguished and partly summarised in the categories threatening behaviour (all agonistic behaviours involving threats) and aggressive behaviour (all agonistic behaviours with physical contact or attempt of physical contact) (Tab. 1).
**Agonistic Behaviour**

<table>
<thead>
<tr>
<th>Approach</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approach</td>
<td>Approach of one horse with ears pointing forward or laterally is followed by another moving away so that distance is maintained or increased, without noticeable aggression [22,23].</td>
</tr>
<tr>
<td>Push</td>
<td>“Pressing head, neck, shoulder, body or rump against another in an apparent attempt to displace” the target animal [24].</td>
</tr>
</tbody>
</table>

**Threatening behaviour**

<table>
<thead>
<tr>
<th>Threat</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>Threat</td>
<td>“The extension of the aggressor’s head and neck towards another individual while laying the ears against its head [25].”</td>
</tr>
<tr>
<td>Bite threat</td>
<td>“Bite intention movement with ears back and neck extended, with no actual contact [14].”</td>
</tr>
<tr>
<td>Kick threat</td>
<td>“Kick intention movement, performed by swinging rump or backing up, and waving or stamping hind leg towards another horse, without making contact [14].”</td>
</tr>
</tbody>
</table>

**Aggressive behaviour**

| Bite                       | “Opening and rapid closing of the jaws with actual contact to another horse’s body. The ears are back and lips retracted [14].” |
| Kick                      | “One or both hind legs lift off the ground and rapidly extend backwards towards another horse, with apparent intent to make contact [14].” |
| Attack                    | “Ears laid back, head raised, open mouth and pursuing another animal for more than a three body-lengths distance, attempting to close teeth on its body [22].” |
| Chase                     | “One horse chases another (trotting or galloping) with ears laid back [14].” |

**Table 1:** Ethogram of observed agonistic behaviour

In addition, data on group composition (group size, age, years of residency, sex ratio), space allowance per individual and feeding management were recorded. Parameters of the feeding management included the feeding system in which hay was provided, duration of daily roughage availability (hay, straw), temporally fixed feeding regime (within 30 min) and the number of feeding places per individual. Further, the ambient temperature during observational days was taken from the nearest meteorological measuring station [19]. Statistical analysis was conducted in R 2.15.2 [20]. Two different outcome variables for agonistic behaviour were analysed; threatening behaviour and aggressive behaviour. Generalized linear mixed-effects models (glmer method; package ‘lme4’ [21]), whereby outcome variables were dichotomized. The final model was obtained by a stepwise backwards reduction with a p-value of 0.05 as the criterion of exclusion. Statistical assumptions were checked through graphical analysis of residuals (normal distribution, homoscedasticity). To assess the relationship between the fixed effects and the outcome variables, the odds ratio (OR) was calculated.

**III. Results**

**a) Feeding management (descriptive)**

Feeding of hay (or haylage) was proceeded mostly 2 - 3 times daily in either one of the seven different feeding systems “floor”, “fodder rack”, “feed fence”, “net”, “feed stand with contact at front”, “feed stand without contact at front” or “mixed” (i.e. more than one of the above systems were combined). 56% of the groups (237 horses in 28 groups) had a temporally fixed feeding regime. The number of feeding places per individual varied between 0.8 and 3.6 (\(\bar{x} = 1.4 \pm 0.6\)). In 6% of the groups (13 horses in 3 groups) less than one feeding place per individual and in 50% of the groups (192 horses in 25 groups) more than one feeding place per individual was provided. The duration of hay availability varied from 1.5 - 24 hours a day (\(\bar{x} = 9.3 \pm 7.8\)). Only 26% of the groups (84 horses in 13 groups) had access to hay for 12 hours or longer. Straw was available ad libitum for 78% of the groups (328 horses in 39 groups). On the other hand, 14% of the groups (42 horses in 7 groups) had access to straw for less than 2 hours or not at all. Water was available ad libitum for all groups.
b) Agonistic behaviour

A total number of 1976 agonistic interactions, ranging from 0 to 24 per individual, were observed during the 50 hours of observation. Threatening behaviour accounted for 63.5% of the observed agonistic behavior and occurred in every group.

During the pre-feed period, the proportion of horses showing threatening behaviour was high in the feeding systems “floor”, “fodder rack” and “mixed”, and lowest in “nets”. Whereas during the feed period, it was high in “floor”, “fodder rack”, “feed fence” and “mixed”, and low in “nets” and “feed stands” (Fig. 1; feeding system x period: \( \chi^2 = 25.4, p < 0.001 \)). Furthermore, threatening behaviour increased with an increasing proportion of mares in the group (sex ratio: \( \chi^2 = 5.0, p = 0.025, \text{OR} = 2.7 \)) and it was slightly more likely to occur the longer a horse was resident of a group (years of residency: \( \chi^2 = 4.4, p = 0.036, \text{OR} = 1.05 \)). On the other hand, threatening behaviour was not influenced by group size, age, space allowance per individual, number of feeding places per individual, duration of daily availability of hay or straw, temporally fixed feeding regime or ambient temperature. Aggressive behaviour accounted for 7.0% of the observed agonistic behaviour and occurred in 76% of the groups. The proportion of horses showing aggressive behaviour was highest in the feeding systems “floor” (OR = 1.00) and “mixed” (OR = 0.99), reduced in “fodder rack” (OR = 0.58), “feed stand with contact at front” (OR = 0.52) and “feed stand without contact at front” (OR = 0.48) and lowest in “feed fence” (OR = 0.23) and “net” (OR = 0.18) (Fig. 2; feeding system: \( \chi^2 = 13.0, p = 0.043 \)). Further, an extended duration of daily availability of hay decreased the probability of showing aggressive behaviour substantially during the feed period (ORfeed = 0.20), while it was marginally increased in the pre-feed period (ORpre-feed = 1.08) (availability of hay x period: \( \chi^2 = 7.1, p = 0.008 \)). On the other hand, aggressive behaviour was not influenced by group size, age, years of residency, sex ratio, space allowance per individual, number of feeding places per individual, duration of daily availability of straw, temporally fixed feeding regime or ambient temperature.

III. Discussion

a) Effects of group characteristics

The proportion of horses showing threatening behaviour was greater with an increased ratio of mares in the group. This finding is in accordance to a study with yearling horses, where fillies performed more than three times more agonistic behaviour during feeding as geldings [26] but contradicts findings of Vervaecke et al. [27] and Jørgensen et al. [11], who did not find gender differences in the frequencies of agonistic behaviour. Further, the probability of horses showing threatening behaviour was slightly increased the longer an individual was resident in its group. Consequently, it is especially important for groups with frequent and/or recent changes in composition, that the feeding system either allows maintaining individual distances or offers separate feeding places in...
order to protect recently integrated individuals. Further, although several studies found higher levels of agonistic behaviour in larger groups [28,29,30], no influence of group size was found in the present study.

b) Effects of feeding system and feeding management

The proportion of horses exhibiting agonistic behaviour was rather high but varied distinctly in the different feeding systems. Contrary to our expectations, levels of agonistic behaviour were high in the feeding system “floor”. With hay mostly being distributed widely in a larger number of piles than horses in the group, “floor” was the feeding system closest to natural feeding conditions. Considerable amounts of agonistic behaviour were also observed in “fodder rack” and “feed fence”, both feeding systems that demand horses to stand in close proximity. Similar findings were made by Clutton-Brock et al. [31] who observed that feeding systems demanding close proximity resulted in more agonistic interactions or avoidance of the feeding situation all together in highland ponies. Also Tyler [32 (cited by 15)] recorded more frequent encounters when horses were feeding close together. Further, this is in accordance to McGreevy [33] and Zeitler-Feicht [8] who stated that horses preferably maintain a personal distance of 1 - 1.5 m while feeding. Hence, if external conditions (e.g. space allocation) demand that groups are being fed in close proximity, horses should be provided with individually separated feeding places which are limiting or preventing physical contact. Accordingly, “feed stands” facilitated the lowest levels of agonistic behaviour during the feeding period in the present study. This is in agreement with Houpt & Wolski [34] who found that dominant ponies were less aggressive when separated by a fence during feeding. On the other hand, solid partitions might increase the level of aggression initiated by superior individuals and lower-ranking individuals may feel unsafe and thus may hesitate to feed when they have no information about their surroundings [17,35]. Therefore, Zeitler-Feicht [36] recommended that partitions in feed stands should be solid in the lower part and have viewing slits in the upper part in order to allow the horses to oversee the other individuals. The present study only distinguished between “feed stand without contact at front” and “feed stand without contact at front” but could not reveal noticeable differences in the proportions of horses showing agonistic behaviour. The feeding system scoring the lowest level of aggressive behaviour, and also a rather low level of threatening behaviour, was “net”. Likewise, Benhajali et al. [13] found that provision of forage opportunity in form of hay nets reduced agonistic interactions in Arab breeding mares. In this regard, it must be considered that “net” is a feeding system which is automatically associated with a prolongation of the duration of hay availability. Feeding with narrow-mesh nets, compared to loose hay on the floor, was found to prolong the intake duration of 1kg hay significantly from 40 minutes to 86 minutes [37]. Since horses are adapted to a continuous feed intake and feeling of satiety is achieved by a fatigue of the masticatory muscles [8,9], our findings were in line with the expectation that a prolonged hay availability reduces agonistic behaviour. Remarkable is the fact that the duration of straw availability had no influence on threatening or aggressive behaviour.

Conclusion

In conclusion, “feed stands” promoted the lowest levels of agonistic behaviour, followed by “net”. Meanwhile, “net” was the feeding system with the lowest probability of aggressive behaviour, hence bearing the least risk of injuries by other horses. This stands in connection with a positive effect of an extended duration of daily availability of hay, which is automatically induced by feeding with narrow-mesh nets. Consequently, it is highly recommended to provide horses nearly ad libitum not only with straw but also with hay. Furthermore, the occurrence of agonistic behaviour was also reduced by the distribution or partitioning of feeding places. Therefore, feeding systems in which feeding places are either distant from each other or individually separated by partitions are recommendable in order to allow horses to maintain their individual distances. These main aspects should definitely be taken into account when choosing a feeding management for group housed horses.

Acknowledgments

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References


Organisms

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Pattern of social interactions after group integration: a possibility to keep stallions in group

Abstract

Horses are often kept in individual stables, rather than in outdoor groups, despite such housing system fulfilling many of their welfare needs, such as the access to social partners. Keeping domestic stallions in outdoor groups would mimic bachelor bands that are found in the wild. Unfortunately, the high level of aggression that unfamiliar stallions display when they first encounter each other discourages owners from keeping them in groups. However, this level of aggression is likely to be particularly important only during group integration, when the dominance hierarchy is being established, whereas relatively low aggression rates have been observed among stable feral bachelor bands. We investigated the possibility of housing breeding stallions owned by the Swiss National Stud in groups on a large pasture (5 stallions in 2009 and 8 stallions in 2010). We studied the pattern of agonistic, ritual and affiliative interactions after group integration (17-23 days), and if the experience of group housing of the horses influenced the frequency of interactions. We found that the frequency of agonistic and ritual interactions decreased quickly within the first three to four days. The frequency of affiliative interactions increased slowly with time before decreasing after 9-14 days. Males had also less agonistic, ritual and affiliative interactions if they had already been housed in a group the previous year. Therefore, we found that breeding stallions could be housed together on a large pasture, because the frequency of agonistic interactions decreased quickly and remained at a minimal level from the fourth day following group integration. This housing system could potentially increase horse welfare and reduce labour associated with horse management.

Keywords : dominance hierarchy, group integration, housing system, social interactions, stallions

I. Introduction

Despite being social animals, domestic horses (Equus caballus) are very often kept in individual housing systems. This is especially true for stallions used for breeding are also traditionally housed individually, because the high level of aggression that unfamiliar males display towards one another when they first encounter each other discourages owners to keep them in groups [1–3]. However, individual housing systems can have several disadvantages for horse welfare, and particularly for their mental health, when they are not designed properly (e.g. inducing confinement and preventing social contact [4–6]). Horses housed in individual stables are partially or even totally deprived of physical contact and of activities that are seen under natural conditions, such as locomotion and social behaviours [1,7–9]. Consequently, they display more stress-related behaviours than horses stabled in pairs [10]. They are also likely to develop stereotypies like weaving and cribbing [4–6]. Furthermore, a lack of social contact, especially during ontogeny, may predispose horses to impairments in social skills and to an inability to cope with social challenges [2,11,12].

Feral stallions (Equus ferus) are harem breeders that defend a group of females instead of a particular territory [14]. When they do not have a harem, most stallions form associations known as bachelor bands. These bands contain two to 15 individuals, and are relatively stable over time, although less stable than harem bands. They are composed of yearling or young stallions that have not yet acquired a harem, and are in an intermediate state of development between sexual and
social maturity. Bachelor bands can also include older stallions that have lost their harem [15–17]. Agonistic and ritualized behaviours like fights, threats, avoidance and submissive behaviours occur among bachelor bands [18,19]. These aggressive interactions could play an important role in improving skills and physical stamina necessary for stallions to acquire and maintain a harem [16,19]. However, as in many other species, when they interact, stallions typically display the minimum amount of aggression required by the situation [3].

Housing stallions in outdoor groups is likely to have two main benefits, if enough space is available. First, it could increase horse welfare by allowing them to fully express their natural behaviours including social interactions and locomotion [1,2,13]. Second, it could potentially reduce labour required for housing cleaning and exercising horses (H. Besier and I. Bachmann, unpublished data). According to recent reviews on group housing [1,3], the main reason that prevents owners to keep horses in groups is the potential risk of physical aggression.

In this study, we investigated the possibility of housing breeding stallions owned by the Swiss National Stud in groups on a large pasture. For this purpose, we observed the changes in social interactions over a period of 17-23 days after group integration. We differentiated ritual and affiliative interactions, which do not involve physical aggression, and agonistic interactions, which can potentially involve physical aggression [3,19]. A rapid decrease in the frequency of agonistic interactions with time would indicate that stallions can be housed in group, because the risk of physical aggression is low after these interactions reach their minimum rate. We also investigated if the experience of group housing of stallions affected the frequencies of agonistic, ritual and affiliative interactions during group integration.

II. Materials and methods

A. Subjects and management conditions

The study was carried out at the Swiss National Stud Farm, Avenches, on two groups of Swiss breed stallions (Franches-Montagnes): one group of 5 individuals in 2009 and one group of 8 individuals in 2010. Four individuals were included in both 2009 and 2010 groups (n = 9 stallions in total). These stallions were 8-19 years old and had been kept at the Swiss National Stud for 5-16 years. They were used for breeding and for driving. They had all but one, been regularly hitched next to each other for driving. Before the study, they had been housed on several occasions in adjacent stables, but they had never been in a group. Therefore, all the stallions used in this study were familiar with each other, but had no experience of group housing.

Because prior exposure can reduce aggression between horses during physical encounters [22], the stallions were housed for 14 days next to each other in indoor individual stables (9 m²) separated by partitions with a rail at the top half, allowing them to interact. They could therefore hear, see, smell and partially touch each other. Stallions were then moved together to an outdoor pasture (4 hectares) for six months. Horseshoes were removed before group integration in order to minimize the risks of injuries. In pasture, hay was distributed during winter according to horses’ needs. Pasture fences and horse health was checked daily. Finally, the group was housed in a pasture away from mares and other horses. After the study, stallions were put back in their previous individual stables and used for breeding.

B. Group integration procedure

Following a preliminary experiment in 2008, in which four stallions were successfully integrated together, we repeated the same procedure. In July 2009 and 2010, the stallions were handled individually on a halter and brought to the pasture. The persons handling the stallions walked once around the pasture and then released all the stallions at the same time. Ten people holding driving whips were present and ready to intervene in case of serious fight.

C. Observations

Social interactions were scored daily either at 09:00 h - 11:00h, 13:00 h - 15:00 h and 17:00 h - 18:00 h, or at 07:00 h - 09:00 h, 11:00 h - 13:00 h and 15:00 h - 17:00 h from the first hour to the 557th hour (23 days) after group integration in 2009 and to the 413th hour (17 days) after group integration in 2010. Because the frequency of interactions was considerably higher during the first two days after integration, these data were analysed later from videos filmed by two experimenters. Data for the
The rest of the study were scored by direct observation by two experimenters. All data were collected from an observatory post, from which the whole pasture (i.e. all horses at all time) was visible. We scored the frequency of the following social interactions continuously using the behaviour sampling rule, i.e. by observing the whole group and scoring every interaction with details of which individuals were involved: agonistic interactions; ritual/investigative interactions and affiliative interactions. Agonistic interactions were defined as non-contact or contact interactions that resulted in increased distance between two stallions (e.g. chase, push and kick). Ritual/investigative interactions (thereafter "ritual interactions") were defined as non-contact interactions between two stallions used to assess each other's social status without fighting (i.e. faecal pile display, sniff and sniff and squeal). Affiliative interactions (i.e. non agonistic and non ritual) included allogrooming (or mutual grooming) and play. Interactions were analysed as frequencies per hour per horse.

D. Statistical analyses

We used generalized linear mixed model (GLMM) fit by the Laplace approximation (lmer function in R [24]) to investigate the effects of the time after group integration and the experience of group housing of the stallions on the frequency of social interactions. In the first model, we included the time after group integration (1-557 hours) as a fixed effect (model 1). To test for the effect of group housing, we carried out a second model (model 2), in which we added the experience of group housing (i.e. if they had been housed in group already the year before: coded as 1 for 2010 horses that were in group in 2009 and 0 for the others as a second fixed effect (with the time after group integration). For both model, we included the year of observation (2009 or 2010) and horse identity as random effects to control for year and individual differences. We fit fixed effects as linear, quadratic or log terms based on the lowest Akaike’s information criterion value. All models were fit with maximum likelihood estimation (ML). We used the likelihood-ratio tests (LRT) to compare models within a given set and to assess statistical significance of the factors, by comparing the model with and without the factor included. All categories of interactions were log-transformed and fit with a Gaussian family distribution and identity link function. Q-Q plots and scatterplots of the residuals of the dependent variables were inspected visually to ensure their normal distribution. We carried out statistical analyses using R v.2.9.0 [25]. All means are given with standard errors (SEs).

III. Results

Agonistic and ritual interactions decreased quickly with time (Fig. 1a and b; GLMM, log-transformed time: agonistic, X² = 589.95, p < 0.0001; ritual, X² = 695.96, p < 0.0001).

![Figure 1](image-url)

**Figure 1**: Changes with time in the frequency of social interactions after group integration. Frequency of interactions per hour (mean ± SE per day; agonistic (a), ritual (b) and affiliative (b) interactions) as a function of time (days) in 2009 (black square) and in 2010 (empty squares). The best fit (log or quadratic) is indicated with a solid line for 2009 and dashed line for 2010 data.
Their frequencies decreased during the first 3-4 first days after group integration and were maintained at their lowest values for the rest of the study both in 2009 (mean interactions per hour before day 4: agonistic, 8.92 ± 0.88; ritual, 7.84 ± 0.64; n = 160 frequencies; after day 4: agonistic, 1.22 ± 0.07; ritual, 1.17 ± 0.06; n = 385 frequencies) and in 2010 (mean interactions per hour before day 4: agonistic, 5.28 ± 0.77; ritual, 9.07 ± 0.74; n = 256 frequencies; after day 4: agonistic, 1.56 ± 0.15; ritual, 3.84 ± 0.18; n = 440 frequencies; Fig. 1a and b).

Affiliative interactions increased during the first days and decreased later on (Fig. 1c; GLMM, square root transformed time: \(X^2 = 41.21, p < 0.0001\)). Their frequency increased from day 0 to day 14 in 2009 and from day 0 to 9 in 2010 and decreased afterwards (mean ± SE: 2009, 0.30 ± 0.03; n = 545 frequencies; 2010, 0.30 ± 0.04; n = 969 frequencies; Fig. 1c).

The experience of group housing had a significantly effect on the frequencies of interactions (GLMM: agonistic, \(X^2 = 5.04, p = 0.025\); ritual, \(X^2 = 4.20, p = 0.04\); affiliative, \(X^2 = 5.54, p = 0.019\)). In 2010, horses with no experience of group housing had more agonistic interactions (model residuals controlled for the effect of time after integration: -0.025 ± 0.015), more ritual interactions (0.098 ± 0.016) and more affiliative interactions (0.012 ± 0.005; n = 4 horses and 1241 frequencies) than horses that were already in group in 2009 (agonistic interactions = -0.050 ± 0.014; ritual interactions = 0.003 ± 0.013; affiliative interactions = -0.015 ± 0.003; n = 4 horses and 1241 frequencies).

### IV. Discussion

**A. Pattern of social interactions after group integration**

We found that agonistic and ritual interactions decreased quickly within the first three to four days after integration. These changes were very similar between the two groups studied in 2009 and 2010. In contrast, affiliative interactions increased slowly with time and then decreased after 9-14 days.

Social interactions play an important role in the establishment and maintenance of hierarchies. Within a social group, a stable hierarchy functions to regulate aggression and thus reduce the number of serious fights [26]. When two males encounter each other, they perform a ritual that allows them to assess each other’s fighting abilities using information contained in visual, olfactory or acoustical signals, without having to fight [21]. These mutual assessments are effective alternatives to real aggression, but can escalate into serious fights over resources of any kind, when the degree of asymmetry in fighting abilities between the two individuals is low, or if there is an ambiguous hierarchy [3,20,26]. In contrast, the increase in the frequency of affiliative interactions at the beginning of the study indicated that social bonds were being established. In horses, typical affiliative behaviours are play, allogrooming and anti-parallel standing rest [9,23]. The main function of affiliative relationships is to reduce social tension between group members and therefore, to increase group cohesion [2,13]. We suggest that the following decrease in affiliative interaction observed after 9-14 days in our study could be due to the fact that the frequency of affiliative interactions required to establish social bonds is higher than the frequency required to maintain these bonds.

**B. Factors affecting social interactions**

Our results show that stallions had less agonistic, ritual and affiliative interactions if they had already been housed in group the previous year. These results could be linked to stallions’ experience of group living. Previously singly stabled stallions have been shown to display more aggressive interactions (e.g. bite threat), but also more affiliative interactions (allogrooming and play), than previously group housed ones [2]. Furthermore, horses might need to acquire social competences in order to behave appropriately in group [3,11,28]. The proportion of “inappropriate” threats directed towards more dominant individuals decreases with age [27], indicating an important role of experience on social skills [3]. Horses that have been living in group have more refined social skills and are less aggressive towards other horses and even towards humans during training [2,12,29,30]. Therefore, these results suggest that the stronger the social experience of horses that are integrated in a group is, the lower the frequency of agonistic interactions would be.
Conclusion

Housing horses in groups fulfils many of their welfare needs, including the access to social partners and the establishment of a social structure [1,9]. Such system could potentially increase horse welfare and reduce labour associated with horse management. In this study, we showed that stallions can be housed in groups under specific conditions, because agonistic interactions, which are potentially linked to physical aggression, decrease and are kept at a minimum rate after only three to four days following group integration.

References


Organisms

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Keeping horses in groups – is separating horses for riding or training purposes a problem?

Abstract

The aim of this study was to investigate how difficult it was to halter and separate a horse from a group for riding or training purposes and to describe how human-horse interactions could affect this common procedure. A total of 20 different horse groups from 14 different farms in Eastern Norway were included in the study. In each group, five horses were randomly chosen and exposed to two tests, giving data from a total of 100 horses. The handler was asked to enter the enclosure and approach and catch the horse, attach a rope to an already present halter, lead the horse by the rope towards and through the exit gate. Ninety-nine horses were caught at the first attempt and only one horse moved away from the handler but was caught on the second attempt. When the handler was approaching the target horse, the other horses moved away from the handler in 89 cases, while in 11 cases the other horses remained stationary or approached the handler in a non-threatening manner. In 96 cases, the target horse followed the handler towards the exit gate without delay. We conclude that separating a horse from its social group can be considered relatively safe and unproblematic, with good management practices and trained handlers.

I. Introduction

The focus on loose housing, exercise and social contact has increased in recent animal welfare regulations for many species of farm animals (e.g. Council Directive for calves: 91/629/EEC, pigs: 91/630/EEC, laying hens: 1999/74/EC). The motivation for social contact is strong in horses (1,2), and social isolation is thought to be one of the most serious stressors known for a horse (3). For horses however, the common practice of individual stabling in single boxes and single paddocks outside is still widespread (4, 5, 6) and apparently fully accepted by horse owners. Several myths around keeping horses in groups seem to exist. One of them is that it is more difficult to catch a horse when it is kept in a social group. Also, some horse owners claim that such horses become overly attached to their group mates and thus become nervous and difficult to handle and ride when alone. Following these arguments, another concern is that human safety may be at risk when entering an enclosure with several horses, due to lack of control of each individual horse. Interestingly, Hausberger and colleagues (7) emphasize in their review on human-horse relationships that there is a need for more descriptive knowledge on the potential problems or risks associated with catching and handling horses.

Surveys done on accidents with human injuries involving horses, both professional jockeys (8, 9, 10) and non-professional riders (11, 12) reveal that most accidents are caused by falling or being thrown off the horse. The human’s behaviour and attitude is of great importance when he or she enters a paddock to catch the horse. In a study on horses, Hausberger and Muller (13) found significant differences in the reaction towards an unknown human between 28 different groups of horses, each of which had one caretaker. The behaviour of each caretaker therefore influenced his or her horses to react positively or negatively to an unknown person. The presence of a human handler can also aid significantly in a habituation process (14), and the process of being separated from the social group is a fear eliciting situation that probably requires some form of habituation (15).
The aim of this study was to investigate how difficult it was to halter and separate a horse from a group for riding or training purposes and to describe how human-horse interactions could affect this common procedure.

II. Materials and methods

A. Herds

Thirty-four horse farms in the eastern part of Norway that kept riding horses in social groups with at least five horses in each group were contacted by phone and asked to participate in the study. From these, a total of 20 different horse groups from 14 different farms were included, based on the premise that all horses had to be regularly handled and taken out of the group for purposes other than feeding. Also, the horses had to have been kept in their group at least three weeks prior to our visit, and for at least six hours per day. In each group, five horses were randomly chosen and exposed to two tests, giving data from a total of 100 horses.

B. Handlers

The person referred to as the handler was the horse’s owner, keeper or another caretaker that the horse was very familiar with. A total of 43 different handlers participated in the study, thus in some groups one person handled more than one horse. In 98 of the trials the handler was female and only two male handlers participated in the study. Fifty-one trials were performed by handlers aged over 30 years, 29 trials with handlers aged 20 to 30 and in 20 trials the handlers were between 10 and 20 years old.

C. Horses and enclosures

Mean group size was 8 horses (min 5, max 24 individuals per group), representing mares, geldings and stallions, and 35 different breeds from ponies to Thoroughbreds. The horses ranged in age from 1 to 26 years and the four stallions that participated were 1-4 years old (kept together in one group). In order to test for the effect of horse age on behaviour during the horse alone test each individual horse was later allotted to one of three age categories, chosen according to the amount of human contact that the horse had experienced. Since most hobby horse are not ridden before the age of 3 years, category 1; age 1-4 describe a category of young horses, category 2; age 5-10 a category of adult horses in training or use and horses older than 10 years might be termed experienced with a high degree of human contact and social separation. The main use of the horses varied from riding school ponies exercised most days per week to retired hobby horses exercised less than one day a month, with the “average horse” being exercised four to six days a week.

The mean enclosure space was 928 m²/horse with a range from 300 to 2333 m²/horse. The vegetation in the enclosures varied from several types of forest, bushes and scrub to grass land. On several of the farms, the horses were kept individually during the night.

D. Test 1. Catching the horse and leading it out of the enclosure

In order to assess the ease of catching and to describe possible risk factors when going into a horse group, the handler was asked to enter the enclosure and approach the target horse as normal (phase A). Subsequently, the handler should try to halter the horse, or attach the rope to an already present halter (phase B), and then lead the horse by the rope towards the exit gate of the enclosure (phase C). At the gate the handler should open the gate, lead the horse through and then close the gate (phase D).

E. Test 2. Horse alone test

Immediately following the test described above, the horse handler was asked to continue leading the horse until they reached an area out of sight of the other horses (e.g. behind the stable) and then keep the horse stationary for two minutes.
F. Behavioural observations

In test 1, the handler and the target horse were video-recorded continuously using a handheld digital camera (Panasonic NV-GS230 3CCD mini DV, 10 x opt. zoom) from the moment the handler entered the enclosure until the horse and handler had passed the gate and the handler had closed the gate behind them. From the video recordings, the behaviour of the target horse, its handler and the other horses in the group in each of the four phases (A – D) were scored into predefined categories.

The horse alone test (test 2) was also video recorded using the same video camera as described above, starting when the horse was asked to stand in the desired position, out of sight from the other horses. Position of head and tail, locomotion and physical contact between the handler and the horse was scored with the instantaneous sampling method every 10 seconds for the entire two minute period.

Before the observations took place both the handler/horse owner and the stable owners were asked to rate the group housing of their horses as either ‘unproblematic’, ‘ok’ ‘problematic’ or ‘not functioning’. If the person rated the group housing as ‘problematic’ or ‘not functioning’ he or she was asked to give an explanation on why it was so in their opinion.

G. Statistical analysis

In order to test the effect of horse age on behaviour during the horse alone test, we analysed the data using a Glimmix model of analysis of variance with horse age (1-4 years, 5-10 years, >10 years old) as a class variable. Group (1-20) was specified as a random effect. Differences between means were found using a LS-means test.

III. Results

A. Test 1. Catching and leading the horse out of the group

Ninety-nine horses were caught at the first attempt (category 1), and only one horse moved away from the handler but was caught on the second attempt (category 2). When the handler was approaching the target horse, the other horses moved away from the handler in 89 cases (category 1), while in 11 cases the other horses stayed stationary or approached the handler in a non-threatening manner (category 2). We did not observe any cases where other horses approached the handler in a threatening manner (category 3).

Phase B considered the horses’ head position when haltered, but 34 of the target horses were already wearing a halter (category 3). Of the remaining 66 horses, 62 horses kept their head in a normal position (category 1) and only four horses raised their head during haltering (category 2).

In 96 cases the target horse followed the handler towards the exit gate without delay (category 1). When being led out of the group, only three horses resisted leading by stopping or running out (category 2), while one horse ran away from the handler (pulling the lead rope from the handler’s hand) 5 times before being successfully led out of the group (category 3). Fifty-four handlers led their horse on a loose rope (category 1) and 46 led their horse on a tight rope (category 2). Seventy-nine handlers walked in front of the horse (category 1), eighteen walked by the horse’s head (category 2) and three by the horse’s shoulder (category 3) (Figure 1). The three horses in category 3 were all led by handlers aged > 30 years. Young horses (aged 1-4 years old) were all led with the handler positioned by the horse’s head.

In 75 cases the other horses did not interact with the target horse and/or handler (category 1), while in 22 cases the other horses did not move away, or approached/followed the handler in a non-threatening manner (category 2) (Figure 2). In three cases the other horses threatened the horse being led (category 3).

In the gate phase (D1), 72 handlers turned the horse around before closing the gate (category 1) while 26 did not turn the horse around and were thereby exposed to the target horses’ hindquarters in close proximity to their heads (category 2). In the remaining two cases, another horse escaped through the gate before the target horse (category 3).
B. Test 2. Horse alone test

The majority of the time in an area without visual contact with other horses was spent with head and tail in a normal position, while 7.4% of observations were scored as having head raised but tail normal. Only 0.1% of observations were scored with both head and tail elevated during the 2 minute horse alone test.

Most horses stayed stationary or took a few steps, whereas 4.9% of observations were scored as “horse moves around”. Just 0.2% of total observations were registered as “the horse tries to break free from the handler” and this corresponded with two individual horses on two different occasions.

No physical contact between horse and handler was the most common category scored. The handler initiated contact with the horse in 15.4% of total observations, while incidents where the horse bumps into the handler were rarely seen. From the video recordings we observed that one horse defecated, four horses vocalized, five horses pawed once and one horse pawed twice during the two minutes horse alone test.

Younger horses (aged 1-4 years old) showed more alertness during the horse alone test by keeping their head raised and their tail in normal position compared to horses aged 5-10 years and horses >10 years old (F=5.5, P<0.01). In addition, horses from the youngest age category spent more time moving around during the horse alone test compared to 5-10 year olds and horses older than 10 years (F=5.3, P<0.01). There were no significant group effects for head and tail position or moving.

C. Results from questionnaire

Seventy-seven percent of the handlers/horse owners rated the group housing as ‘unproblematic’ and the remaining 23% rated it as ‘ok’. In comparison; 65% of the stable owners rated the group housing ‘unproblematic’ and 35% rated it as ‘ok’. No scores was made in the ‘problematic’ or ‘not functioning’ categories, therefore we did not get any opinions on why or when such group housing is unfavourable.

IV. Discussion

Overall, the procedure of catching and separating a riding horse from its social group was unproblematic for the handler. This is interesting since a considerable amount of people (mostly young females) are involved in horse related accidents every year (16) and about 20 percent of the trials in the present experiment were performed by relatively young, female handlers.

Looking at the target horse’s behaviour, there was little variation in behaviour scores and very few incidents of difficulty; only one target horse could not be haltered at the first attempt, four horses raised their head away from the normal position when being haltered and four horses resisted leading by stopping or running away from the handler. In 46% of all cases the target horse was led on a tight rope but this could just as easily be an effect of the rope not being long enough or the position of the handlers hand in relation to the halter, rather than a direct effect of the target horse being reluctant to leave the group. The figures from the present experiment are much better from a
handling and safety point of view than reported in a corresponding haltering and leading test of dairy cows in a tie stall (17). This is not surprising since dairy cows are probably less habituated to being haltered and led by a human than riding horses in daily use.

We found that in only three cases the other horses in the group approached the target horse in a threatening manner and on two occasions another horse escaped through the gate, which could be explained by the handler not paying enough attention and ‘hushing’ the other horses away in time. Despite these several possibilities for failure, all target horses in our experiment were successfully separated from the groups without physical ‘horse to horse contact’. The behaviour of the other horses in the group towards the handler and target horse is perhaps one of the most important parameters to consider regarding human safety in the handling situation.

In the present experiment 26 handlers closed the gate with the horse’s hindquarters close to the handler’s body. This could be a potentially dangerous position for the handler to be in, especially when other horses are present at the gate. Other factors influencing how easy the horse is led through the gate are size, shape and design of such gates. Some form of sluice arrangement (a small holding pen on the other side of the gate), might be a good idea together with gates that are easy to open and close with just one hand.

In general, horses were calm or took only a few steps during the horse alone test. Most handlers had no physical contact with their target horse, while some initiated contact with the horse themselves, often by stroking the horse’s head and neck. In less than 0.5 % of total observations the target horse bumped into the handler causing the handler to have to move or protect him/herself. We found that younger horses (age 1-4 years) showed behaviours indicating a higher level of alertness and spent more time moving around compared to older horses (> 5 years old), but this is not surprising since older horses often are more experienced in being handled and separated from their group mates (18, 19). Hence, there is no evidence for the common belief that group housed horses get overly attached to their group mates and therefore become difficult to handle or separate from the group.

Conclusions and animal welfare implications

Group housing results in many positive effects on behaviour, health and welfare of the domestic horse. Nevertheless, many horse owners prefer to keep their horses in individual housing systems despite the ever growing consensus that farm animals should have access to social contact and free exercise. The common myth that group housed horses become difficult or dangerous to separate from the group for riding or training purposes cannot be supported. In fact, our results suggest that separating a horse from its social group can be considered relatively safe and unproblematic, with good management practices and trained handlers.

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Safety settings in equestrian facilities

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Abstract
In recent years an increased attention has been paid to the risks that can emerge within the equestrian environment. In fact, the activities that are carried out every day, whether of working or sport nature, can cause serious traumatic events. The main problems are related to the following risks: biological and physical contact, followed by chemical, electrical, mechanical risks that are common to also a lot of other situations. All these specific risks, of which we talk about in this work, can be contained through proper training and information of workers. The likelihood of accidents can be reduced also applying appropriate behavioural requirements and certain quality and construction parameters used in structures. Inside the equestrian facilities all the main safety systems should be well indicated, also through appropriate signs.

Keywords: horse, risks, prevention

Introduction
Analysis and definition of risks involves great difficulties due to the presence of horses both in permanent structures, that in an unknown environments such as a sport or show events. Safety rules should always be known to all the operators and put into effect in every phase of any activity that has an interaction between man and horse or horses’ dedicated structures and should be respected, in every least detail, during the carrying out of any procedure. Beyond this, it is very important to check out the construction characteristics of the entire stable, laying on eye on dimensions of stalls, doors, passages and every place where a horse will transit along with a person on his side. All kinds of plants, installations and machineries, such as treadmills, drying lamps and so on, must strictly respond to the rules and be maintained in perfect conditions of use and each worker must know how to use them correctly.

Methods
The risk from physical contact with the horse
Among those who work around a horse, many, but not all, know that all his behaviours are intrinsically and instinctively aimed at the search for pleasure or to avoid pain and suffering, which can also be identified in the intolerance with respect to a person or a situation. However operators do not always consider the effect that the instinct has on the perception of these sensations: sometimes the stress caused by the frustration of instincts can be worse than the pain itself for a horse.

The stress state is of such importance in the horse that its presence is detected also by the increase in blood levels of cortisol and catecholamines. Consequently, an important equestrian safety parameter consists in understanding the instincts of the horse and acting so to create less emotional conflicts possible. Forcing the horse to do something against his will, is equivalent to significantly increase his level of emotional stress and to make him react in an unpredictable and dangerous manner.

This premise wants to indicate of the most frequent and harmful physical agent investigated: the aggressive action of the horse, which is manifested by kicking, biting and crushing with his limbs or body.
Evaluating the percentage of trauma occurring in equestrian activities, it has been shown that these activities are having one of the highest risk percentage of traumatic events among all sports, including motorcycling and motoring. The most frequent causes of injuries are falls from the horse, the crushing from the horse, bites and kicks. The majority of serious and fatal injuries consists of head injuries that could have been less severe if the rider had worn properly a specific helmet. Even the use of shoes or boots with reinforced tips could prevent a good part of traumatic events or otherwise reduce their severity. The obvious conclusion from what above is that the equestrian injuries are a serious health problem (still undervalued), which deserves a focused commitment to prevention, in each category of workers affected, by stressing the importance, for preventive purposes, of training the personnel in order to raise awareness of the correct perception of the risk, the use of personal protective equipment and the use of appropriate procedures.

The biological risk

There is talk of biological risk to human health in relation to exposure to organisms and pathogenic microorganisms or not, animals and human endoparasites, which may be present in the workplace. The biological agent is any organism, even genetically modified, ecto- and endoparasites, of animal or human origin, being capable of causing infection, allergy or poisoning. According to the Legislative Decree 81/2008, biological agents are classified into specific classes according to the degree of danger. This type of risk assumes a high importance in our context, thus diversifying this type of activity from those that, even if in the presence of animals, do not provide for such a close and ongoing relationship with them and claiming, in this case, greater attention measures to be put in place. The biological risk consists, on the one hand, in the danger that a disease of the horse can be transmitted to humans, generating in them a pathology similar for the etiological agent and often also for symptoms: in this case we speak about zoonoses. Zoonoses can spread from animal to animal and from animals to humans and, usually, are not transmitted from man to man. Therefore a man gets sick only by contact with animal fluids or breath. The assessment of this type of risk must be done in collaboration with the company physician, which must have a deep knowledge of diseases communicable to humans that can affect the horses with whom operators work and the related clinical manifestations in man himself. There must be a well-established and constant synergy between the Physician, the Responsible for the Service of Prevention and Protection and the Veterinarian who knows the health status of the stable in order to monitor the situation and immediately implement measures of organizational, technical and procedural to prevent transmission. In this contest, a great relevance is given by the use of personal protective equipment, such as masks and goggles and work gloves. Preventive and periodic visits must be carried out for the operators in the sector, which determines that do not exist conditions of particular sensitivity to infections, and to which a program of vaccine prophylaxis will follow along with the constant monitoring of the effectiveness of protection measures applied.

Another risk factor of great importance is the dust in stables, made up of particles that are derived from fodder, from litter trays, hair of horses and drying of manure. Workers subject to risk are those who have prolonged contact with animals and that manipulate bedding and feed. The danger of dust is due to the ability to carry pathogens, as well as animal and plant particles with allergenic effect, at the level of the respiratory system (e.g. fungal spores). It is mainly the spores of fungi (mushrooms) and thermophilic actinomycetes, which originate from the hay and straw poorly preserved, the main cause of the onset of lung diseases such as e.g. bronchial asthma, chronic bronchitis and a common disease known as farmer's lung. In addition, the horse dander, dust mites, hair, saliva, droppings and debris from plant foods can cause allergic respiratory diseases, lung disease or pneumonia awareness, as well as chronic bronchitis. The same applies to environmental allergens such as pollens, richly present in the rural environment where this type of work is done.

To avoid as much as possible the exposure to various environmental pollutants, it is necessary to regularly use masks, in particular during the cleaning operations; it should be noted that the higher concentration of the different pollutants is revealed precisely in conjunction with these operations.
Outside housing

All animals must be kept in proper housing conditions which must follow the rules described below:
- minimal surfaces are defined by the height at the withers;
- the stall must be designed so that horses can lie down, rest and rise appropriately and
beddings must be dry, abundant, free from dust and always kept clean;
- floors should not be slippery or dry;
- there must be provided in the paddock a rest area clean, dry, soft, which allows the horses
to remain lying down for long times;
- in the stables where the horses are kept in groups, the lower-ranking animals must be able
to avoid those of higher rank;
- horses kept permanently outdoors should have a place to find a protected shelter from
strong winds, heavy rainfall and, taking advantage of the shadow, as a protection against
flies,
- external soils must not be slippery and the mud must not exceed the crown of the foot,
- shelters must be easily accessible and spacious so that animals can lie down and get up
normally, must be constructed in such a way that there is no risk of injury.

Working on walkers and treadmills

While bringing the horses to work within a walker or on a treadmill, the following procedures must
be observed with attention.
The walker must always be completely stopped before opening the door to let the horse in. Once
inside, you will reassure the horse and take off the halter. After closing the door, you can restart the
walker, first at a moderate speed and then adjusted to the desired speed. At this point, it’a a good
habit to follow the trend for some moment, keeping an eye on the attitude of the horse just
introduced and on the other horses already present, and only after verifying that their attitude is
quiet, it’s possible to leave them alone, without ever leaving the situation totally uncontrolled.
More attention should be paid when placing horses on a treadmill, especially if the horse is not
used to this type of equipment and movement. In fact, the walker is “down to earth” while the
treadmill is on a structure slightly raised off the ground, which can also be adjusted with a variable
inclination and the horse is moving alone, not in company of other horses that may calm him. It is
therefore suggested to perform this operation with the presence of two operators, at least until the
horse has acquired a familiarity with the equipment and the situation. With the treadmill turned off,
you drive up the horse and then block the back side with the appropriate bar that is placed
behind the horse’s croup and the front side with a bar at chest level. Usually two lungs or chains
with a safety release system for cases of emergency are used to tie the horse by the halter. Once
set the treadmill in motion and settled the speed and time of training, the horse can be left to walk
by himself, without being distracted or disturbed by external elements. The safety system of
treadmills provides that if the horse bumps abruptly against the rear or front bar, the whole system
stops and the front bar is unlocked. If the horse is not in difficulty he will remain stationary, tied
on the platform, but in case of panic, the tie will break allowing him to get off the treadmill. Despite this
safety system, the horse should never be left completely unattended during this workout and the
treadmill should be located in a secluded and segregated place so that the horse cannot run
away scared.

Grooming Operations

The term “grooming” regards all the operations of cleaning and tidying of a horse performed in
everyday life with which you shall keep clean the horse according to good standards of hygiene.
Wild horses are able to take care of themselves, of their skin and their mantle, but if domesticated
and in captivity, they lose this instinct and man has to provide for them. It is important that at least
once a day, in housed horses, all the cleaning operations are executed taking care of every single
anatomic part, regardless of the use of the equine.
Thanks to the grooming operations is also possible to monitor the general conditions and preserve
the horse from many diseases, both internal and external, because it turns out to be a thorough
inspection of the body of the animal with the result of constant monitoring.
This kind of activity that places man in a very close contact with horses is definitely, of all the
operations, the most risky, but cannot be avoided; nevertheless if approached with caution,
attention, in proper operating conditions and supported by proper training, the residual risk can be reduced to an acceptable level. The risks that operators may encounter during grooming are indeed many, from simple stepping on a foot, to small bites, up to the crushing of body and feet. The intensity of the risk varies depending on the difficulty and the character of the horses with whom you have to deal: we must therefore pay close attention to every little gesture and the way in which it is accomplished. Keep in mind that a calm and reassuring voice predisposes the horse to a positive attitude towards the person who takes care of him: always takes advantage of this tool. The grooming operations should always take place in “safe” areas, such as dedicated spaces inside the stables and never inside the stall.

It can happen that the horse identifies the stall as his home and may trigger in him an attitude of ownership and protection towards all those who access it. This aspect produces nervousness and does not allow man to be able to have confidence. Also, inside the stall, the necessary supports for tools are lacking and it is difficult to perform a correct and deep cleansing of the body (especially in the lower limbs) due to the presence of litter and dust, but especially this situation does not allow a convenient and ready escape.

The service areas should contain all the equipment needed to carry out these operations and the position of the working tools should be conceived to favour the ergonomics of the working phases and operator. These places must be kept clean and tidy and we recommend the reorganization after the passage of each horse. They should also be equipped with good lighting and escape routes.

You should pay particular attention to bring the tools near the body of the horse with kindness, in such a way that he will not be afraid, just as it would be good, before working in the lower parts of the body, that the horse perceives the presence of man and his intention.

The operator’s concentration must remain always high and abrupt movements are not allowed. Inside the service areas the horse should be tied “to the two winds”, to avoid that he can turn abruptly and be kept as still as possible. It is also true, however, that certain horses, especially young ones, are very nervous when they feel immobilized and bounded, and so they start to pull on the lunge, with the risk of tipping, slipping, of injury in various ways and injuring the operator. With these subjects a balance must be seeken between the operator’s safety and the horse’s tranquillity, gradually getting them used to being tied, leaving them attached just to one side of the halter, in a confined place, with a loose lead rope and if necessary with the assistance of a second person.

With patience and attention, even these difficult subjects can be made more tolerant to the situation.

After working, the horse must be taken back in his stall, he must proceed slowly and behind the man who, once inside, will have to move over to let the horse enter completely and then prepare to exit, releasing first the halter and closing the door behind him. It is important that during this final operation man and horse never give each other the shoulders, and that, while the operator exits the stall, also the horse stands with his head turned towards the entrance.

Conclusions

Analyzing the procedures aims to encode and teach management habits for every worker, in order to protect their life and safety during the contact with horses and at the same time to assure to the stable good operating conditions and productivity that will make it competitive towards other stables in which the fundamental safety concepts are lacking. A working activity based on safety of structures, plants and procedures and on the application of rules of prevention surely brings to the appeasement of operators involved, which will be able to operate in greater serenity conditions.

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Measurement of kick loads from horses on stable fittings and building elements

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Abstract

Fittings and fixtures in horse stables may cause injuries to horses when trapped and there is a great risk of an accident to animal and handler when releasing a horse. The risk of injuries to horses and handlers must be minimised by correct structural design and appropriate choice of building material. The physical load of horse kicks were measured in order to obtain data for the design of safe horse fittings and fixtures.

To record the forces exerted by horse kicks a measuring wall and a computerised measuring system were constructed and used in single horse boxes. For reference, the characteristics of the measuring system were determined by a drop hammer test. Through regression analysis a linear relation was found between the field recorded impact values from horse kicks obtained by the measuring system and drop hammer impact values. The drop hammer method can thus be used to test fittings.

Impacts recorded in the field tests were rapid, often shorter than 0.03 s and 90% had a maximum value below 1924 N. The greatest impact force and impulse caused by a horse kick were 8722 N and 131 Ns respectively, with no statistical difference between provoked and unprovoked kicks. Considering the data obtained and allowing a certain safety margin, the impact resistance of horse fixtures and fittings in single horse boxes, to be used for horses of up to 700 kg mass, should be at least equivalent to 150 Ns exerted by a horse shoe at 45°.

Keywords: horse kick, physical load, fitting, fixture, equine safety

Introduction

Fittings and fixtures in horse stables, e.g. dividing grids and box wall boards or planks, may cause injuries, for instance when horses kick under-dimensional structures and the hoof becomes trapped. In addition, there is a risk of injury to humans releasing the trapped horse. To date, according to the author's knowledge, the structural design and appropriate choice of building materials and form have been based on past experience. To prevent injuries caused by inadequate design and strength of stable fittings and fixtures, more knowledge is needed about the physical loads (force, impulse, energy) acting when horses kick items in their physical environment. Problems with insufficient strength of tubular steel grids have also focused attention on other parts of the horse box, such as windows, walls, fittings, doors, etc.

Swedish animal welfare legislation and regulations [1] require box and stall walls to have sufficient strength to withstand horse kicks and the design should exclude the possibility of horses becoming trapped by head, jaw or hoof. There are design criteria for horse stables but they do not provide mandatory material dimensions or minimal resistance to impact forces. Manufacturers are interested in guidelines and test procedures based on objective information, in order to manufacture safe equipment for horses while still meeting the demand for economical use of materials. At present horse owners/keepers, welfare inspection personnel and equipment manufacturers have difficulties in following the intentions of the welfare legislation because of a lack of objective knowledge about safe stable design. The design guidelines have to allow manufacturers and building contractors within the horse sector to fulfil the demands of the authorities.
There are none official statistics on horse injuries, according to the authors’ knowledge, diagnosed as caused by horse kicks against stable fittings and fixtures. However, in a web-based inquiry short 2% of Swedish horses get injured related to fittings within 10 years, of which the half related to box grids, sometimes with serious leg (e.g. pastern) wound as a consequence of the hoof getting trapped in the grid [2]. Other cases of hoof trapped involve skull fractures when horses tumble over and bang its head on hard floor. A scenario when a hoof gets trapped in a vertical tube grid is that the horse kick hits between the tubes and the tubes are not strong enough comparing to the energy impact and/or have inappropriate distance comparing to hoof dimensions so that the tubes yield letting the hoof pass and then bending back.

The severity of the horse kick depends on the force; a peak force from horse kicks of 19 kN has been reported from Germany [3]. However, available published information on forces experienced by the hoof and limbs comes from experimental measurements of the ground reaction force during normal locomotion or jumping. Dahlin et al. [4] showed that the maximum vertical force component acting on the forehoof of a trotter at a speed of 6.5 m s\(^{-1}\) was about 8000 N. Using a force plate, Schambardt et al. [5] recorded the ground reaction force (GRF) patterns at take-off and landing between the hooves and the of 5 Dutch Warmbloods \((640 \pm 24 \text{ kg})\) jumping a 0.8 m vertical fence from the right-leading canter. The GRF parameters were compared to averaged GRF-time patterns of 20 Dutch Warmbloods at the right-leading canter. In the trailing left forelimb, the most powerful vertical GRFs, were found, both in take-off and in landing, to average 8320 N. Comparable results from 3 examples of left forelimb GRF for jumping horses were approx. 16 N per kg body mass, equivalent to 10240 N. In a study by Kangro [6] a constructed measuring wall was used to characterize the loads from finishing pigs (90 kg). A calculated course of impacts that covered 95% of all recorded impacts had a maximum impact of 550 N corresponding to 0.6 of the animal’s weight (impact weight quotient = 0.6) with a duration to maximum impact of 0.17 s and total duration of 0.42 s. The biggest load registered had duration of 0.2 s and was 2144 N, which corresponds to 2.4 times the weight of the animal.

To be able to determine the energy impact of a horse kick, the kicking velocity of the horse limb is of interest. If the movement of the horse leg kicking can be regarded as a total or a part of an ordinary swing phase at walk, trot or jumping, with a horse hind limb length of 1.35m (wither height 1.65 m) and a target height of 0.65 m above the ground level, the kicking distance could be estimated to be 1.35 m. Swing phases at walk, trot, canter and jumping are 0.44, 0.40, 0.22 and 0.20 s, respectively, according to [7], [8] and [5]. With a constant distance, the speed can be calculated at the different swing phases, which leaves a probable speed range of 3.1-13 m s\(^{-1}\) if the movement of a kicking horse hind limb can be considered to be a total or a part of the swing phase.

In 2007 a pilot investigation of material strength was conducted at Swedish University of Agricultural Sciences (SLU), former Department of Rural Buildings and Animal Husbandry, Alnarp, Sweden, using a drop hammer. The effect of impact kinetic energy on tubular steel grids was studied under specific conditions. The results showed that an artificial hoof (drop hammer mass 16 kg, drop height 2m) with a calculated kinetic energy of 324 J at impact was able to penetrate a prefabricated standard vertical tubular steel grid for horses. The grid dimensions were: tube length 730 mm with fixed ends, tube diameter 20 mm, tube wall thickness 2 mm with spacing between tubes of nominal 68 mm. The drop hammer method has recently been applied when testing and characterising different types of wood and wood-plastic composites [9].

**Aims and objectives**

The overall aim of the present study was to provide data support for guidelines on designing suitable horse box fixtures and fittings and thus significantly reduce the risk of injury to horses. The first objective was to characterise the loads exerted on the physical environment of unprovoked and provoked horses through kicks, by using a measuring wall equipped with load cells and a computerised measuring system. The measurement was to be obtained with no constraints on the horse. The second objective was to propose methods for evaluating and testing different materials and structures in order to allow new constructions of stable structures and fittings to be designed and existing systems to be improved.
Materials and methods

A. Measuring Wall and Drop Hammer

The measuring system was based on a measuring wall with four load sensors placed in each corner of a measuring sheet of 22 mm plywood. The sensors were connected in parallel, with a maximum load carrying capacity of nominal 20 kN per sensor, measuring compressive and tensile forces. The four load sensors were connected to an amplifier and a computer-based measuring programme. The measuring wall construction was tested to determine whether the same values could be registered over the whole plywood sheet area. A static calibration test was made by laying the measuring wall horizontally, and placing a mass (32 kg) distributed over the plywood surface; as well as a dynamic impact calibration under a drop hammer and dropping masses (6.5, 16.5, 26.5 and 36.5 kg) from a height of 0.5, 1.0, 1.5 and 2.0 m. Ten measurements were made for each mass and height combination of the drop hammer, with the samples distributed over the plywood surface of the measuring wall.

The drop hammer used consisted of a frame, a drop shaft and a test ram, which ram could be lifted to a maximum of 2.3 m and released by a handle. The end of the ram was fitted with a horse shoe (size 2) placed at an angle of 45° so that the shoe tip hit the target. Describing of the measuring system, the calibration and the drop hammer, respectively, is done more detailed by [10].

B. Experimental Design

Field measurements were carried out at 3 different stables measuring kicks from in total 16 horses with body mass 500 – 660 kg. The measuring wall was placed on partition walls in horse boxes with known kicking Swedish Warmblood or Standardbred trotters; and allowed long-term, continuous measuring periods to be sampled, since the frequency of horse kicks can be low. To only measure forceful horse kicks, a triggering function was used as a sorting mechanism, thus avoiding registration of small kicks or movements less than 100 N, e.g. from a horse leaning on it. In addition to spontaneous kicks, all horses were provoked to kick. The provocations included method of feeding, the order in which the horses were taken out for exercise and by placing an unfamiliar horse and/or a horse of different sex in the neighbouring horse box.

C. Data recording and Processing

From the data, the following parameters were derived: horse kick maximum force, horse kick duration and time of the day and night of the horse kick. In the data processing, a paired t-test was used for recorded and theoretical calculated impulse values to determine if there were differences between original recorded impulse values by the measuring wall and theoretically calculated using the drop hammer parameters.

The force was detected using a computer based measuring program with a sampling rate of 238 Hz. Because the sampling rate of the measuring system was lower than anticipated, a cubic spline interpolation was performed in MATLAB® [11] to give an upper magnitude to the peak values. This was partnered by the original peaks representing the lower probable magnitude. By applying the cubic spline interpolation more information can be obtained from the sampled data.

Results

After force bouts of longer duration were removed a total of 472 values remained. Most of the impacts (90%) had a maximum value less than 1924 N. The highest maximum value obtained was 8700 N. Furthermore the total duration of registered impacts was short: 2% had duration shorter than 0.001 s, while the majority of the impacts (93%) had duration between 0.001 and 0.05 s. The distribution of the impacts through the day showed that they coincided with activities such as morning and evening feeding, but also other activities during the morning. The greatest impact caused by a horse kick registered in this investigation amounted to an impulse of 131 Ns.
**Discussion**

**The Measuring Wall Construction**

The measuring wall construction, through the elasticity and yield of the plywood sheet material due to its dimensions and the reinforcement steel profiles along the back of the plywood sheet, could affect the recorded impulse and the possibilities for appropriately replicating the experiment. The possibility that the drop hammer might not meet the ideal situation of free fall, e.g. that a certain amount of friction might arise along the drop hammer shaft, was not accounted for in this study. The system of unloading the sensors from the weight of the plywood sheet may also have influenced the measured results.

**The Measuring Wall Calibrations**

The method of using the drop hammer together with the measuring wall was successful. It was possible to use the drop hammer method as a calibration instrument for the measuring wall and in that way the field measuring values could be related to the laboratory method. The relatively steady measurement values derived when using the drop hammer on the measuring wall could characterise the measuring wall working process and indirectly give a quantitative measure of the measuring wall construction. The measuring wall was calibrated with methods that could be considered reasonably easy to replicate. Because of the lower than optimal sampling rate of the measuring system, the cubic spline interpolation was used together with the original recorded values to give an estimate of a lower and upper probable magnitude of the peak values, making the obtained horse kicking data set more robust.

**Field Measurement Values**

The impact duration of the drop hammer is within the range of the measured kick duration. In the present study, the range of the horse kick impact forces could be compared with the range of vertical forces from trotters [4] and jumping horses [5]. Due to the short duration of the highest recorded impact value, its impulse value was rated in 13th place. However, it is difficult to determine how representative the recorded horse kick values are in terms of maximum impact for horses in general, as only a limited number of horses were included in this experiment. An indicator of this could be that the biggest impact load from pigs was 2.4 times the weight of the animal [6] compared to 1.35 from a horse in this study.

**Design Considerations**

In testing materials and as a guideline for the structural design of horse boxes, the dimensioning value used has to be based on general considerations. The highest recorded impact value from the field measurements corresponded to an impulse value of 131 Ns, which is equivalent to a theoretical impact energy of 350 J \((2.67 \times 131)\), where 2.67 is the coefficient of the gradient line between theoretical calculated impulse and impact energy based on all drop hammer mass and height combinations. This impact energy is consistent with the amount of energy needed (drop hammer mass 16.5 kg, height 2 m) to deform a standard vertical tubular steel grid to penetration according to the previous pilot test performed at the Department.

The parameter of interest for designing box fittings and structures to resist horse kicks is the impact energy. As a safety margin 150 Ns is proposed instead of 131 Ns. This limit value of 150 Ns corresponds to theoretical impact energy of 400 J \((2.67 - 150)\). Furthermore, the horse hoof velocity at impact is assumed to be \(3.13-6.27\) ms\(^{-1}\), which was the velocity range of the drop hammer in the laboratory tests. It is likely that hoof velocity at impact can be faster resulting in greater impact energy in relation to impulse. Analysis of a kicking horse, filmed with an ordinary video camera (30 frames per second), indicates a hoof velocity of approx. 12 ms\(^{-1}\) (range 8-16 ms\(^{-1}\)) at impact. The same velocity range could be calculated based on the swing phases of trotters and jumping horses [5], [7] and [8]. This makes sense if comparing the full speed of a racing Standardbred trotter and considering the required rear hoof velocity when pushing the horse onwards. If the hoof velocity at impact is 10 ms\(^{-1}\), the impact energy at impulse of 150 Ns will be 750 J. However, actual hoof velocities should be confirmed in future studies. Based on existing knowledge, it can be
concluded that building materials and forms designed for horses up to 700 kg mass should be able to withstand at least 150 Ns impulse resulting from a point load from a corresponding horse shoe. The recorded impact values in the field experiment were increased by 15%, which can be considered to be a reasonable minimum safety margin. This consideration takes into account the fact that the largest horse included in the experiment had a mass of 660 kg and that we probably did not record the hardest kick possible by a horse.

Conclusion

The impact of a horse kick is rapid, often shorter than 0.03 s. The greatest impact caused by a horse kick registered in the study amounted to 8722 N and 131 N s respectively. Considering the recorded values and taking into account a certain safety margin, the impact resistance requirement for conventional horse boxes to be used for maximum 700 kg horses should be at least equivalent to 150 Ns caused by a hit of a horse shoe inclined at 45°. In order to obtain more statistically significant data, leading to more accurate design values, extended measurements, supplemented with kicking speed measurements, should be carried out on greater numbers of horses. Horses are probably able to kick harder than was recorded in our study.

Acknowledgments

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References

Equestrian structures, safety and disabilities

Introduction

This contribution will discuss issues of equestrian structures that are open to the public, and more particularly equestrian centers that must meet, like any public building open to the public, certain requirements for fire rules and the reception of disabled guests.

It will also address the transformation of a strictly private equine structure (e.g. livestock breeding) into a building open to the public (accommodations, for example) and the regulatory implications of this change of structure.

Fire regulations in public buildings

In terms of the safety of public buildings, the guiding principles for regulations are intended to ensure that these buildings are designed to:

- reduce the risk of fire,
- warn occupants in case of an emergency,
- facilitate evacuations while avoiding panic,
- alert emergency services and facilitate their intervention.

Preventive measures against fires involve all the aspects of the construction, whether related to the creation, development or modification of these buildings. They also apply to all "life" phases of the design, construction and operation of the building.

Description of a public building open to the public

Public buildings refer to all buildings, premises and enclosures that are open to the public, whether freely or for a fee, or in which meetings are held that are open to anyone or only by invitation, for a fee or not.

Equestrian centers are no exception to this rule, regardless of the size of the staff or public received. Horse pensions are also included in this definition, as are sales facilities open to the public.

Protection against fire and panic in public buildings

The requirement to protect against fire is very broad, to the extent that it is binding on all persons (other than employees and the public) who are related to the establishment and applies not only during the construction phase, but also during the operation of the facility.

Definition and enforcement of safety rules

Builders, owners and operators of public buildings are therefore required, both at the outset and during operation, to comply with preventive measures and to ensure the safety of those in the building.

These measures are determined by the nature of the operation, the size of the premises, the method of construction and the number of persons allowed in the building.

Typology of the establishments

Lecturer : T. Le Borgne
Author : T. Le Borgne
All public buildings have different characteristics of size, purpose, use and risks. They are divided into categories according to the nature of their operations, and are also categorized by the size of the public and staff. They are subject to common general provisions as well as specific provisions of their own, stemming from the safety regulations against fire for public buildings. The typology of the establishment, which corresponds to the nature of its use, is designated by a letter. There are 30 different types of establishments.

- Establishments located in a building. Equestrian centers are usually classified as X “Covered Sporting Facility” and as L “Meeting or Multi-purpose Areas.”
- Special establishments. Equestrian centers, when equipped with external structures for equestrian purposes and hosting competitions can also be classified as PA, “Outdoor Establishments.”

Public buildings are also classified into five categories, determined by the size of the public received by the establishment. Most equestrian centers are classified as “small establishments”, in the 5th category. In this category, only the public hosted simultaneously is considered in the calculation.

Regulations for handicap access in public buildings

The accessibility of public buildings for persons with disabilities (whether permanent or temporary) follows specific rules.

- Article L114 of the French Code of Social Action states that “is considered as accessible to disabled persons any building or land that allows, under normal operating conditions, persons with disabilities to have the greatest possible independence: in terms of movement, access to premises, equipment use, orientation, communication and receiving the benefits of the services for which the establishment or facility has been designed. The conditions of access for disabled persons must be the same as for non-disabled persons or, alternatively, must offer an equivalent quality of use.”
- “The obligation of accessibility covers the outer and inner parts of the establishments and facilities, and concerns movement, some of the car parking spaces, elevators, premises and equipment.”

The concept of disability

According to the International Classification of P. Wood, a disability is:

- A deficiency: An injury, bodily harm or alteration, whether physical or mental, temporary or permanent. It refers to the medical diagnosis of a congenital abnormality, trauma or illness, etc. which causes a disability.
- A disablement: The consequence of an impairment. It results from a deficiency of bodily functions. It refers to the existence of a restriction of activity beyond the norm for an individual.
- A disability: The result of an impairment. It refers to the social disadvantage experienced by a person with an impairment. The disability may be visible or invisible, just like the impairment.

Types of disability

- Motor disability: Difficulty moving, whether in a sitting or standing position.
- Visual impairment: Visually impaired or blind persons.
- Hearing impairment: Persons who are deaf or hard of hearing or have impaired hearing.
- Mental disability:
  - Psychic: Impairment related to behavior (neurosis, depression, claustrophobia, etc.).
  - Mental (cognitive): Mental impairments vary widely between individuals.
- Persons of "all sizes"

Definition in the French 2005 law
"A disability within the meaning of this Law refers to any limitation of activity or restriction on participation in social life, experienced in a given environment by a person, caused by a substantial, lasting or permanent alteration of one or more physical, sensory, mental, cognitive or psychological functions, or by a multiple impairments or by disorders impairing health."

Statistics:
- Disabled population: 10% of the French population, approximately 6 million people.
- Persons with reduced mobility: 42% of the population with one or more disabilities.
- People with disabilities: Everyone at some point in their lives.
- The disabled population is estimated to be at 5.26 million people:
  - 1.5 million visually-impaired persons.
  - 60,000 blind people.
  - 1.4 million people with a mobility impairments and other disabilities.
  - 850,000 people with motor disabilities.
  - 1 million people with mental disabilities.
  - 450,000 hearing impaired or deaf persons.
- Each year about 300,000 people become disabled ("accidents of life").
- The three main impairments that cover 85% of accidents are:
  - Mechanical and motor impairments 42.2%.
  - Aesthetic impairments 21.5%.
  - Sensory impairments 21.5%.
- Reduced mobility persons
  - People with burdens (packages, luggage, etc.) 5-15%.
  - Elderly or convalescents 14.8%.
  - Children or persons of small stature 7.1%.
  - Disabled persons 2.9%.
- Pregnant women 0.2%.

Understanding disability

A building or facility is considered handicap-accessible when it allows people with disabilities to function under normal conditions and with the greatest possible independence:
- To move about.
- To access the premises and equipment.
- To orientate themselves.
- To communicate with others.
- To benefit from the services for which the establishment or facility has been designed.

Disabled persons might meet difficulties such as:
- Standing without support.
- Moving on slippery or uneven floors.
- Overcoming obstacles, uneven floors, narrow passages.
- Reaching and using certain facilities (door handles, counters, toilets, vending machines, etc.).
- Moving across long distances.
- Grasping an object, turning a handle.
- Entering and leaving a room.
- Moving between rooms.
- Accessing the corners of rooms.

Elements to consider in equestrian facilities

Outdoor parking
- Specific dimensions
- Handicap logo on the ground
- Signpost
- Percentage of required handicap parking
External movement - lighting
- Ground made of solid material, non-reflective and not acting as an obstacle to wheels.
- Adapted guide lines (visual contrast, differentiated appearance).
- Adapted directional signs.
- Lighting must be adapted:
  - Sufficient number of lights.
  - Automatic turn on (at twilight and motion detection).

Exterior and interior doors
- Minimum width.
- Grip.
- Resistance (50 N max).
- Differentiated colors between woodwork and metal.
- Visual strips.

The reception area - Interior circulation
- Ground made of solid material, non-reflective and not acting as an obstacle to wheels.
- Information signs and adapted information.
- Magnetic strip.
- Adapted guide lines (visual contrast, differentiated appearance).

The reception desk must be equipped with a reception area for a wheelchair and a magnetic strip. The supervisor and the club-house must permit reception and movement for a wheelchair. If the clubhouse overlooks the riding area, the kicking boards must be adapted visually.

Sanitation facilities - Showers
Sanitation facilities must be adapted:
- Reception and movement area for a wheelchair.
- Adapted stall and usage.
- Appropriate handles.
- Appropriate sink and usage.
- Mirror at appropriate height.
- Light flash.
- Contrast between ceramics and visual strips.

The showers must be adapted:
- Reception and movement area for a wheelchair.
- Walk-in shower.
- Adapted seat and handles.
- Adapted faucets and usage.
- Light flash.
- Contrast between ceramics and visual strips.

Changing rooms
- Reception and movement area for a wheelchair.
- Adapted handles.
- Flash light (if for one person).

Saddleries
- Reception and movement area for a wheelchair.
- Adapted handles.
- Adapted saddles.

**Boxes**
- Reception and movement area for a wheelchair.
- Adapted handles.
- Guideline.
- Adapted stock.

**Shower and preparation areas**
- Reception and movement area for a wheelchair.
- Adapted handles.
- Adapted faucets and usage.
- Man-lift equipment.

**The riding area**
- Construction method (taking into account of mental disabilities in particular).
- Magnetic strip.

**Sleep areas**
- Reception and movement area for a wheelchair.
- Adapted toilets.
- Adapted washbasin and usage.
- Adapted handles.
- Adapted sink and usage.
- Mirror at appropriate height.
- Walk-in shower.
- Adapted seat and handles.
- Adapted faucets and usage.
- Light flash.

**Conclusion**

Welcoming people with disabilities, in addition to the public, as users of the equestrian facilities may seem complicated or overwhelming. The rules that must be followed for public buildings for fire safety and disability accommodation are, however, clear and easily identifiable. Do not hesitate to ask for advice during the entire process, from both the initial studies to the final execution, from trained professionals (architect).

**Organism**

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The role of bedding material in recycling the nutrients of horse manure

Abstract

In Finland, horses produce around 700 000–800 000 m3 of manure per year, over half of which is composed of the bedding material. The manure should be efficiently recycled in agriculture avoiding any uncontrollable loss of its nutrients into the environment. In this study, we compared the nutrient cycling properties of three bedding materials: peat, wood shavings and pelleted straw. Their composting characteristics, ability to store nutrients while subjected to rainfall and their effect on mineralization-immobilisation of N during incubation were examined. The differences in the N and P concentrations between the fresh manures were small. The amount of total N ranged between 10 and 15 g kg⁻¹ dry weight (dw) and the concentration of total P between 2 and 3 g kg⁻¹ dw. The relative proportions of water soluble N and P were rather high (30-40% N, 50-60% P), which poses a risk of nutrient leaching. Peat manure was shown to be especially susceptible to P loss when subjected to rainfall. The C:N ratios were high in all the fresh manures, which led to net N immobilisation when mixed with soil. Composting increased the nutrient concentrations and decreased the C:N ratios. Therefore, the composted manures had a slight positive or an insignificant fertilizer effect. Manure with pelleted straw bedding had superior composting characteristics.

Keywords: horse bedding, manure, composting, nutrient cycling, fertilization

I. Introduction

The 75 000 horses in Finland are estimated to produce around 700 000–800 000 m3 manure yearly. Faeces comprise only 20 - 30% of the manure while bedding material makes up over half of the volume. The choice of bedding has thus a marked effect on the properties of the manure. For the welfare of both horses and their caretakers, stall bedding should be easily available, affordable, absorbent, dust free, hygienic and easy to apply and remove. From environmental perspective, the bedding should also have high capacity to retain nutrients during use and storage but at the same time efficiently release them once recycled into agricultural soil.

Horse manure has typically a high C:N ratio, meaning that the decomposing microbes need to absorb N to satisfy their growth requirements [1]. Due to this net immobilisation, horse manure is not very desired fertilizer. Composting provides a way to improve the fertilizer value of manure since it reduces the overall volume and thus increases nutrient concentrations and the C:N [2]. In this study, three bedding materials, peat, wood shavings and pelleted straw were compared in relation to their nutrient content, ability to store nutrients during storage even under rainfall, compostability and ability to release N when used as a soil amendment.

II. Materials and methods

A. Collection of manure

Manure was collected from six Finnhorse mares rotated in six boxes, of which two of each were bedded with either peat, wood shavings or pelleted straw. Enough bedding was used to ensure adequate absorption of urine yet allowing easy maintenance. In total, the consumption of clean bedding per 2 boxes was 740 kg peat, 730 kg pelleted straw and 440 kg wood shavings during a 5-week study period (4 weeks of manure collection and 1 preceding test week). Soiled bedding and
dung were removed daily by same person. A portion of the manure removed was weighed and placed into a 0.5 m³ storage box, one for each manure type. The total quantity of manure produced was not recorded. After a one-week collection period, the manure acquired into each box was mixed thoroughly and sampled for chemical analyses. Temperature sensors were installed in the middle part of each manure pile, after which the boxes were transported to a storage barn. The one-week collection period was repeated four times in January-February 2013 to obtain four replicates of each of the three types of manure.

B. Composting

Composting of the manures was conducted between January and September 2013 in 0.5 m³ containers placed under roof in outdoor temperature. The composting process was enhanced by aerating and moistening the materials. The masses in each box were turned manually in the beginning of June and July. Deionised water was added once during the latter turning. Temperatures of the manures were recorded automatically in every four hours to follow the changes in microbial activity. Finally, the boxes were weighed to define the loss of dry mass and the material sampled for chemical analyses. Changes in the structure of the materials during composting were examined using bulk density measurement.

C. Nutrient concentrations and leaching

Nitrogen (N) and phosphorus (P) concentrations were analysed from both fresh and composted manure samples to assess differences in the content and solubility of nutrients. The total concentration of N was determined by the Kjeldahl method, whereas total P was analysed by ICP after dry combustion. The water soluble ammonium-N (NH₄-N), nitrate-N (NO₃-N), total N and total P were analysed from 1:60 water extracts with an autoanalyzer. In addition, the total content of carbon (C) was determined via dry combustion (Dumas method). The ability of the bedding materials to retain nutrients during storage was studied by rain simulation. Both fresh and composted manure samples of 3 l volume were subjected to artificial rainfall with an intensity of 9 mm h⁻¹ for a period of 2 h 15 min. The percolated water was collected, weighed and analysed for total N and P concentrations with an autoanalyzer.

D. Incubation

The N mineralisation potentials of fresh and composted manures were determined by an incubation study conducted according to ISO14238. Aliquots of manure providing 100 mg of N kg⁻¹ of soil and NH₄NO₃ providing an additional 30 mg of N kg⁻¹ of soil were mixed with fine sand and let to incubate at 20 °C for 48 d. During incubation the soils were kept at a constant moisture level of 18.8% corresponding to 48% of water holding capacity. The soils were thoroughly mixed twice a week. Subsamples for N analyses were taken after 0, 7, 14, 28 and 48 d of incubation and extracted with 1 M potassium chloride (KCl) solution for soluble N. The total N content of the extracts was determined with an autoanalyzer after an oxidation treatment.

III. Results

A. Composting characteristics

At the end of the one-week collection period, the temperatures of the manures stored in the 0.5 m³ boxes were around 30-40 °C in the pelleted straw and wood shavings manure and 20-30 °C in the peat manure. After transferring the boxes into outdoor winter temperatures, the manure piles started cooling and between mid March and early May the masses were frozen. During the first half of May, the temperatures begun to increase peaking around 30°C in the manures containing peat, 30-50 °C in those with wood shavings and 40-60 °C in the ones containing pelleted straw. The aerating actions initiated further temperature peaks especially in the manures containing pelleted straw. During August, the temperatures of all manure piles decreased to below 20 °C. Composting reduced the total dry mass by 48 ± 3% in the straw pellet manure, 31 ± 1% in the manure with wood shavings and 17 ± 3% in the peat manure. The bulk density was highest in the manure containing pelleted straw (106 ± 12 g dry matter l⁻¹) followed by manure with peat (89 ± 4
dry matter l-1) and that with wood shavings (72 ± 4 dry matter l-1). Composting had no significant effect on the bulk densities of the manures.

The C:N ratio was highest in the fresh manure containing wood shavings (Table 1). Composting decreased the C:N ratio in all manures but especially in the one with pelleted straw. The nitrate concentrations of fresh manures were very low, ranging between 0.003 and 0.07 g kg-1 dry matter. During composting NH4-N was nitrified, which caused a decrease in the NH4-N:NO3-N ratio. However, variation in the NO3-N concentration between replicates was substantial.

<table>
<thead>
<tr>
<th>Bedding material</th>
<th>C:N Fresh manure</th>
<th>C:N Composted manure</th>
<th>NH4-N:NO3-N Fresh manure</th>
<th>NH4-N:NO3-N Composted manure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peat</td>
<td>33</td>
<td>29</td>
<td>532</td>
<td>0.5</td>
</tr>
<tr>
<td>Wood shavings</td>
<td>45</td>
<td>32</td>
<td>276</td>
<td>55</td>
</tr>
<tr>
<td>Pelleted straw</td>
<td>31</td>
<td>14</td>
<td>491</td>
<td>15</td>
</tr>
</tbody>
</table>

Table 1: Ratios of C:N and NH4-N:NO3-N in fresh and composted horse manures containing different bedding materials. The results are means of four replicates. Standard errors (se) and least significant differences (lsd) within columns are shown in italics.

**B. Nutrient storage capacity**

In the clean bedding, the total nutrient concentrations were highest in pelleted straw (9.1 ± 0.4 g N kg-1 dry matter dm-1 and 1.4 ± 0.1 g P kg-1 dm-1), followed by peat (8.7 ± 0.2 g N kg-1 dm and 0.3 ± 0.1 g P kg-1 dm). Wood shavings were clearly the poorest of the beddings in N and P (0.6 ± 0.0 g N kg-1 dm and < 0.1 g P kg-1 dm). In the fresh manures, the total N content was similar in the peat and pelleted straw manure but somewhat lower in the wood shavings manure (Table 2). The total P content was highest in the manure containing pelleted straw, likely due to the relatively high P content of the straw. Composting increased the nutrient concentrations of all manures due to loss of dry mass.

The proportion of water soluble N from the total was greatest, nearly 40%, in the fresh manure with wood shavings (Table 2). The corresponding percentage for both peat and straw pellet manure was around 30%. The proportion of water soluble P from the total was high in all the manure types, around 60% in the ones bedded with peat or wood shavings and nearly 50% in the manure containing pelleted straw. The relative proportions of water soluble N and P decreased due to composting in the wood shavings and pelleted straw containing manures, though the soluble concentrations tended to increase.

Around 5-10% of the total N content of the manures was leached within the percolated waters of the simulated rainfall. The percentages of the total N lost by leaching from the different types of manure were the following:

1) Fresh manures   
   a) Peat 5 ± 2%   
   b) Wood shavings 11 ± 2%   
   c) Pelleted straw 6 ± 2%

2) Composted manures   
   a) Peat 9 ± 4%   
   b) Wood shavings 4 ± 1%   
   c) Pelleted straw 6 ± 3%

P was most readily leached by the simulated rainfall from the manure containing peat bedding. The percentages of the total P lost by leaching from the different types of manure were the following:

3) Fresh manures   
   a) Peat 14 ± 3%   
   b) Wood shavings 8 ± 1%   
   c) Pelleted straw 5 ± 1%

4) Composted manures   
   a) Peat 23 ± 8%   
   b) Wood shavings 12 ± 1%   
   c) Pelleted straw 7 ± 2%

The gaseous loss of N was estimated using the total N contents of the fresh and composted manures and the mass balances calculated over the composting period. This coarse inspection showed no marked loss of gaseous N, the percentages of total N lost being 12% in peat and wood shavings manure and 1% in manure with pelleted straw (SE 6, LSD 20).
Table 2: Total and water soluble (1:60) concentrations of N and P in fresh and composted horse manures containing different bedding materials. The results are means of four replicates. Standard errors (se) and least significant differences (lsd) within columns are shown in italics.

C. Fertilizer value

The incubation study showed that additions of fresh horse manures caused decreasing nitrogen concentrations in soil (net immobilisation) relative to the soils incubated without manure amendments (Fig 1a). In the manures containing wood shavings or pelleted straw, an immobilisation – mineralisation –immobilisation cycle seemed to occur, whereas with peat the decrease in soil soluble N was steadier. In contrast, the composted manures containing pelleted straw and especially the one with wood shavings released N into the soil (Fig 1b). In the soils amended with composted peat manure, no clear trend in the soluble N concentrations of soil could be seen.

Figure 1: The effect of fresh (a) and composted (b) horse manure containing different bedding materials on the soluble N concentrations in soil. The results are means of four replications ± standard deviation. The background N concentrations of soil incubated without manure have been subtracted from the values.

IV. Discussion

The compostability of horse manure containing either peat, wood shavings or pelleted straw as the bedding material was assessed by the temperature profiles of the manures during composting, changes in the C:N and NH4-N:NO3-N ratios and the loss of dry mass. According to these indicators, manure containing pelleted straw composted most efficiently whereas the manure with peat decomposed only partially. The poor compostability of peat manure could be explained by the initially high decomposition stage of the peat bedding. However, Airaksinen et al. [3] found peat manure to compost satisfactorily. Komar et al. [4] reported good composting characteristics of straw-based materials. In this study, active aeration was needed to maintain the composting
process in all the manure types. In addition, it can be noted that at least when carried out in small piles, the decomposition ceases totally during the cold wintertime of Finland. The inherently low N content of wood shavings and relatively high P content of pelleted straw were reflected in the N and P concentrations of the corresponding manures but in general, the differences in the total and water soluble N and P were small between the fresh manures studied. In the composting, dry mass was lost which led to increases in the nutrient concentrations. This phenomenon was most significant in the manure with pelleted straw, in which the N and P concentrations were doubled due to nearly 50% loss of dry mass. The proportion of water soluble N and P was rather high in all the manures, which poses a risk of nutrient leaching. Composting tended to decrease the water soluble proportion of both N and P but increased resistance against N leaching only in the composted wood shavings manure. Peat manure appeared to be more susceptible to loss of P than manures with wood shavings or pelleted straw.

In the incubation study with fresh manures, N was immobilised in soil as suggested by the high C:N ratios of the manures [1]. Composting decreased the C:N ratios but in the manures containing peat and wood shavings the ratios remained rather high. Yet no immobilisation was observed in any of the soils amended with composted manures. Though the N fertilizer value of the composted manures clearly remained low or non-existent, they could serve as soil improvement materials since the negative fertilizer effect, i.e., N immobilisation was eliminated.

In conclusion, none of the bedding materials compared was found superior to the others in relation to nutrient recycling of horse manure. Peat was shown to be more susceptible to P loss through leaching than pelleted straw or wood shavings. Composting proved to be useful since it reduced the manure volume, increased the nutrient concentrations and eliminated the N immobilisation effect of manure added to soil. Pelleted straw had the best composting characteristics.

References


Organisms

(1) MTT Agrifood Research Finland - Plant Production Research - Jokioinen, Finland firstname.lastname@mtt.fi
(2) MTT Agrifood Research Finland - Animal Production Research - Ypäjä, Finland firstname.lastname@mtt.fi
Stork Nest Farm - Integration of equestrian equipment

Introduction

We were asked to design the revitalization of a farmstead, which would be used for company presentation, holding of corporate events and, last but not least, staff training and their leisure activities. The farmstead Semtín near Benešov, which was selected for this project, was in desolate state, but its strong Genius Loci with a large water reservoir and Nature park Džbány-Žebrák nearby destined the project for a special approach.

The landscape character resembles a submontane region with a large complex of woods, wide meadows with groves and wetlands and a no less significant system of ponds.

The stork nest on the top of the distillery’s chimney with its nearly 90-year history gave the complex its name and widely influenced the process of forming the horse-riding arena.

It became a symbol of the symbiosis between man and animal, or (if you like) the client’s company - specialized i.e. in manufacturing natural products - and nature. It wasn’t a formal symbol for us. We were fascinated by stork’s fidelity. Almost 90 years generations of storks are returning from Africa to the farm and we tried to design the farm in order to bring back people here again.

These birds also fascinated us by their endurance in building their nest. After decades they construct still the same, no doubt about the shape and material, still in the same place and with no desire for originality, which bother all architects and builders nowadays. Storks don’t look for exceptional places. They don’t want to distinguish themselves and compete with others. Storks became a symbol for us in the approach to construction. Our design of the farm was led in humility to these bird architects.

The old farmstead consisted of an enclosed yard of an almost square ground plan and addition of a piggery. The yard contained two dwelling houses, a distillery, a barn and a stable. The buildings for stabling were torn down; also a small dwelling house had to be removed due to bad technical state. The remaining buildings (villa, distillery, barn) were intended for reconstruction.

At the beginning of the design was the idea of creating two independent functions – recreationally educational with accommodation and agricultural - which can work either together or separately. Therefore the buildings were conceived as enclosed units, which neighbour on one another and can be easily connected or separated. New buildings have been added to the existing ones to restore the form of the original farmyard.

The agricultural function got its own service yard connected with an educational path, where the visitors can see the animals kept on pastures. The animal breeding on the farm is not motivated by economic profit, but only constitutes a means of forming a rural framework for the other functions of the complex. It enables the visitors to relax in immediate closeness to traditional domestic animals of the Bohemian country-side.

The dwelling yard is tied together with an agricultural trail, which makes the visitors acquainted with agrarian cultivation. A fishing trail leads to the pond and culminates in a sightseeing building in close contact with the dam. Maintenance of the surrounding fields does not reach the state of high farming, as well as fish breeding in the pond, which serves only for breeding trophy fish, recreational fishing, bathing and swimming.

The Stork Nest Farm should serve for work and recreation, mental and physical progress of the visitors. For this purpose there are more than 90 hectares of land consisting of green areas, sport grounds, a pond, drifting and pastures, biotope and a golf driving range.
Multifunctional arena

The new building of a riding arena was designed for the needs of horse breeding and riding sport during winter season. Moreover it should serve for all sorts of presentations, sports, and cultural events. The internal equipment of the building and its position among other buildings are adapted to this use. The arena is situated in a close proximity of the main service yard with stable and is directly connected with a restaurant, which acts as a snack-bar. There is also a connection with the residential yard, where the visitors are accommodated.

The arena’s appearance should evoke the stork’s nest, a symbol of home, safety and security. The arena is 12.5 meters high, its external diameter is 35 meters, the diameter of the indoor riding surface is 24 meters.

The foundations are formed by a massive concrete ring. The roof is supported by an atypical glulam timber beam structure. An external cladding of translucent polycarbonate boards was fixed between these beams. The external oak logs, giving the structure an expressive appearance, provide also shading. They were fixed to the building at the total amount of 200 tons at the length of 4, 6 and 8 meters. A secondary steel grid-frame construction was added to the timber beams to achieve the external shape of the nest and also to provide the method of fixing the logs to the structure. The central sky-light with a diameter of 8 meters serves for intensive ventilation of the internal space by natural air flow. The fresh-air inlets are placed under the stand, the air outlets are placed around the perimeter of the sky-light’s ring. In the case of a high solar heat gain there are ventilation fans on the roof that fulfill a supporting role to the natural ventilation.
The arena’s surface of the riding area is covered by sand with capillary irrigation for riding sport, which can be covered with plywood boards during all sorts of events. The riding area is surrounded by a wainscot (protective barrier) and a stand for c. 200 people, also with a VIP stand upstairs.

The riding arena became a landmark in the area of the farm and an element which attracts attention in wide neighbourhood. The Stork Nest Farm was completed in 2010. Later, our firm designed other additions to the farm: the Environmental Education Center and a large rectangular riding hall.

**Main stable**

The main stable building is just beside the circular riding arena and the main service yard. The stable consists of a two-storey middle-part and two single-storey wings beside. The middle-part’s groundfloor contains offices and special premises, such as: saddle room, quarantine box, feed storage and cloakrooms for riders. The first floor is reserved for small flats and cloakrooms for staff. The building’s wings are used for stabling. The left wing is for reserved for horses and the right wing for other animals like cattle, ponies, sheep, goats and rabbits. The horses are stabled in stalls. The large height of the stable space assures intensive ventilation and a healthy climate.

The stall’s flooring is made of rubber mats. It is easy to clean and it generates low stress of hoof and protects tendons. It is used with a small amount of absorbent bedding. The flooring in the corridor is made of oak wood bricks.

**Barns**

The Stork Nest Farm is surrounded by large meadows. Four barns were placed there. They contain hay storage and stable. The barns are connected with the meadows so that animals can be out to pasture all day.
Rectangular riding hall

The large riding hall serves to satisfy the needs of equestrians because the circular arena is too small for equestrian riding. There is small horse stable beside connected to the riding hall. Every stall has a direct view to the outside and is connected to a minipaddock. The riding hall also contains a restaurant upstairs with VIP stands and is also used by the guests of the nearby Environmental Education Center ("Ekocentrum"). There is a good view from the restaurant into the riding hall, as well as into the "Ekocentrum".

The riding hall’s structure is simple due to low cost and durability. There is a column system of reinforced concrete in combination with glulam timber beams with steel rods. The steel rods are used to eliminate pressure of the roof and allow to make the timber beams thinner. The building is clad in wood from the exterior and the interior as well. The exterior cladding was made of thermally modified pine wood due to durability. The interior cladding was made of spruce wood due to reduce cost. The surface of the area for riding contains sand with capillary irrigation – the same system as the one in the circular arena. The area for riding is surrounded by a protective barrier from plain plywood.

Environmental Education Center - “Ekocentrum”

The “Ekocentrum” was built between the farm yard and the meadows with barns. It consists of a vernacular courtyard with 3 wooden houses and a labyrinth with facilities for hurt animals – aviaries and enclosures. Visitors can observe eagles, owls, water birds, foxes, otters and many other animals. Also a new enclosure for lemurs has been built last year. The “Ekocentrum” is visited mainly by families with children and schools. The adjacent rope park is very popular too.

Other facilities for horses and equestrian sport designed by SGL PROJEKT

Feeding modules (National Stud Kladruby nad Labem)

The feeding modules in the courtyard of the stud was built in order to ensure enough water for all horses coming back from the pasture to the stable. The manger is made of terrazzo elements on a brick base wall. The fountains for warming-up water are made of one whole precast terrazzo piece. Sharp edges are covered by a wooded plank-ring wrapped by a steel strap to avoid injuries of animals. Pillars for dressage of the horses were placed into the middle of the court. The building won in The Architecture Grand Prix - National Architecture Award 2003 for Artwork in Architecture.

Equestrian center in the North Bohemia

This equestrian center was designed in 2000. There is large riding hall, stables and accommodation for equestrians and guests as well. The stable is beside the riding hall, but every stall has a direct view to the outside.

Equestrian center in Sadska

The project of this equestrian center was designed in 2001. It is interesting in building configuration, which was designed in order to eliminate outdoor ways and to separate the movement of horses, fees, staff and equestrians.

Rural farmhouse with horse breeding in the Central Bohemia

At the beginning there was a devastated rural farmhouse. We designed a renovation of the old buildings and added a stable and a small riding hall. The stable has a capacity of 12 horses. This facility has a very nice small scale.
Riding Hall in Humpolec

This project was designed for the Czech University Of Life Sciences. Unfortunately the hall wasn't built up. Nowadays there is an old equestrian stadium with stands in a very bad condition. There isn't even a riding hall to host eventing and driving events. It could be a nice equestrian facility. We designed a riding hall with a stable for approximately 40 horses and there should have been an outdoor stand with a view overlooking the stadium. At the end they only built an outdoor riding arena there.

Development plan of the National Stud Kladruby nad Labem

National stud Kladruby nad Labem is the oldest major stud in the world. The old Kladrub’s whitehorses have been bred there. They are is a well-known harness and ceremonial breed. In 2004 we created a development plan for the whole grounds of the National stud, which is comprised of approximately 12 square kilometers. We dealt with traffic, movement of horses, staff, feed or manure and areas for development. In 2008 we worked on 3 smaller projects of this development. First we designed a large hall for riding, because the National Stud has none. We designed large complex with a riding hall for competition and another one for training. They were situated beside the outdoor riding arena so we designed outdoor stand for visitors too. The second task was the design of a conversion of the Borek farm into leisure and practice riding facility. And finally the third task was to design the houses for accommodation and catering of guests. But none of those designs have been built.

Farmstead Čečelice

The farmstead in Čečelice is another design of equestrian facilities. We are working on this project presently. In its range it is similar to the project Rural place in Central Bohemia. Now we are expecting to obtain the planning and building permits.

Farmstead Lány

This is one of our latest projects. We designed a rural home for the elderly, which is connected to an equestrian facility.

Rural place with horse breeding in the Central Moravia

This is our latest project. It is smaller facility with horse breeding. We are working on it presently.

Organisme

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The EquuRES label: references and tools for environmentally-responsible equine farms

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Abstract

The environment is at the heart of regulatory and societal concerns. With this in mind, the Horse Council of Lower Normandy has decided to anticipate future developments and provide the equine industry with a tool for managing the quality of its environment. Saving energy, flow control, resource conservation and biodiversity, soil, water and air quality: the EquuRES label provides solutions for all of these subjects. The work undertaken to create the label has produced the first references for the environmental impact of equine activities. On this basis, priorities and actions have been identified to support the equine industry in heading towards greater environmental protection.

Keywords : Horse, environment, quality, impact, welfare

1. References on the environmental impact of equine activities

In order to target the topics addressed by the label, a study was undertaken to develop the first references on the environmental impact of the equine industry. It was thereby possible to identify the most important impact factors and for which concrete actions for improvement exist.

These references were formed by a large data harvesting operation in 9 so-called “Pilot Stables”. All the flows in these structures were identified and quantified: energy, water, feed, manure, equipment... This data was then analyzed using three complementary methods:

- Simplified Lifecycle Analysis
- Environment study
- Energy audit.

Simplified Lifecycle Analysis provides an overview of the issues and impacts associated with an activity. The inventory of the flows in each test stable was performed throughout the entire production system of the equine industry. In order to compare the different “domains” of the equine industry, the functional unit used was the “sheltering and maintenance of one horse for one year.”

Figure 1 : Reference Unit for the Lifecycle Analysis
The environment study resulted in field surveys across several different subjects. Topography, pedology, geology, hydrography and hydrogeology have an impact on the fragility of a site for different types of pollution. These aspects must be considered at several levels of the production system in order to control environmental risks.

The energy audit focused on energy consumption in all buildings sites. Our pilot stables have not implemented a sub-metering system to differentiate the energy consumption of residential buildings and the energy consumption stemming from the production system, so the diagnosis included both.

These three studies have shown that the “food and litter” domain has the most important impact on the environment. This is due to the volume it represents. Feed (hay and pellets) contributes 70% of the impact in this area. Water is another domain that deserves attention.

On average, 6,245 m$^3$ of water are consumed per year for a horse at work, which represents the equivalent of 110 French citizens. Devices used to recover water have a very positive effect on reducing consumption. The carbon footprint of a horse is estimated to be 2.8 tons of CO$_2$ per year, which represents 34% of the emissions of a European citizen. Finally, the energy analysis has shown that private units (residence buildings), when they are on the same site as the equine operation, represent the largest single consumer of energy.

These results must be relativized, under consideration of the wide variety of structure types and the small sample size under consideration. They helped however determine the subject priorities, in order to reduce the environmental impact of equine activities. It is on this basis that the strict criteria of the EquuRES were developed. These criteria relate to both:
- global issues: global warming and the preservation of water resources,
- and local issues: integration into the landscape and animal welfare.
2. Nine subjects for the assessment of the environmental quality of a horse hosting unit

The EquuRES label allows the level of maturity and the environmental quality of equine entities to be evaluated according to 105 criteria divided into 9 subjects:

- Food and litter
- Animal welfare and veterinary care
- Travel, transport and agricultural machinery
- Water
- Energy (heating, lighting, equipment)
- Outdoor spaces and landscape
- Manure and waste
- Building management
- Team management and communication

These subjects represent the most significant impact factors. Each subject is governed by principles that are designed to meet the following commitments:

- Conserving natural resources (water, air, soil, etc.)
- Promoting local sources for food and litter,
- Ensuring animal welfare and appropriate veterinary care,
- Limiting the impact of travel, transport and the use of agricultural machinery related to the activity,
- Controlling energy consumption (heating, lighting, equipment) in order to use energy rationally and to reduce the emissions of greenhouse gases,
- Maintaining outdoor spaces and the landscape as environmental heritages and and preserving biodiversity,
- Reducing, managing and making use of manure and waste,
- Maintaining buildings and equipment to ensure ecological efficiency and landscaping,
- Sensitizing stakeholders to the importance of respecting the environment.

2.1. Food and litter

Food and litter are at once environmental, health and economic issues. Controlling the supply of food and litter has a direct impact on the performance of horses and, more generally, on the site as a whole.

The objectives of this subject are:

- Promoting local products (reducing transport),
- Promoting products derived from the most environmentally-friendly practices,
- Promoting food with nutritional value that are suitable for the animals (depending on their health, age, activity),
- Asking suppliers, and keeping records, of the quality control and the exact origin of the products.

In order address this subject in an equine site:

- Ask each vendor about the provenance, the production method and the quality of the purchased food and litter.
- If the production locale is truly unknown, use the supplier's place of shipment.
- When choosing a vendor, compare not only the price but also all of this information.
- With each order, enquire about the accuracy of this information if they are not listed on the package. Keep documents containing this information for each order.

2.2. Animal welfare and veterinary care

Animal welfare is very difficult to define scientifically. However, the definition of the "5 freedoms" by the (British) Farm Animal Welfare Council appears to be the most complete. It promotes the respect of "5 freedoms":

- The absence of hunger or thirst (keeping the animals healthy),
- The absence of discomfort (appropriate environment, including shelter),
- The absence of pain, injury or disease,
- Freedom to express the normal behavior of its species (social behavior, eating habits, etc.),
- The absence of fear or distress.

In order to limit the impact of these domestic conditions, it is important to respect the natural needs of the horse:
- Respecting the basic needs: food and drink, depending on the metabolism and the physical activity each horse.
- Providing protection against the weather that is both suitable (the number and size of pasture shelters, waterproofness) and adapted to the animals (size of boxes, ventilation of the stables).
- Adapting the facilities and the management of the horses to match, as closely as possible, their natural behavior: the need for social contact, for eating fiber much of the day, for moving at low speeds on a daily basis over long periods (release to pasture).
- Strictly monitoring the health of each horse (de-worming, prevention of animal diseases, pharmacy management and end of life).

In order to address this subject in an equine structure:
- Take into account all the needs and natural behavior of the horses, whether primary: drink, food, shelter from the weather, or secondary and sometimes overlooked: the need for social contact and daily outings, eating large amounts of fodder.
- Take care of the health of the animals (follow-ups by the pharmacy and the management of drugs, isolating sick animals).

2.3. Travel, transport and agricultural machinery

The widespread and increasing use of motor vehicles contributes to air pollution and global warming. The horse industry, however, requires the use of powerful motor vehicles, which is rarely compatible with low fuel consumption. Energy savings are generally found in optimizing the size of the equipment used, by adapting the vehicle power to the requirements and by choosing an appropriate form of travel.

In addition, vehicles can also contribute to the pollution of soils and waters in the case of an oil leak. A suitable storage place helps avoid this form of pollution. Employees should also be aware that driving is also an important parameter.

To limit the environmental impact of travel and transport, it is necessary:
- To limit fossil fuel consumption by optimizing equipment (using suitable sizes and power), by driving in an energy-efficient manner, by reducing travel to a minimum and by promoting carpooling, clean transport and public transport for employees and customers.
- To avoid the pollution of soil and water from vehicle malfunctions by the use of suitable storage areas and by regularly maintaining the vehicles.

In order to address this subject in an equine structure:
- Consider the motor vehicles in use and their fuel consumption, one of the measures that can be undertaken is the harrowing of the riding paths with a horse/pony for example.
- Take into account the pollution risks (soil, air, water) associated with these vehicles, with a view of mitigating them,
- Promote alternative modes of transport with employees and/or clients.

2.4. Water

Equestrian events lead to large amounts water expenditure, particularly for the irrigation of training grounds (paths or terrains). Thought should be given to reducing consumption, because these measures will have not only environmental but also financial implications. Different parameters allow the reduction of water consumption:
- The source of the water used: rainwater can be recovered in flexible, large-volume tanks,
- The quality of the soil: techniques and materials used to reduce the need for watering,
- The watering period: water in the evening or at night to avoid loss through evaporation,
- Regular maintenance of the facilities: in order to avoid leaks,
- Awareness-raising among the users of the facilities: water savings, especially during droughts.

It is also important to avoid all forms of water pollution, caused by, for example, manure storage near riverbanks, or the watering the horses directly from the river, which they can pollute with their droppings.
- To control the environmental impact on water sources, one must:
  - Not pollute groundwater and/or surface water,
  - Reduce the consumption of water,
  - Manage discharged water (washing facilities, rainwater, wastewater).

In order to address this subject in an equine structure:
- Measure and monitor the water consumption, and be aware of the main consumption points,
- Limit water consumption by the regular maintenance of the facilities (no leaks), and by optimizing watering (quantity, time of day, water source, good quality training tracks and terrains),
- Consider how discharged water can be used (recovery of rainwater and on-site treatment of waste water).

2.5. Energy (heating, lighting, equipment)

Energy considerations are both environmental as well as economic. Taking care when making use of water resources and being aware of its consumption, help avoid waste. The implementation of practical solutions to control water consumption and/or to produce energy, may be as a second stage.

In order to control the environmental impact related to energy production, one must:
- Take care to avoid unnecessary consumption,
- Monitor energy consumption (electricity, lighting, heating, hot water, etc.),
- Perform an energy audit,
- Take steps to ensure energy independence by using specific equipment and renewable energy,
- If possible, make use of the biomass produced on-site.

In order to address this subject in an equine structure:
- Establish an inventory of consumption for a few years and implement monitoring indicators,
- Schedule an energy audit to identify the highest energy consuming areas and take corrective actions. (Financial and technical support measures are available to help improve the energy performance of the structures),
- Pursue energy independence through the installation of renewable energy sources.

2.6. Outdoor spaces and landscape areas

There are multiple issues at stake when considering outdoor spaces and landscape areas. They include landscaping, the conservation of ecosystems and biodiversity and the proper management of grasslands:
- The practices an equestrian facility, as with all agricultural activities, have an impact on the landscape; the choice of outdoor facilities must be considered.
- The respect of the environment, already valued in the agricultural sector, must also be integrated into the horse industry.
- Protecting the natural environment means being aware of it, hence the importance of making inventories of the flora and fauna on the site.
- The proper management of the prairies allows grazing and biodiversity to be combined (conserving hedges, practicing rotation, avoiding overgrazing, optimizing deworming).
In order to address this subject in an equine structure:
- Be aware of the biodiversity present on the grounds.
- Implement sustainable grazing practices by avoiding overgrazing and the destruction of soil, and by maintaining hedges for example, in order to keep the pasture in good ecological condition.
- Consider the impact of the facilities on the landscape, before undertaking any new construction. Use materials and colors that blend into the landscape (wood).
- Make the stable greener by planting vegetation (using local varieties), which will help manage water and the thermal control of the structure.

2.7. Manure and waste

The management of manure is an almost inescapable problem for farms in the horse industry. New waste recovery systems are emerging and manure is generally no longer considered as a waste with a disposal cost, but as a source of energy (e.g. for methane) or organic material to fertilize grasslands (as direct application or compost or as the digestate from methanation). The following websites provide more information on the topic: www.cheval-fumier.com and www.fibiores.com

The main waste-related issues are:
- The prevention of health risks,
- The prevention of pollution risks,
- The reduction of pollution being released into the environment using waste treatment processes,
- The reduction of the consumption of natural resources through recycling.

It is important to note that any producer of waste is responsible to its final disposal. The waste produced by the activities of facility must be monitored.

In order to address this subject in an equine structure:
- Become aware of and respect the Departmental Sanitation Regulations (Règlement Sanitaire Départemental, which differ from one department to another), especially with regard to storage arrangements (e.g. for manure, see Article 155 of the DSR).
- Monitor the amount of manure produced, ensure that it is reduced as much as possible without compromising the comfort of the horses; become aware of the antibiotics in the manure management system, because they destroy the bacteria involved in composting or methanation.
- Promote composting and local spreading, or as locally as possible.
- For each category of waste, ask the following questions:
  o Is this type of waste present on the farm?
  o Is it possible to reduce its production?
  o Is it recoverable?
  o Is there a collection system in your domain?
  o Do you use it? If not, why?

2.8. Building management

As part of equestrian activity, sustainable management of buildings must be taken into consideration from its design to its use. Several basic principles must be applied in the respect of the welfare of horses and the environment:
- Consider the surrounding area, either at the level of the integration of facilities into the surrounding landscape, or in terms of nuisances (noise, smells, etc.).
- Ensure that the buildings are in good condition, and that they are optimized.
- Integrate wildlife that is naturally present in agricultural facilities, in the buildings, in order to better coexist in the surrounding environment.
- Reduce and adapt night lighting, to save energy and limit the disturbances of wildlife.
- Be aware of toxic materials and products (asbestos sheets, rodenticides) and gradually replace them with more environmentally friendly options.
In order to address this subject in an equine structure:

- Make a list of the toxic products used for building maintenance (paints, cleaning products, etc.) for limiting pests, and look for alternative solutions.
- Use every new building development to optimize the operation of the building and harmonize the entire structure.
- Maintain a clean interior and exterior, in order to ensure that the site is pleasant for both employees and for customers.
- Educate all the users of the site on the need to limit night lighting, and the obligation to turn off all lights at the end of work activities.
- Monitor the general atmosphere in the buildings (temperature, humidity, etc.).

**2.9. Team management and communication**

Sensitizing the stakeholders is one of the challenges of all processes geared towards the protection of the environment. Nothing can be done without the involvement of everyone responsible for the structure: employees, visitors and users.

**3. The EquuRES Label: A mark of environmental quality at the service of the domain**

Valorizing good practices and positioning as a leader... The label was designed primarily as a tool to help equine operations. Beyond the recognition of a high level of environmental quality, the label offers an approach and an accompaniment that provides companies with a marked path of consolidation in order to progress in combining rigorous management and quality research. This practical guide will be a collection of regulations and best practices geared towards helping candidates for the label improve their own practices. The label has three levels, to enable companies to gradually move up the ladder, in the spirit of continuous improvement. EquuRES can therefore be considered a tool for the profession in order to support the reflection by companies on the requirements related to the environment.

The EquuRES label covers all equine facilities (trainers, breeders, equestrian centers, etc.) regardless of their activity and size. It originated in Normandy and was developed by the Horse Council, with the goal of expanding throughout the region in order to become a national label. We must also point out that no equivalent label exists in the other countries of the European Union. It could therefore serve as a reference for the development of a European standard, if the need arose.

Soil or water quality, biodiversity, waste, energy, landscaping, animal and human welfare, etc. All these subjects are at the heart of regulatory and societal concerns affecting the industry. The EquuRES label breaks them down by subject under 9 evaluation tables. Each of these subjects is divided into criteria that allow for accurate assessments, according to 3 levels, on the basis of the requirements to be respected. The “proofs” (documents, invoices, on-site verifications, etc.) are specified. The subject rubrics, accompanied with a reference describing the attribution process, and a guide for supporting equine operations are the three components of the label.

The cost of certification is ultimately borne by the operators, and they expect a return in their investment. It includes the support for evaluations and the entire system in place, to which must be added the costs of entering into compliance that are incurred by the equine operations. These are highly variable, depending on the initial conditions. Much of these expenses are regulatory in nature and should have been expended even before the label process. For equine operations, it should be noted that the label is a mark of environmental quality that can be used for promotional purposes. It is also a sign of good management. The label requires the rigorous maintenance of accounting records, and the careful management of customers and suppliers, which can only be conducive to the economic health of the operation. The information guide and the other methodological documentation, the remainders of best practices and regulation, are also part of safety and good management procedures. This process will help advance the profession in meeting the challenges of regulatory compliance and the control of natural resources. It is difficult to quantify these benefits, but they are confirmed by the results of companies engaged in similar efforts in other areas.
The labelling procedure is described in the EquuRES label documentation. It follows the schema described above and consists of several steps:

- **Application**: The candidates for the label put together a file by signing a commitment by conducting a self-evaluation.
- **Evaluation**: In the absence of non-compliance, the Horse Council appoints an assessor who visits the site to assess the operator's compliance with the requirements of the label and its level. The assessors are experienced professionals or members of professional bodies, trained in evaluation procedures.
- **Decision**: Based on the assessor's report, the Committee forms an opinion. The label is granted under the authority of the Horse Council of Lower Normandy, but under the supervision of an organization certified by the French Accreditation Committee (COFRAC), which verifies both the proper operation of the system put into place, and verifies the compliance of the equine operations with the requirements of the label. The presence of an external and independent body is necessary to ensure the reliability and recognition of the label.
- **Duration of attribution**: The label is granted for 3 years, but intermediary annual audits (documentary or on-site) occur.
- **Evolution of the label**: The Committee keeps abreast of labelling decisions, and supports the entire device. It has power to change the assessment based on feedback from the field.

**Organism**

Conseil des Chevaux de Basse-Normandie, Caen, France
Weather effects on horse thermoregulation during winter

Lecturer: G. H. M. Jorgensen
Authors: G.H.M. Jorgensen (1), L. Aanensen (1), C. M. Mejdell (2), K. E. Boe (3)

Abstract

The aim of this experiment was to investigate the effects of different winter weather conditions on shelter seeking behaviour of horses and their preference for additional heat. A total of 17 horses from different breeds were habituated to an experimental paddock with a two-compartment shelter. In one of the compartments a 1500 W infrared heater provided radiation heat, the other compartment was not heated. Horses were turned out in their regular paddocks for two hours (without rugs or blankets) and then moved to the experimental paddock, where they could stay either in the heated compartment, in the non-heated compartment or outside in the paddock. Using instantaneous sampling at one-minute intervals for one hour, a present observer recorded horse’s behaviour and location. A Kruskal Wallis test was administered to the preliminary data. Shivering was only observed during relatively mild but rainy winter weather. Outdoor behaviour did not differ significantly according to weather factors, but more horses used the shelter on days with low temperatures and precipitation as snow than on days with only low temperatures (P<0.05). The individual variation in use of shelter was large. Small coldblood horses spent less time inside shelter and more time outdoors compared with small warmblood horses (P<0.05), and horses with a low haircoat sample weight used the shelter more than horses with a large sample weight (P<0.05). Individuals with a high body condition score moved around more than individuals with a low body condition score (P<0.05).

In conclusion, not only the horses breed but its body condition and haircoat characteristics affect thermoregulation behaviour during winter weather. Horses with free access to a shelter rather than rugs may be more able to cope with changing and challenging winter weather conditions.

Keywords: shelter; haircoat characteristics; breed effects; behaviour

1. Introduction

Horses are highly adaptable homoeothermic animals. They live in areas with a wide range of climatic conditions and can acclimatize to temperatures from –30 °C in Mongolia [1] to +30 °C in Tunisia [2]. An animal’s thermal environment consists of five major components: air temperature, air speed, air vapour pressure, radiant-environmental temperature and contact-medium temperature [3]. Even if the ambient air temperature is commonly used to quantify environmental heat demand [3,4], increased wind speeds will increase heat loss through convection, and precipitation that makes the skin wet increases evaporative cooling [3,4]. The level of an animal’s heat loss is dependent upon its body size and relative surface, its skin thickness, subcutaneous fat deposits and ability to grow a protective haircoat [3]. Feeding [5], age, production, housing and management add even more variables to the equation [6].

Domestic horses tend to use man-made shelters to a small degree, but shelter seeking behaviour increase up to 62 % of observations during precipitation combined with wind [7]. This finding is supported by other studies under Nordic weather conditions, where low ambient air temperatures also have increased the horses’ use of shelter [8,9,10]. Horses adjust to cold and harsh weather by producing a thick winter haircoat [10]. Many owners find this winter coat impractical due to increased sweating during training and excessive shedding in the spring. Horse owners therefore often clip their horses and use blankets. This eliminates the horses own ability to control loss of heat to the environment, during changing weather conditions. Hence, the horse’s ability to handle real winter weather conditions should be further investigated.
The aim of this experiment was to investigate the effects of different winter weather conditions on shelter seeking behaviour of horses. We also studied their preference for additional heat in the shelter, assuming that horses would choose a heated compartment during inclement weather.

2. Materials and methods

A. Location

The experiment was conducted from February to April 2013 in Sandnessjøen (65°N) at the coast of Nordland county in Norway.

B. Experimental design

At test days, the horses were turned out in their individual home paddock to acclimatize to prevailing weather factors. After two hours, each horse was led into the experimental paddock where they had free access to a shelter with two identical compartments (A and B). In one of the compartments additional heat was provided. All horses were tested repeatedly under different weather conditions, but only once per day.

C. Shelter and paddock

Two identical experimental enclosures were established, each with an outdoor paddock of 11 x 11 m (121 m²) and a shelter with two compartments each measuring 3.3 x 3.0 m (9.9 m², see Figure 1). Two individual horses could be observed at the same time, in separate experimental enclosures. Horses could not see each other, but could see other horses in paddocks approximately 20 meters away.

D. Experimental procedures

Before horses could be tested in the experimental set-up, they were trained to enter both compartments in the shelter and were given time to habituate to the paddock outside the shelter. Individual horses were led by halter into each compartment and offered 0.5 kg of hay. When horses voluntarily (and without being led) entered both compartments in the shelter and ate the hay, the horse was ready to start the experiment.

On each test day, horses were offered their normal ration of feed before they were turned out into their home paddock. After the test, the horse was either led into the barn to dry up, or (in most
cases) dressed with its rug and led back to their home paddock. Horses were ridden and trained as usual and fed three times per day during the test period.

**E. Horses and samples**

A total of 17 horses from different breeds and ages (3-28 years) were used. Breed categories were suggested according to horse weight, height and whether the horse came from a typical warmblood or coldblood breed [11].

Hair coat samples were collected from a 3x3 cm area above the gluteal muscle and the clipped hairs were dried for 2 days and weighed. Hair samples were later categorized according to weight: 1: low hair coat sample weight (0-1 g); 2: medium hair coat sample weight (1-2 g) and 3: large hair coat sample weight (2-3.3 g). One horse was clipped before the test, making it difficult to collect a coat sample.

Body condition was scored using an adjusted standard scoring system [1-9] on different body parts [12]. Each horse was given a total score, this mean score was categorized as follows: 1: low body condition score (3.0-3.5); 2: medium low (3.6-4.0); 3: normal (4.1-4.5); 4: medium high (4.6-5.0) and 5: high body condition score (5.1-5.6).

**F. Behavioural observations**

The horses were observed by a present observer for one hour from the start of the test. The following mutually exclusive behavioural categories were scored using instantaneous sampling at 1-min intervals (Table 1).

At the same time as the horses behaviour was recorded, the observer also noted where the horse was located, using three location alternatives: 1: outside in paddock, 2: in heated compartment, 3: in non-heated compartment.

<table>
<thead>
<tr>
<th>Behaviour</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stand relaxed</td>
<td>Standing in a relaxed body posture, may also sleep</td>
</tr>
<tr>
<td>Stand tense</td>
<td>Standing with fore feet and hind feet closer together. Head low. Body tense. Tail tucked between hind feet.</td>
</tr>
<tr>
<td>Shiver</td>
<td>Stand or move slightly with involuntary muscle shivering.</td>
</tr>
<tr>
<td>Moving</td>
<td>The horse moves around, walking or running</td>
</tr>
<tr>
<td>Other</td>
<td>All other behaviours: sniff, roll, urinate/defecate, scratch</td>
</tr>
</tbody>
</table>

**Table 1 : Ethogram of behaviours recorded**

**G. Weather parameters**

Weather factors were continuously recorded by the present observer and by a professional weather station (ITAS), located 15 meters from the shelter. Data on wind (directions and speed), precipitation, air temperature and sunshine were gathered. Weather during the tests was later defined into four categories as follows: 1= ≥ 0 °C (3 days); 2= ≤ 0 °C (6 days); 3= ≥ 0 °C and precipitation (7 days) and 4= ≤ 0 °C and precipitation (5 days). There was little wind during tests. The effect of wind was therefore not included.

**H. Statistical analysis**

A Kruskal-Wallis test was performed on the effects of weather, body condition and hair coat sample weight on horse behaviour and location. Weather category (1-4), body condition score category (1-5) and hair coat weight category (1-3) was treated as class variable and each behaviour or location was tested against these separately. All tests were performed using the Npar1way command in the statistical analysis software SAS 9.2.
3. Results

A. Use of shelter

The weather conditions significantly affected the time spent inside the shelter. When the air temperatures were below 0°C combined with precipitation, the horses spent around 60% of the time inside the shelter whereas at air temperatures below 0°C and no precipitation the horses spent around 30% of the time in the shelter (Fig 2). Even when it was raining, the horses spent only around 35% of the time inside.

During cold and snowy weather the horses were observed inside the shelter more than on days with low temperatures and no precipitation (weather category 2) \((x^2=7.8; P<0.05)\). Coldblood horses spent less time inside shelter and more time outdoors compared with warmblood horses \((x^2=9.9; P=0.007; \text{Fig } 3)\).

B. Thermoregulatory behaviour

The most common behaviour observed was “stand relaxed” (Fig 4). Muscle shivering was only observed on a few occasions, and both “shiver” and “stand tense” was in fact mainly observed during relatively mild but rainy weather (Fig 4). Significant differences in horse behaviour between weather factors could however not be found.

Small coldblood horses were more active and walked more around \((26.7 \pm 5.5 \% \text{ of total observations})\) than horses of all other breed categories (ponies: \(4.0 \pm 0.1\%\); large coldblood horses: \(7.7 \pm 2.1\%\); small warmblood horses: \(5.4 \pm 2.0 \%\) and large warmblood horses: \(6.0 \pm 2.3 \%\); \(x^2=18.5; P=0.001)\).
C. Effects of haircoat and body condition

Horses with a low haircoat sample weight showed a tendency to use the non-heated compartment more (29.0 ± 5.5 % of total observations) than horses with a high sample weight (11.0 ± 2.1 %) (x²=5.8; P=0.053). Horses with a high haircoat sample weight seemed to spend more time outdoors, but the difference between categories was not significant.

Horses with a high body condition score (category 5) showed a tendency to be outdoors more (77.4 ± 4.9 %) than horses with a low body condition score (category 1: 50.4 ± 9.3 %; x²=9.4; P=0.051). When outdoors, these horses with a high body condition score (5: 15.7 ± 4.5 %) also walked around more, compared to horses with a low body condition score (1: 3.1 ± 0.8 %; x²=11.8; P=0.018).

4. Discussion

As given in table 1, horses did not change their general behaviour according to the studied weather factors, but increased their use of shelter during cold and snowy weather. This indicates that riding horses of a wide range of breeds can handle winter weather quite well. Correspondingly, other studies from Sweden and Finland report little to no change in behaviour in thoroughbred horses [8] and American standardbred horses [9] as winter temperatures dropped considerably. Clipped horses will however need additional weather protection when air temperatures drop below 6°C [13].

The presence of the behaviours “shiver” and “stand tense” were only recorded during mild weather and rain. This finding is in accordance with Mejdell and Bøe [10] who also recorded only one occasion of muscle shivering in one individual during similar weather. Low temperatures per se were not a problem, although horses in our study increased their use of shelter when low temperatures were combined with snow. This is perhaps due to the relative mild coastal climate and high humidity. Air temperatures were never lower than -7 °C and hence snow was possibly much wetter than reported in inland Sweden [8], Finland [9] and Norway [10].

Small coldblood horses were much more active than the other breeds, and spent more time outdoors and less time inside the shelter. Cymbaluk and Christison [14] reported that yearling horses increased their play activity during cold weather while other studies have claimed a decrease in movement as temperatures decreased [15]. It is still a question whether horses adopt the strategy of increasing or decreasing activity in cold weather. We also found that horses with a high body condition score walked around more in the outdoor paddock compared to horses with a low body condition score, indicating a possible correlation between breed and body condition scores. On the other hand, this may reflect the fact that fatter horses were less affected by the winter weather conditions, and walked around investigating the paddock. These possible correlations will be further investigated using additional data from 2014 and adjusted statistical models to include and correct for such effects.

More important for evaluating the need for rugs and blankets, may be the insulation properties of each individual [11, 13], regardless of breed. We found that horses with a low haircoat sample weight showed a tendency to use the non-heated compartment more than horses with a high sample weight and horses with a high body condition score showed a tendency to be outdoors more than horses with a low body condition score.

Offering access to a shelter during turnout may be better than applying rugs and blankets. With a shelter, the horse is also able to adjust its heat loss to the environment [7,16] as weather changes during the day. It may get the benefit of sunshine and scratching itchy places, and it will not get sores from chafing or get its movement restricted by the rug(s). At the same time, the horse is able to get away from wind and precipitation and find shade [7].

In conclusion, weather conditions that make the horse wet are more difficult for them to cope with than low temperatures per se. The horses body condition, size and coat characteristics may be a better indicator of its ability to handle cold winter weather, rather than horse breed. Providing shelters in paddocks may be better than using rugs and blankets, allowing horses with intact hair coats to control their heat loss during shifting weather throughout the day.
Acknowledgments

The authors would like to thank the Swedish-Norwegian horse research fund for financing this project. We thank Arne Johan Vold who helped to build, and secure the shelter and paddock. We also appreciate that private horse owners let us borrow their horses and that the stable owner helped organizing, feeding and moving horses on test days.

References


Organisms

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Barns and green construction, what are the stakes and the solutions?

Lecturer: J.Y. Blanchin
Author: J.Y. Blanchin

Summary

Green construction means creating a building that respects the environment as much as possible. The agricultural profession is increasingly engaging in sustainable development initiatives for its operations and its farming practices. These approaches can be applied to farm buildings, by using the charter entitled “Building environmentally friendly barns.” It consists of four main topics around which the choices for designing of an environmentally-friendly revolve:

I. Insertion into the site for a green design/renovation of farm buildings;
II. Materials, construction techniques, resources and construction waste: limiting the use of raw materials and waste, maximizing recycling;
III. Energy, water and waste activities: limiting needs, limiting pollution emissions, promoting renewable energy;
IV. Comfort and health: protecting the health of staff and animals, improving their comfort.

These four areas include 67 points, one third of which are considered essential and must be followed for any green building project or renovation. In order to facilitate the use of this approach, a technical guide for farmers, their advisers and building designers is offered as a companion to the charter. It allows the goals and the challenges of the different points to be assessed correctly, and it also facilitates consulting. The guide demonstrates through practical examples the technical solutions currently available and provides reminders about regulations, for each point in the charter.

This charter is one of the outcomes of a research program entitled “Application of green building and environmental management approach for farm buildings,” which brings together partners from the world of agriculture and construction, funded by CASDAR/MAAPRAT.

Keywords: barns, construction, energy, environmental impact, building materials.

You will find below the evaluation scale of the charter "Building environmentally friendly barns". For each one of the 4 topics, the first line of the table allows to evaluate actions and steps of the project:

<table>
<thead>
<tr>
<th>Topic</th>
<th>Commitment during the project phase</th>
<th>Validation after completion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete action implementatio or comments</td>
<td></td>
<td></td>
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<tr>
<td>Point unavoidable</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ecobél éco-construire un bâtiment d’élevage</th>
<th>Yes</th>
<th>No</th>
<th>Yes</th>
<th>No</th>
<th>Not applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vgets of the HQE approach</td>
<td></td>
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</tr>
</tbody>
</table>
### I. Integration into the site for an environmentally-friendly design/renovation of farm buildings

#### I.1. Relationship between the building and the site - [target 1]

1-1 I try to recover existing buildings

1-2 I take down abandoned buildings

1-3 I consider the natural and scenic qualities of the site when considering the building's location

#### I.2. Traffic and transportation - [target 1]

2-1 I limit the movement of vehicles in and around the buildings

2-2 I organize the access to the site for deliveries, pick-ups and collection

2-3 I organize the circuits towards the plots and I make use of rotation to reduce distances

2-4 I analyze the possibility of exchanging plots to optimize the farm's layout

#### I.3. Rainwater and runoff - [target 1]

3-1 In designing the building, I am mindful of the hydrology of the site

3-2 I install a collection system for roof rainwater and runoff (ditches)

3-3 I separate roof rainwater and runoff from waste water

3-4 I recycle and re-use roof runoff.

#### I.4. Impact on the neighboring area during the use of the building - [target 1]

4-1 I have an architectural project drafted (choice of building form, materials, colors ...)

4-2 For the construction of a new building, I limit environmental nuisances (noise, dust, odors)

#### I.5. Biodiversity on the site

5-1 I conserve and develop vegetated areas using native species

#### I.6. Local resources

6-1 I choose a building system that is adapted to local resources (straw, ...)

### II. Materials, construction techniques, resources and construction waste: limiting the use of raw materials and waste, maximizing recycling

#### II.1. Economy of materials - [target 2]

1-1 I optimize the design and quantities of materials in the construction plan (building, annexes and surroundings)

1-2 I try to allocate space for multiple purposes whenever possible

#### II.2. Materials and construction techniques - [Target 2, 3, 7 and 12]

2-1 I consider the lifecycle analysis of the materials used.

2-2 I choose green-certified materials

2-3 I use precaution with materials that may pose health risks

#### II.3. Construction waste - [target 3]

3-1 I verify that companies have organized the sorting and the management of construction waste and the recovery of polluting effluents from the site

3-2 I verify that the company has planned and
assessed the costs of waste treatment in the documents responding to the call for offers

3-3 I plan for the management of excavated soil and demolition rubble, working with companies already implicated on the site

II.4. Site nuisances (noise, dust, traffic, visual appeal) - [target 3]

4-1 Together with the construction companies, I organize the construction site to minimize the nuisances and I make sure that the organization is effective

4-2 I inform local residents about the progress of my site and I take their opinions into consideration

4-3 I choose low nuisance construction materials and techniques for the site

4-4 I ask that companies to agree to use machinery that respects acoustic regulations

II.5. Organization of the site

5-1 I am aware that I must appoint an SHP coordinator (Safety Health Protection)

III. Energy, water and waste activities: limiting needs, limiting pollution emissions, promoting renewable energy

III.1. Energy savings - [target 4]

1-1 I forecast future energy consumption in the design phase of the building

1-2 I undertake an energy audit once the building is in operation

1-3 I put my electrical system in accordance with norms

1-4 I install counters (electricity, gas, oil) for the building

1-5 I install one or more devices for heat recovery or energy efficiency

1-6 I favor natural ventilation solutions where possible (unless heating or health constraints)

1-7 I evaluate and optimize the heating and ventilation systems, when possible

1-8 I optimize the manure processing sites using efficient methods in order to avoid excessive energy consumption

1-9 I use natural lighting whenever possible

1-10 I choose low consumption lighting systems that are switched on only when needed

III.2. Use of renewable energy - [target 4]

2-1 I look into various solutions for the use of renewable energy (use, power ...), as tailored to my needs

2-2 I try to give priority to renewable energy (hot water, electricity, heat pumps, biomass, ...).

III.3. Water consumption - [targets 5 and 14]

3-1 I forecast water consumption in the building design phase

3-2 I check my water consumption, once the building is in operation

3-3 I install a water counter that is specific to livestock

3-4 I plan to use materials and water saving
<table>
<thead>
<tr>
<th>Practices</th>
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</thead>
<tbody>
<tr>
<td><strong>III.4. Waste, livestock waste and gas emissions</strong></td>
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<tr>
<td>4-1 I install a sorting system if waste sorting facilities are available</td>
<td>X</td>
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<tr>
<td>4-2 I choose low maintenance materials to minimize waste associated with building maintenance</td>
<td></td>
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<tr>
<td>4-3 I respect the maintenance procedures, the product dosages, and I limit their use as much as possible</td>
<td>X</td>
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<tr>
<td>4-4 I create a protected storage space for animals found dead</td>
<td>R</td>
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<tr>
<td>4-5 I analyze the management of organic fertilization and I respect the plan for spreading</td>
<td>R</td>
<td></td>
<td></td>
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<tr>
<td>4-6 I use equipment or practices that reduce greenhouse gases</td>
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<tr>
<td>4-7 I choose a treatment system for effluents that is low impact</td>
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<tr>
<td><strong>III 5 Building maintenance</strong></td>
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<tr>
<td>5-1 I maintain my building to keep it running optimally</td>
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<tr>
<td>5-2 I assure the maintenance work is undertaken using non-polluting and nuisance-free techniques</td>
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<tr>
<td><strong>IV. Comfort and health: protecting the health of staff and animals, improving their comfort</strong></td>
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<tr>
<td><strong>IV.1. Bioclimatic requirements = temperature, humidity, air velocity, gas</strong></td>
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<tr>
<td>1-1 I determine the climate comfort requirements according to the physiological state of the animals, and I put into place the means necessary to meet them</td>
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<tr>
<td>1-2 I implement a system for the exchange of air and the control of air currents and minimize animal discomfort</td>
<td>X</td>
<td></td>
<td></td>
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<tr>
<td>1-3 I study the ergonomics of workstations and I optimize them</td>
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<tr>
<td><strong>IV.2. Acoustic comfort</strong></td>
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<tr>
<td>2-1 I limit the noise sources of the materials and equipment</td>
<td></td>
<td>X</td>
<td></td>
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<tr>
<td>2-2 I install soundproofing on equipment and engines</td>
<td></td>
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<tr>
<td><strong>IV.3. Lighting comfort</strong></td>
<td></td>
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<tr>
<td>3-1 I provide the correct quantity and quality of light, for both the working environment and the animals</td>
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<tr>
<td>3-2 I choose bright colors for materials, but ones that promote calm behavior in the animals</td>
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<tr>
<td><strong>IV.4. Food safety</strong></td>
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<tr>
<td>4-1 I choose materials so that the VOC, glycol ether and formaldehyde levels remain below the levels recommended by the WHO</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4-2 I design my building for easy maintenance and good hygiene (cleaning and disinfection)</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4-3 I put up a sanitary barrier before the entrance to the animals (with disinfection)</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4-4 I avoid the crossing of clean and waste water channels (forward movement principle)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4-5 I design my building to comply with good farming practices (I am certified by the Charter of</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
good animal husbandry practices, or I try to apply the Best Available Techniques)

IV.5. Water quality - [targets 5, 14]

5-1 I undertake annual studies of the water used

5-2 I protect the land surrounding private sources

References


Links for more information


Organism

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Abstract

The welfare of horses in a stable depends on many factors but one of the most important is the quality of the air. The horse diseases of the respiratory system have different names depending on the developmental stage of the disease but in the origin they address all the same triggering conditions: the extreme sensitivity of the horses’ respiratory system to many allergens that may be present in the environments in which they live and/or the contact with the ammonia present in a badly treated bedding.

Keywords: horses, equine welfare, ventilation, air quality, lung disease

Introduction

The presence of the allergens causes an allergic response/inflammatory of the bronchial tree that is expressed with cough. Bronchospasm that occurs with time progressively narrows the lumen of the terminal portions of the bronchial tree, disrupts the normal flow of air to the deepest parts of the lung, reducing the normal exchanges necessary for the oxygenation of the blood and for elimination of carbon dioxide.

Therefore, the most important health concern for horses living stabled is ventilation. Natural ventilation, including vertical ventilation, is the most important design consideration, both in new buildings than in renovation. The barn must be designed to be a natural machine, not just a static structure. It’s important to use the Bernoulli principle and the chimney effect to create it. The barn should be placed perpendicular to the summer prevailing breeze in order to take the most advantage of the site.

The main source of allergens that cause respiratory problems are present in the hay and in the grains dust. The condition is even more enhanced if the environments where the horses stay are inadequate and lack of proper ventilation. Irritants are also present in beddings, both in clean and new that in dirty ones. So it appears that respiratory diseases on an allergic basis are among the most feared diseases in the stable. Let’s explore this issue more deeply.

Under this heading there are a number of diseases of the respiratory system of the horse, that are often called by different names (chronic obstructive bronchitis, COPD, disease of the small airways, pulmonary emphysema, pulmonary emphysema, chronic bolsagge...) but they all recall that the origin of the disease is always the extreme sensitivity of the respiratory system of the horse to many allergens (dust, fungi and mildew) that may be present in the environments in which they live or for the contact with an untreated beddings or a bedding which is renewed with too long intervals. In fact, the ammonia present in the dehiscence becomes irritating for the horse at very low concentrations. The contact of these allergens with the respiratory system of the horse elicits an allergic / inflammatory response at the level of the bronchial tree. This is expressed by the presence of cough, which in turn is caused by stimulation performed by phlegm produced in response to contact with the allergen. If the stimulation of these environmental agents persists over time, it results in a condition of continuous bronchospasm that with the passing of the months progressively narrows the lumen of the terminal portions of the bronchial tree (bronchioles and terminal bronchioles) and disrupts the normal flow of air to the deeper parts of lungs, reducing very much the normal exchanges necessary for the oxygenation of blood and for the elimination of carbon dioxide. This situation means that the breathed air remains trapped inside as the pulmonary alveoli...
progressively lose their elasticity (leading to emphysema). If the condition persists, the lung of the horse, as well as having reduced the respiratory exchanges, also alters its shape resulting in the so-called "barrel chest"; in an attempt to help especially the expiratory phase of respiration, which in normal conditions is mostly passive, auxiliary breathing muscles get involved with the action of the intercostal and some of the abdomen muscles. Unfortunately this condition, with the recurrence of episodes and once past the acute phase, determines irreversible anatomical and functional abnormalities of the respiratory system. This means that in case of chronic conditions a real healing in the sense of a complete functional recovery of breath is no more possible. A horse suffering from a mild form of bronchitis on an allergic basis, promptly diagnosed and treated, in the future will not have problems related to a past pathological episode, while a horse with a chronic form of pulmonary emphysema will have serious problems to carry out even a simple walk.

As said above, the main source of allergens which cause these conditions is the dust present in the first place in the hay; if a minimum grade of "contamination" may be unavoidable it's absolutely disgraceful to give the horse dusty or moldy hay. It would be like triggering a bomb! The condition is even more enhanced if the stalls themselves are inadequate and lacking of proper ventilation. Also the quality of the feeded grains must be taken into account as a source of dust-laden allergens. Irritants may be present again in beddings, particulary if you use shavings of poor quality, if they are not correctly cleaned daily or if the air circulation is not adequate. The basis of allergic diseases may be of varying degrees from horse to horse and the clinical manifestations found in horses that live in the same conditions may also be different as, of course, a certain individual susceptibility plays a role. But we must consider that all horses have extreme susceptibility to respiratory diseases on allergic basis and then inevitably, any horse that is frequently in contact with these allergens will encounter respiratory diseases.

There is no drug therapy or improvement of the products used that makes sense if at the same time you do not take appropriate measures to remove the source of these allergens.

Methodology

Also any stressful condition in the respiratory system may increase the incidence of other diseases of the same apparatus. So at least the regular vaccination against equine influenza virus is always proper and necessary. To try to limit as much as possible the contact between horse and dust / mold and agents capable of causing relapse, it is strictly necessary to adopt some simple rules:

- Ensure the horse a stable with the correct air exchange.
- Give the horse only good quality hay, absolutely free of dust and mold.
- Soak the hay before giving it to the horse.
- Feed only high quality grains free from dust.
- Put the grains in a bucket and cover them with water a few hours before the horses’ meal.
- For particularly sensitive horses use pellet hay.
- When cleaning stalls, avoid horses being inside during this operation.
- Provide for regular vaccination of the horse at least with regard to equine influence.

The most severe forms of these diseases, reducing the performance of the horse, if hidden under sale, make the horse unacceptable, resulting in a financial loss for the owner or the breeder.

Insight

Ventilation is one of the most important considerations when designing a barn that is healthy for horses. It is essential in every barn, regardless of whether it is located in a hot or cold climate. And, luckily, good ventilation does not require purchasing expensive equipment or running energy-guzzling systems. A ventilation system that both reduces the risk of disease and benefits the environment is simple to achieve - with the right design knowledge and techniques.

The goal for a healthy stable is vertical ventilation. Mechanical systems, in the form of electric exhaust fans, are not only expensive to maintain and run, they can put the safety of your barn at risk. Most obviously, mechanical systems can be a fire hazard. Yet they also pose danger in the way they ventilate; exhaust fans draw air laterally across the barn. This horizontal airflow increases the risk of passing pathogens and unhealthy gasses from one animal to the next.
Upward, vertical ventilation actually reduces the risk of disease for horses by minimizing the amount of damp, stale, contaminated air in their stables. Designs that create this ventilation harness natural solar and wind power to effortlessly provide a strong interior current and upward movement of air in the barn. The air current within a well-designed barn is strong enough to ventilate the interior, even on a still summer day.

Maximizing natural light is also an integral part of our sustainable design efforts in horse stables. Not only does relying on less electricity save money and energy, plentiful natural light fosters a healthy environment for owners and their horses. In addition, fewer electric lights reduce fire hazards. While eliminating electric lighting is unrealistic, there are several techniques that make the most of natural light. The result is a healthy stable for your horses that is friendly to the environment and efficient for owners and breeders.

In the drawing below, you will see how the placement of adequate and properly placed openings, along with the installation of translucent surfaces in the roof which allow the heating of the air in the upper part of the stable, can create the correct natural air circulation, which with its flow removes all harmful agents present in suspension, on the ground and in stored materials.

Correct air flows inside the stable (from J.A.Blackburn – Healthy Stables by Design)

Results

Without the need for mechanized air circulation or large windows, the correct positioning of air vents allow optimum air quality for the breathing of horses. This leads to a substantial reduction of all those diseases of the respiratory system generated by allergens, mold, dust and irritation given by a high percentage of ammonia in the air.

Conclusion

During design and construction, or in the renovation of existing structures, it is of paramount importance, before thinking about the aesthetic aspects of a stable, to carefully examine the details needed to create a healthy environment from all points of view, before all the air that horses breathe.
Oakhaven Ranch – Austin, Texas – The installation of translucent surfaces in the roof allow the heating of the air in the upper part of the stable, creating the correct natural air circulation. A good number of opened surfaces, correctly positioned, allow natural air circulation (stall doors, windows with fins on the roof and on the upper part of perimeter walls.) (from J.A.Blackburn – Healthy Stables by Design)

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Housing for horses in Normandy

Introduction

The Calvados Chamber of Agriculture has a long history of accompanying projects of housing building of all variety of animals. We help project managers make their decisions on future investments in construction. Though housing dimensions and animal species may differ, there are a set of common, basic standards for animal welfare, work conditions and ventilation that must be followed. However, the issue of adult horse housing in a single box is unique, with economic and production concerns that differ from other kinds of animals.

Over the past few years, we have been responding to an increasing demand for horse housing with the design of facilities that generally conclude with the application for a building permit. Our constructions are often internal stables, which are more sensitive to ventilation problems for this reason.

The ventilation of stables in Normandy often makes use of what is known as “natural ventilation,” which is to say ventilation without the use of mechanical means (fans, extractors). Indeed, the closed buildings are generally fairly large and are therefore easy to ventilate. In order to ensure proper functioning and good ventilation, a dual-slope building must not exceed 20 meters in width. Certain rules must be followed, however, in order to regenerate the air in the stables. Ventilation will contribute to healthy animals and a healthy building, helping to evacuate gas, steam and stale air. By converting food into energy, animals generate heat. They also release heat through respiration and perspiration. Manure also produces gas.

The atmosphere in a stable should be free of dust and gas, and the air should be renewed regularly.

For this type of ventilation, there must be a temperature difference between the inside and the outside. Cold air entering into the building will be heated and will rise before being exhaled through an open ridgepiece. The inlets are spread along the sides of the building and will be open at the ridgepiece along the length of the roof. This system allows air to enter and exit without drafts. The openings are placed rather high along the long sides so that the air does not fall directly onto the horses. In this case, the openings may be equipped with covers, but care must be taken not to create protrusions that can injure the horses.

Poorly ventilated buildings are easily identified. Traces of condensation can be seen on the walls or on the structure, or the smell of ammonia will be noticeable.

For construction projects and general principles of ventilation, we work with complete and long-standing studies developed by the Institute of Livestock and the Chambers of Agriculture.

Wind effects

Before examining the proper ventilation of the building, the zone in which the building will be constructed or located must be understood. Depending on the natural elements and obstacles in the zone, we can determine how the ventilation of the building will take place. This is a first step towards understanding and recognizing the wind effects that will help ventilate the building. Many different wind effects exist in nature; the main ones are listed below.
Using this diagram, it is possible to see how the wind will act with a corridor effect that will strike against or through the building. This type of construction will require a natural protection in front of the building at a distance of 15-20 meters.

This sectional diagram shows us all the wind effects against a building, a wall or a hedge. There are two important phenomena that must be identified: suppression and depression. Suppression allows us to bring “new” air into the building and draw out old air. The “plan view” diagram below highlights the wind effects on an obstacle.
The guide effect comes from a wall or a building. The wind slides along a wall. The corridor effect can be likened to an air stream; in order to reduce this effect, there must be at least a dozen meters between the buildings and the natural elements.

In this diagram we can observe a wind effect that often perturbs the ventilation in buildings. We regularly find this type of obstacle on site in the form of slopes or hedges.

In this diagram, we can see how the wind glides over the construction and prevents the ventilation of the second. This type of construction should generally be avoided.

The orientation of the building is important; we typically orient our buildings south-southeast, which provides a large amount of sun during the winter. This also produces less exposure to prevailing winds.
Physiological requirements

<table>
<thead>
<tr>
<th></th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Température</td>
<td>5°</td>
<td>30°</td>
</tr>
<tr>
<td>Humidity</td>
<td>40 %</td>
<td>70 %</td>
</tr>
<tr>
<td>Volume &lt; 148 cm at the withers</td>
<td>20 m³</td>
<td>27 m³</td>
</tr>
<tr>
<td>Volume &gt; 148 cm at the withers</td>
<td>27 m³</td>
<td>40 m³</td>
</tr>
<tr>
<td>Air inlets</td>
<td>Winter 30 cm²</td>
<td>Summer 90 cm²</td>
</tr>
<tr>
<td>Air outlets</td>
<td>Winter 12 cm²</td>
<td>Summer 36 cm²</td>
</tr>
</tbody>
</table>

The physiological needs of horses are taken into account, of course. The temperature range is wide but little or no freezing may occur, and it is important to know whether the horses will be housed in the summer. In this case, it may be necessary to insulate the building, at least on the roof. Moreover, even if the stables are insulated, they must be ventilated. Humidity is important, because high levels of humidity may damage the insulating properties of the horse’s coat, and low levels can dry the horse’s nasal mucosa, keeping it from working effectively. Adequate building volumes help avoid abrupt changes in temperature that can harm the health of the horses. For internal stables, the volumes are often important if the central corridor is used in the calculation.

Air inlets

In order to bring air into a box without a draft, a window may suffice, but it brings in air at the same height as the animals. It is better to reserve these openings for satisfying the natural curiosity of the horses and for supplementing the summer air inlets. Wherever possible, it is preferable to construct air inlets using a slatted wood sidings (15 cm planks spaced at 1.50 cm). This type of installation will reduce the speed of air flow and will distribute air throughout the long side wall without drafts. The installation will be placed above the animals, at least 2.40 meters above the litter. In contrast, wood siding, though helping to integrate the building into its environment, must be accompanied by a system for natural lighting. The surface coefficient is used to calculate how much siding must be used.

<table>
<thead>
<tr>
<th>Selection criterion</th>
<th>Wood</th>
<th>Perforated sheet</th>
<th>Wind-breaking net</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface coefficient</td>
<td>7</td>
<td>7.3</td>
<td>1.29 à 2.15</td>
</tr>
<tr>
<td>Longevity</td>
<td>++</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Mechanical strength</td>
<td>++</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Ventilation efficiency</td>
<td>++</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Rain protection</td>
<td>++</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Luminosity</td>
<td>+</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Resistance to dust</td>
<td>++</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Integration with landscape</td>
<td>++</td>
<td>-</td>
<td>+</td>
</tr>
</tbody>
</table>

For example, for a horse whose winter needs are 0.30 m², the width of the box is 3.50 m and the siding chosen is slatted wood. To find out the height of the siding, we calculate as follows:

Winter needs x surface coefficient / the width of the box, which yields:

$$0.3 \times 7 / 3.50 = 0.60 \text{ m of siding height}.$$  

In this case, the siding must be 2.40 m above the floor of the litter; the building being 3.00 m minimum up to the bottom of the gutters.

If we use a wind-breaking net with the surface coefficient of 2.15, we calculate as follows:

$$0.3 \times 2.15 / 3.50 = 0.20 \text{ m of siding height}.$$  

Air outlets

The air outlet systems available today are mainly open ridges and are the simplest to implement. However, skylights are much more interesting because, in addition letting hot air escape, they limit the amount of air reflux. In addition, these skylights are sold with translucent covers, making them not only useful for lighting purposes, but also helping to avoid the patchwork effect of roof plates that hinder the integration of the building into the landscape.
Chimneys are more difficult to implement; they are reserved for the conversion of existing buildings. They must not exceed the ridge-piece by more than 50 cm. A chimney is effective at a maximum radius of about 7 meters. We have not tested the effectiveness of turrets.

**Natural light**

Natural light also helps create a good atmosphere in the stable. Many buildings have transparent roof panels. This is an economical solution that is offered by manufacturers to project managers. However, roof plates help promote sudden changes in temperature. Roof lighting should therefore be installed in the central corridor and a translucent strip along the long side.

**Conclusion**

The building of a stable is an important moment in the life of a horse breeder, due to the many factors that must be considered, such as the housing of the horses, of course, but also work and economic factors. Any project is often a compromise. Nevertheless, the building’s ventilation must be taken into account from the very beginning, because problems can start from the layout of the building.

**Organisme**

Chambre d’agriculture du Calvados, Caen, France
Ventilation impact on environment of horse stables and indoor riding arenas during cold weather

Lecturer : E. E. Fabian-Wheeler
Author : E. E. Fabian-Wheeler

Abstract

Cold weather usually presents the most challenging conditions for maintaining good air quality in equestrian facilities throughout most of North America with limited fresh air exchange due to closed windows and doors. Poor indoor air quality is particularly true with the trend to tighten construction to ‘residential’ standards in horse stables rather than recognizing horses as ‘livestock’ needing special consideration. Construction ventilation openings are recommended based on long-term experience and the results of two on-farm studies of stables and indoor riding arenas. Instrumentation for humidity and temperature were installed to monitor conditions related to ventilation performance within five naturally-ventilated stables and eight indoor riding arenas. The facilities are characterized in terms of ventilations system parameters, riding surface material characteristics, air temperature and humidity. Results found that horse stables were adequately-ventilated when construction included permanent openings that allow air exchange even in the coldest weather. But stables were often more humid than outdoors during cold weather as measured by absolute humidity. Well-ventilated stables have an abundance of planned fresh air inlets whether they are eave and ridge vent assemblies or cracks associated with wood board “Yorkshire” siding. A recommendation from these studies and long term observation of horse stable environments is to provide at least 1000 cm² (1 ft²) of permanent opening per stabled horse for cold weather air quality. This opening is best provided as a long, narrow slot inlet, preferably at the eave of each stall exterior wall. Indoor riding arena ventilation varied from 0, 0.3, 0.4, 1.4, 9.1, and 21.5 m² opening per 100 m² arena floor area. A recommendation from these studies is to supply at least 1.4 m² of opening per 100 m² of arena floor area to provide fresh air conditions in the indoor riding environment. Indoor arenas were almost always more humid than outdoor conditions. Air quality and humidity were influenced by the arena riding surface material, particularly related to water use for dust suppression. Elevated absolute humidity inside enclosed riding arenas, versus outdoors, has implications for building materials (such as insulation and metal fasteners) that can handle long-term exposure to humid conditions. There is encouragement that simple construction improvements can be made to easily improve facility indoor air quality with the associated horse comfort and welfare.

Keywords : ventilation, openings, stable, indoor riding arena, environment, humidity, temperature

I. Introduction

The objective of ventilation during cold weather is to provide fresh air quality to each stabled horse. This is achieved simply by providing sufficient, permanent openings throughout the stable or indoor riding arena so that fresh air can enter and stale air exhaust from the facility. Compared to our homes or offices, horse facility air has more dust and molds from feed and bedding or riding surface materials and moisture and odor from deposition of urine and feces. Yet there is a misguided trend to accept residential ventilation practices as suitable for horse facilities often resulting in poor air quality during cold weather. Ventilation might be one of the most over-looked requirements of horse facilities partly because horses have different environmental requirements as they are maintained for longevity and athletic performance [2, 3, 4]. Others suggest that the trend toward insufficient ventilation is a combination
of misunderstood ventilation principles and misguided attempt to provide human-comfortable versus horse-comfortable conditions [8, 12]. Much is written on the importance of good stable air quality (such as [1, 3]) and its impact on equine respiratory health and athletic ability yet very few studies have documented air quality conditions within horse facilities. Poor air quality is more common during cold weather conditions when stable doors and windows are kept closed, often resulting in increased indoor dampness along with associated odor and ammonia.

A damp environment has implications for not only horse health, as aerial disease pathogens are more abundant, but also building longevity. Dust, condensation, and high aerial moisture levels require that building structural components be selected to withstand conditions that are more similar to an outdoor versus a dry indoor climate. Many indoor arenas suffer from chronic dust problems as the riding surface material dries and is then stirred into clouds of dust from horse hoof action [13]. Common dust management practice is to thoroughly dampen the surface material to add weight to the small, light-weight dust particles and to help bind particles together [17]. Much is known about ventilation strategy and design (such as [7]) and ventilation impact, through air quality, on animal performance [3, 9] and now in relation to horse facilities [11, 16]. The use of small, portable low-cost temperature and humidity sensing and recording devices has been demonstrated in livestock housing to monitor conditions related to ventilation effectiveness and good air quality [14, 15].

II. Methods

Findings of two on-farm studies are reported here combined with long-term observations of horse facility ventilation practices that resulted in high quality indoor environments. All stables and indoor riding arenas were ventilated by natural forces of wind and/or thermal buoyancy with no supplemental heat or mechanical (fan) ventilation.

Electronic measurements were made with relatively inexpensive, yet accurate, sensors to not only collect data but also as demonstration of technique. Temperature (T) and relative humidity (RH) were measured with Hobo Pro units [Onset Computer Corporation, Pacasset, Massachusetts, USA; +/−0.4°C [+/-0.7°F] and +/-3% RH in standard resolution mode at temperature range under study]. These were battery powered, wireless sensors with integral data-logger for recording conditions. Outdoor temperature and humidity were monitored, for comparison to the indoor environment, housed in an OnSet radiation shield. Absolute humidity (AH) was calculated from RH and T data and was chosen for analysis to provide a more consistent comparison of the actual amount of water in the air than using RH. Relative humidity analysis is confounded by its dependence on temperature [10]. Sensor location is critical for representative data collection and detail may be found in [15, 18, 19].

Data-logging sensors were installed at multiple locations in each indoor riding arena, one shielded from solar radiation outdoors, and at least one in the stable. During stable environment studies multiple sensors were located in the horse stalls. For analysis, a 72-hour (3 day) time period was selected for a “study period” based on the criteria of cold temperatures and hypothesized heavy indoor riding arena use. For example, one study period [18] was a winter holiday weekend also being the coldest during the study period with average outdoor temperatures across all six riding arenas ranging from -16.3 to -3.9°C (2.6 to 25.0°F).

A. Background stable and riding arena evaluation

During late winter 2000 three horse boarding stables and two indoor riding arenas were monitored for temperature and humidity profiles. Study objective [19] was to collect background information on ventilation practices and conditions in horse facilities during cold weather conditions since little was known at that time. Sensors were mounted on stall walls and protected by wire cages from horse damage. Surprisingly, horses showed the least curiosity (destructiveness) for the sensors of all livestock environments (poultry, swine, dairy, veal) evaluated with these sensor applications. Two stables were renovated dairy bank barns [Figures 1 and 2] with the third, attached to a bank barn, a well-designed naturally ventilated stable [Figure 2]. All three stables’ ventilation relied on hundreds of meters of 1 mm cracks between barn boards, sometimes referred to as “Yorkshire” board cladding, allowing diffuse air infiltration for cold weather air exchange. The well-designed stable also had substantial eave and ridge vent permanent openings.
B. Indoor arena environment

In a second study, six horse boarding and training facilities were selected based on indoor arena characteristics. The arenas featured a number of characteristics common in indoor arena construction and management (Table 1). Natural ventilation openings consisted of combinations of ridge and eave openings, cupolas and sidewall curtains (detail in [18]). Two of the arenas were directly attached to the horse stable and did (Site 1) or could (Site 3 when doors were open) share common airspace with the horse stable environment. The other four arenas were separate structures from the horse stabling. An estimate of the ventilation opening size of each arena used during the study period (Table 1) ranged from 0.3 to 9.1 m² of opening per 100 m² of arena floor area with two exceptions. One arena provided no cold weather openings with ridge vents and access doors all closed tightly. The second exception was a curtain-sided arena that was kept fully open, even during cold weather, for 21.5 m² opening per 100 m² arena floor area. Ventilation opening size was estimated from dimensions at each facility and then adjusted, if necessary, for treatments over those openings, such as window screens (66% open area) or perforated soffit material (5% open area) that inhibit airflow as characterized in [11].

Each arena had a different riding surface, or footing, material ranging from a moist, organic stall waste (Table 1, Site 1) to dry, inorganic washed sand. The other organic footing, wood chips, was kept rather dry while inorganic footings were very dry (Table 1). Manager experience with the footing material and dust control practices were noted in relation to the temperature and humidity environment found in the indoor arena.

C. Good Ventilation Criteria

Indoor environment was evaluated using criteria that determine how well the natural ventilation was performing. Temperatures uniformity to within 2.8oC (5oF) throughout the structure indicated suitable air distribution within the interior [15]. Appropriate air exchange correlates to interior temperature within 2.8 to 5.5oC (5 to 10°F) of outdoor temperature during cold weather [6, 11]. None of the arenas or stables had supplemental heat so that temperature increase over outdoor conditions was from sources such as solar gain, equipment (lights), and sensible heat from stabled or exercising horses. Relative humidity levels were considered acceptable when they tracked the profile of outdoor conditions. Correlation of indoor and outdoor humidity pattern has been observed during times of adequate ventilation in other livestock housing studies [5]. During inadequate ventilation, or when supplemental heat is used, the pattern of indoor to outdoor humidity levels is inconsistent.
### Table 1: Indoor arena size, ventilation parameters, and riding surface materials

<table>
<thead>
<tr>
<th>Facility</th>
<th>Size (m ft)</th>
<th>Ventilation Openings Used During Study Period</th>
<th>Ventilation Opening Size m² per 100 m²</th>
<th>Footing Material</th>
<th>Footing Moisture (%) &amp; [Organic Matter (%)]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site 1</td>
<td>45.7x19.5 (150x64) Attached</td>
<td>Eave &amp; Ridge Openings</td>
<td>9.1 (91)</td>
<td>Stall Waste</td>
<td>35 [85]</td>
</tr>
<tr>
<td>Site 2</td>
<td>48.8x18.3 (160x60)</td>
<td>Curtains, Eave Openings &amp; Cupolas</td>
<td>21.5 (215)</td>
<td>Hardwood Chips</td>
<td>14 [67]</td>
</tr>
<tr>
<td>Site 3</td>
<td>18.3x45.7 (60x150) Attached</td>
<td>Eave &amp; Ridge Openings</td>
<td>0.4 (4)</td>
<td>New Limestone Gravel</td>
<td>2 [7]</td>
</tr>
<tr>
<td>Site 4</td>
<td>45.7x32.9 (150x108)</td>
<td>All Openings Closed</td>
<td>0</td>
<td>Worn Quartz Sand</td>
<td>5 [5]</td>
</tr>
<tr>
<td>Site 5</td>
<td>48.8x21.3 (160x70)</td>
<td>Eave Opening &amp; Cupolas</td>
<td>0.3 (3)</td>
<td>New Quartz Sand</td>
<td>1 [3]</td>
</tr>
<tr>
<td>Site 6</td>
<td>36.9x18.3 (121x60)</td>
<td>Eave &amp; Ridge Openings</td>
<td>1.4 (14)</td>
<td>Limestone Sand &amp; Wood Shavings</td>
<td>10 [20]</td>
</tr>
</tbody>
</table>

- a. Arena attached to stable with access to stable aerial environment.
- b. Site 4 had no open ventilation openings during the study period.
- c. Ventilation openings and size used during cold weather with additional openings available for warmer weather.
- d. Average values of nine footing samples collected in each arena during study period.

### III. Results

Findings from the first background ventilation evaluation found that the three stables with Yorkshire board-crack ventilation openings performed adequately according to the stated natural ventilation criteria. The stable with eave-ridge vent system, in addition to the board-crack openings, provided the most uniform and desirable environment during cold weather. The indoor riding arena environments were similar to outdoor temperatures but were surprisingly humid, presumably due to the large quantities of water added to the riding surface to decrease dust.

Using the ventilation criteria for characterizing uniformity and air exchange, the six indoor arenas of the second study fell into three groups: "well-ventilated" where conditions met or exceeded guidelines at all times (Sites 2 and 6), "adequate ventilation" where conditions mostly met guidelines, and "poor ventilation" where conditions commonly did not meet guidelines (Site 4). Despite the label of "indoor" riding area, conditions within these facilities were almost the same as outdoor conditions and, for some management styles, even harsher. Indoor arenas have a reputation of being dusty and the data collected showed high humidity. Figures 3 and 4 (at end of article) show temperature and humidity measures for two of the study arenas considered 'adequate' ventilation.

Figure 3 features data including a stable attached directly to the indoor arena. Builders of these facilities have noted troublesome condensation in the arena near the stable connection from warm, humid air. The temperature in the horse stable indicates inadequate ventilation during most nights with high absolute humidity and temperatures, but daytime may compensate with good ventilation. Figure 4 shows temperature and humidity trends that are near outdoor conditions indicating a fresh air environment in the indoor riding arena.
Figure 3: Temperature, absolute humidity, and relative humidity outdoors and at three arena sensor locations in the eave and ridge ventilated Site 3 indoor riding arena. A stable was attached to this arena so stable environment parameters are shown to demonstrate the effect of shared airspace with the indoor arena. “Standard” refers to jump supports.

Figure 4: Temperature, absolute humidity and relative humidity outdoors and at three arena locations in the eave and cupola ventilated Site 5 indoor riding arena.
IV. Recommendations

Furnish horse stables and riding arenas with ventilation openings that are permanently open year-round, even during cold weather.

Each horse in a stall should have direct access to fresh air openings. A guideline is to supply each stabled horse the equivalent of at least 1000 cm\(^2\) (1 ft\(^2\)) of permanent opening into its stall to allow ventilation at all times [11, 12]. The best location for this permanent opening is at the eave (where sidewall meets roof). A slot opening, of 2 to 3 cm wide, along the eave that runs the entire length of the stable is most effective. There are several benefits of this continuous slot opening. The slot provides equal distribution of fresh air down the length and on both sides of the stable, providing every stall with fresh air. The opening's position at the eave, 3 to 4 meters above the floor, allows the incoming cold air to be mixed and tempered with stable air avoiding drafts on the horse. The long slot inlet is desirable during cold weather since air enters the stable through a relatively narrow opening as a thin sheet of cold, fresh air rather than as a large, drafty mass of air provided by an open window or door.

Indoor arenas were well ventilated with acceptable air quality conditions when openings were provided of at least 1.4 m\(^2\) per 100 m\(^2\) arena floor area. This can be provided by long narrow slot inlets at the eaves such as supplied in the horse stable.

A minimum guideline for cold climates is to provide at least 2 cm continuous-slot, permanent opening for each 3 m of building width for horse stables. For a 3.5 m wide stall, a 3 cm wide continuous slot will supply approximately 1000 cm\(^2\) of permanent opening.

V. Summary

Natural ventilation openings for indoor riding arenas allow interior conditions to be similar to outdoor but with protection from challenging conditions such as uncomfortable wind and precipitation.

Despite the label of “indoor” riding area, conditions within these well-managed facilities were almost the same as outdoor conditions but often with higher humidity. Increased air moisture levels were seen in the indoor arenas with stables attached when moist stable air had access to the arena environment.

Moisture from the large quantities of water used to dampen dust in the arena riding surface materials was thought to be the main contributor to the high indoor absolute humidity rather than horse activity alone.

Ventilation opening ranged from nearly 0 (totally closed) to 21.5 m\(^2\) per 100 m\(^2\) arena floor area, the latter for an open curtain-sided building. “Well ventilated” conditions, as determined by humidity and temperature levels, were observed and recommended for unattached arena with openings of at least 1.4 m\(^2\) per 100 m\(^2\) arena floor area.

Observed high humidity condition needs to be recognized for indoor arena construction material selection, such as insulation and metal fasteners, that will maintain long-term integrity in a humid, condensing and dusty environment.

Measurement protocol has been developed for horse stable owners and their advisors (veterinarians, feed suppliers, etc.) to monitor horse stable environment with relatively inexpensive data-logging sensors.

Acknowledgments

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References


Organism

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The effect of design, and management regime on the respirable particle concentrations in 2 different types of horse stables

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Authors : M. J. S. Moore Colyer, E-J. Auger

Abstracts

Respirable particles (RP) of <5 µm in size, found in the stable environment have a major negative impact on respiratory problems in horses and can cause the debilitating allergic condition known as Recurrent Airways Disorder (RAO). The level of dust is influenced by the management regime, e.g. choice of bedding, forage, ventilation rate and stable management activities. The aim of this study was to investigate the relationship between respirable dust in the breathing zone (BZ) of the horse and the general stable zone (SZ) under different management regimes, in either American Barns or straight-block stables.

Ten different American barns (housing 38 individual stables) and 34 individual stables in 9 different straight block designs were used for data collection. Samples of respirable dust were collected from the area close to the horse’s nose (breathing zone) and the middle of the stable (stable zone) using a cyclone personal air sampler (Munro personal sampler AS 200) for each management regime of either 1. Steamed hay and shavings; 2. Dry hay and shavings; 3. Haylage and straw; 4. Dry hay and straw. Stables were sampled between 15.00 and 16.00 during quiet periods in the yards. RP were captured on nitrocellulose membrane filter papers, which were fixed with triacetate and RP counted using a microscope and eyepiece graticule. Results were calculated per litre of air and the data analysed using a Wilcoxon Matched-Pairs test (Genstat 15) with significant differences between means set at P<0.05.

The lowest respirable particle concentrations (< 360 RP/l air) for both stable designs across both zones were found when the management regime was shavings and steamed hay. Straw and dry hay produced the most amount of dust in the SZ and the BZ of 6250 and 5079 RP/l air in American Barns respectively and was significantly greater than the 2901 and 942 RP/l air measured from the straight stables. In contrast, straw and haylage produced significantly more respirable dust in both zones in straight stables compared with American barns. Shavings and dry hay produced significantly more dust in the BZ than in the SZ in both stable types, while straw and haylage produced more dust in the SZ compared with the BZ across both stable designs.

Keywords : Dust, respirable particles, stable, Recurrent Airways Disorder (RAO)

I. Introduction

It is widely acknowledged that dust, particularly respirable particles (RP) of <5 µm in size, found in the stable environment have a major negative impact on respiratory problems in horses and can cause the debilitating allergic condition known as Recurrent Airways Disorder (RAO). Respiratory problems are second only to lameness as a reason for poor performance and lost training days in
racehorses[1,2]. The level of dust within the stable environment is influenced by the management regime, i.e., the choice of bedding[3] and forage[4], and horse care activities, such as mucking out and sweeping[5]. Airspace and ventilation rate are also key factors when considering the removal of dust from the stable. Four changes of air per hour is considered low by some researchers [6] while others [7] propose 27 changes of air / hour to be high.

Many racehorses in Europe are kept in loose-boxes within an American Barn and thus share airspace. Jones and co-workers [8] reported serious negative consequences in terms of respiratory health, when 7 horses shared airspace of approx. 39m², particularly during calm conditions when the ventilation rate was low at only 6.6 changes of air / hour. Increasing the ventilation rate in an American barn system by leaving windows and doors open was reported [9] to significantly decrease particulate matter in the air, however, horse owners often cite inclement weather as a reason for closing doors. In single stables the airspace available to the horse is restricted by box size and roof height and air movement can be negligible if back or side windows are kept closed. However, the horse only inhales dust created from its own bedding and forage and often does not have to be subjected to the dust created by yard-sweeping, filling hay nets, and grooming.

The aim of this study was to investigate the relationship between respirable dust in the breathing zone (BZ) and in the general stable zone (SZ) when horses were kept on different management regimes, in either American Barns or single stables. The objective was to investigate if a certain combinations of bedding and forage made a greater or lesser contribution to dust in either a shared airspace or single box housing system.

II. Methodology

Stables and management regime

Thirty eight individual stables in 10 different American barns, and 34 individual stables in 9 different stable blocks across Gloucestershire, Wiltshire and Berkshire in UK were sampled for respirable dust concentrations during November and December in 2013. Within each housing type the stables were divided into the following 4 management regimes 1. Steamed hay and shavings; 2. Dry hay and shavings; 3. Haylage and straw; 4. Dry hay and straw. An average of 8 replicate stables was sampled for each regime within each housing system. Stables were sampled between 15.00 and 16.00 during quiet periods in the yards when no horse management activities were taking place.

A. Dust sampling

Dust samples were taken from 2 areas within each stable; 1, from the area close to the horse's nose (breathing zone ) and 2, the middle of the stable (stable zone) using a cyclone personal air sampler (Munro personal sampler AS 200). In order to sample the breathing zone (BZ) the cyclone sampler was attached to one side of the horse's head collar, close to the nose and the pump attached to a girth-roller, so the horse could move its head freely and walk around the stable. The stable zone (SZ) sample was taken by holding the cyclone sampler in the middle of the stable for 3 minutes. The horse was free to move around the stable when the SZ samples were taken. The cassettes of the cyclone sampler were pre-loaded with a nitrocellulose filter paper in the laboratory prior to visiting the stables. The cyclone pump was set to flow at 1.9 litres of air / minute in order to facilitate the separation of dust by size. Respirable particles (RP), those < 5 µm in size, were captured on the filter paper, while particles of >5µm were deposited into a rubber pot at the base of the cyclone. The cyclone was run for 3 minutes thus dust from a total of 5.7 litres of air was captured.

B. Dust enumeration procedure

Post sampling cassettes were transported back to the laboratory were the nitrocellulose membrane filter papers were mounted onto microscope slides and fixed in 5 drops of triacetate. Slides were stored in a dust-free incubator and left for a minimum of 3 days so that the filter paper could clear and counting could be done. RP were counted at x40 magnification using a standard laboratory binocular microscope using the procedure detailed in Moore-Colyer [10].
C. Data analyses

Results were calculated per litre of air and the data analysed using a Wilcoxon Matched-Pairs test (Genstat 15) with significant differences between means set at P<0.05. Data were analysed firstly with stable type as the matched pair and breathing zone and stable zone as the y-variates and secondly with breathing zone and stable zone as the matched pairs and stable types as the y-variates. All data was separated and analysed on the four different management regimes.

III. Results

The lowest respirable particle concentrations (<360 RP/l air) for both stable designs across both zones were found when the management regime was shavings and steamed hay as detailed in Table 1. On this regime no significant differences were found between dust levels in either zone or across both stable designs, (Table 2). Dry hay and straw produced 3349 more RP / litre of air (P<0.04) in the stable zone and 4136 more RP (P<0.02) particles in the breathing zone in the American Barn stables compared with the single stables.

Feeding haylage and bedding on straw produced significantly higher (P<0.04) levels of dust in the stable zone in single stables compared with American Barn systems, while the dust levels in the breathing zones remained the same across both stable designs. Dry hay and shavings produced significantly (P<0.008) more dust in the BZ of both stable types.

<table>
<thead>
<tr>
<th>Stable Zone</th>
<th>Breathing zone</th>
</tr>
</thead>
<tbody>
<tr>
<td>American barn</td>
<td>Straight block</td>
</tr>
<tr>
<td>Steamed hay + shavings</td>
<td>314</td>
</tr>
<tr>
<td>Dry hay + shavings</td>
<td>522</td>
</tr>
<tr>
<td>Haylage + straw</td>
<td>972</td>
</tr>
<tr>
<td>Dry hay + straw</td>
<td>6250</td>
</tr>
</tbody>
</table>

Table 1: Respirable particle (RP) content / litre of air in American Barn and single stables when subjected to four different management regimes.

<table>
<thead>
<tr>
<th>Stable Zone</th>
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<tbody>
<tr>
<td>American barn</td>
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</tr>
<tr>
<td>Dry hay + straw</td>
<td>6250</td>
</tr>
</tbody>
</table>

Table 2: Respirable particle (RP) content / litre of air in American Barn and Single stables from the the breathing zone (BZ) and general stable zone (SZ) measured under to four different management regimes.

IV. Discussion

Results from this study clearly demonstrate that different forage and bedding types have major impacts on dust concentrations in horse stabling. Steamed hay and shavings produce the lowest level of respirable dust across both zones and stable types and thus is the preferred management
regime for horses stabled either in America Barns or in single stables. These results are comparable with earlier findings [11,12] that reported significantly lower RP in stables where horses were fed low-dust forage i.e., silage and bedded on wood shavings compared with stables where horses were fed dry hay and bedded on straw.

While dust levels in the stable zone and breathing zone in this experiment were influenced by bedding and forage respectively, generally using straw as a bedding material put more dust into the whole stable compared with using dusty forage and this dust permeated the breathing zones of all the individual horses. However, bedding on shavings and feeding dry hay also put considerably more dust into the stables than when steamed hay was fed. Feeding haylage and bedding on straw produced significantly higher (P<0.008) levels of dust in the stable zones of both American Barns and single stable types compared with the breathing zones. However, the same regime produced significantly (P<0.04) more dust in the SZ in single boxes compared with America Barns stables indicating lower clearance levels possibly due to low ventilation rate or restricted air space in single stables compared with American Barns. The dust in the breathing zone was unaffected by the straw and haylage regime between stable types.

Clements [4] reported that putting just one stable in a row in an America Barn system on a low dust regime can significantly lower RP levels across the barn. The results from this experiment support this finding, as when considering dust levels across both zones, horses fed dry hay and bedded on straw were breathing in significantly more dust particles / litre of air (5664) in the American Barn stables compared with horses on the same regime in single boxes (1922 RP / litre of air), thus showing that dusty forage and bedding in an American Barn system has an accumulative effect by increasing the RP in the shared air space and that dust from one stable has a strong influence on the others sharing the same air space.

General sweeping, grooming or shaking straw and shavings were not standardized in this experiment, however, samples were taken during quite times in all the stables, thus no direct creation of dust occurred. However, Lacey [13] indicated that once dust is airborne, dust particles of 5 µm or less obey Stokes Law and unless removed by ventilation stay in the atmosphere for very long periods. Thus some of the dust sampled could have been a result of stable management activities that morning. However, these results still show the levels of dust horses are exposed to in different stable types and give a real-life measurement of the impact of management regime on dust in the stable environment.

V. Conclusion

Results from this experiment clearly show that feeding steamed hay and bedding horses on shavings produces the lowest level of dust and is thus the preferred regime whether used in American Barn stables or single stables. Feeding low-dust forage or using low-dust bedding will only partially reduce the dust in the stable environment and cannot be recommended as a management regime for performance horses. Dry hay and straw produce a very dusty environment in both stable types but the effect is magnified when horses have a common airspace as in an American Barn. Dry hay and bedding on straw cannot be recommended as a suitable management system for any stabled horse but is particularly hazardous for those animals kept in American Barns.

References


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Use of haynets on the welfare of horses

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Abstract
The welfare of stabled horses is often compromised. Many epidemiological studies point out the prevalence of abnormal behaviours like crib-biting, weaving, woodchewing, pacing etc. Colic and gastric ulcers seem also linked with life in the stable. Some risk factors have been identified: lack of social contact, confinement and lack of roughage in the diet and time spent eating. To increase eating behaviours, stable devices have been put on the market. Haynets made of rugged materials with 32mm and 38mm holes were tested to evaluate their impact on horses behaviours. Ingesting time is greater with nets compared to loose hay and it induces a decrease in chewing rate. Haylage seems to need more chews than traditional hay with shorter fibres. However haylage is consumed more rapidly than traditional hay. New behaviours appear during eating with nets compared to loose hay: the head might be twisted and tossed up. No osteopathic incidence was revealed by a veterinarian for the 2 months long study. We conclude that this type of haynet could be a good device to increase eating behaviours and time spent eating but the type of roughage provided will influence its efficiency.

Keywords: welfare, haynets, haylage, stable device, horse

Introduction
Horse management has come to a point that brings welfare concern to the foreground. Many management practices have been identified as risk factors for developing abnormal behaviours, especially stereotypes like crib-biting, wood-chewing, weaving, pacing (e.g. [1] and a review [2]). More recently, epidemiological studies about gastric ulcers reveal that a great part of sport and even leisure horses are affected [3]. Ulcers may induce changes in behaviour and loss of performance [4] which indicate an altered degree of welfare. Confinement, overtraining, social isolation, lack of roughage in the diet and shortened time spent eating are those risk factors. As free roaming horses do not suffer from these troubles and that domestication doesn’t seem to have had any influence on horses’ time-budget it is thought that tending to a more natural time-budget under domestic conditions would improve the welfare of horses. Increasing visual horizons for observational needs [5], daily turnout to fulfill the need of free movement [6], allowing permanent social contacts [7], have been proved to be successful in reducing the number of abnormal behaviours.

As feeding occupies about 15h of the time-budget [8] and as many horses in stables consume their total amount of food in a few minutes it seems easy to increase the time spent eating and the number of behaviours involved in this activity. Slowfeeders for delivering concentrate like the EquiballTM [9] are successful but do not answer the need for fibre.

Providing ad libitum hay is an easy solution which restores a time-budget similar to a free roaming horse [10]. However two problems arise from this practice. The first is the waste of hay the horses make as they mix some part of the hay in their bedding and will not consume it. The second is the lack of control of the amount of hay ingested. Many horses need a well controlled diet and for this reason need a limited quantity of hay. That’s why the use of haynets is more and more popular and many types are on the market. Their effectiveness has solely been evaluated. One study [11] noted an improvement in the social relationships in a group of mares in a paddock thanks to the provision of hay in nets. The direct action on feeding has been studied only in two papers. Zeitler-Feicht and Walker [12] found an increase of ingesting time with a net (86min/kg vs 40min/kg). Neveux [13]
revealed some prehension behaviours associated with nets of 45mm holes versus 100mm like nuzzling and head twisted. As the type of haynet might have an incidence on behaviour or not, we tested two types of haynets sold on the market with smaller holes: 38mm and 32mm. The length of the fibre plays a role on ingestion too: the higher the vegetation, the more horses chews and the less they bite grass [14]. We also tested the incidence of fibre length on eating behaviours.

Material and methods

The study was conducted during 5 weeks in two parts:

Part A: 5 horses were naïve haynet feeders. They were fed haylage (85% dry matter) on various quantities per horse (from 4kg to 6kg/horse/day). Their behaviours around prehension and posture during hay feeding were noted. Three heights to hang nets were tested: 1.50m, 1.30m (the bottom of the net reaches the floor) and flat on the floor. A veterinarian checked the animals before the study started and after it was completed: body weight was estimated with a barymetric ribbon and osteopathic tensions were assessed.

Part B: 8 other horses were allocated to the follow up of ingestion rate and number of chews depending on the type of haynet (32mm vs 38mm holes) compared to loose hay and depending on type of roughage (haylage of 85% dry matter vs traditional hay). These horses were already used to feed on haynets. They were fed 8kg of hay or haylage/day.

Results and discussion

Part A

Like Neveux [13] found for haynets with 45mm holes, new postures were elicited: upwards head toss for a net hangged at 1.50m (height of the hook) and twisted neck for both hights as opposed to loose hay and hay on the floor for which this behaviour was not existing.

We know that while eating grass, horses have a step between their front legs and also for the back legs. While eating loose hay, this posture was noted but not during other feedings even haynet on the floor. No osteopathic difference was observed by the veterinarian nor any change in body weight during the study. No damage was observed on the incisors. The vet reported that some materials used for nets can have an abrasive effect seen in a few weeks.

Part B

The range of chew rates seems to be influenced by the type of forage even if the statistical tests are not relevant for comparing 4 individuals to 4. A trends exist for a greater number of chews while eating haylage (loose: 71 ± 4.9 / in a net 38 mm holes: 66 ±4.18 / in a net 32 mm holes: 65 ± 1.65) compared to hay (loose: 61 ± 2.45/ in a net 32 mm holes: 41 ± 5.45 / in a net 38 mm holes: 40 ±5.51).

This range of chew rate is in agreement with literature which indicates 1.0 to 1.7 chews/s, which is 60 to 102 chews/min. The number of chewing movements decreases when hay or haylage is provided in nets as opposed to loose hay or haylage. This is probably induced by the difficulty to grasp hay in nets with relatively small holes.

Ingestion time for 1kg of roughage tends to be greater when provided in nets vs loose for the hay (loose: 40 min/kg ±9.48 / net: 93 ±32.9). So the number of chews which rate decreases with the use of nets would be consequently greater if we had an absolute value of chews per day (loose: 15468 ± 3158 / in a net 38 mm holes: 34875 ±19005 / in a net 32 mm holes: 31031 ± 14316). It is estimated that a horse eating fibres chews 57000 times over 24h but could be halved if the diet is modified (500kg body weight, 5kg roughage and 7.8kg concentrate) [15]. In the present study horses were able to consume their straw bedding which will increase the total number of chews. Chewing rate can vary a lot regarding the type of diet. It is illustrated here by the trends to consume haylage in nets more quicker than traditional hay. This could be explained for two reasons: haylage is more appetitive than traditional hay and long fibres are easier to grasp from the net than shorter fibres (traditional hay). Individual differences do exist too. For example the horse named Oxygen eats 1 kg of hay in 64 min in the 38 mm net compared to the horse named Shangai who eats the same kg in 146 min.
Conclusion

We conclude with this pre-study that haynets made out flat rugged strips with 32mm and 38mm holes can increase the time spent feeding. However individuals show different behaviours when using the device. The effect could then be modified depending on the horse. The type of roughage for example haylage vs traditional hay will also influence the foraging time. As haylage is highly appetitive to horses and not provided ad libitum we recommend to provide it in this type of nets to increase the time spent feeding. Some new behaviours arise from the use of the devices. For a 5 weeks use no detrimental effect was detected. Further work should be done to assess the role this devices could have on postural muscles on the long run and if these behaviours are maintained or vanish. The follow up of the wear out of teeth would be of great interest in the long run as chewing rate is impacted by the use of nets.

References


Organisms

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Positive social interactions in horses housed in a stable, due to a partially open partition

Abstract

In domestic living conditions, the opportunities for social interactions between horses (whether in a stable or out in the field) are often limited, despite it having been shown that such interactions are essential for their welfare. One of the causes claimed by owners is their concern of the horses hurting each other. In this study, we randomly observed the behaviour of 12 horses: either living for 5 days in a traditional stable with a single opening (door overlooking a courtyard), or living for 5 days in a stable equipped with an additional partially-open lateral partition, enabling social interactions with the neighbouring stable. The results showed that in the case of an open partition, positive social behaviours were significantly more often expressed than agonistic social behaviours (P<0.01), and that in the case of an open partition, the horses spent significantly less time looking outside the stable (P<0.01) and less time resting in a standing position looking towards the door (P<0.01). The results of this study not only highlighted the fact that horses are able horses to enjoy social interactions when housed in a stable, but also that this entails other behavioural changes. Within a welfare perspective, these results illustrate that a partition allowing horses to freely express their natural behaviour could be a means for improving the living conditions of horses housed in stables.

Keywords: social interactions, housing, stable partition, welfare

I. Introduction

In domestic living conditions, the opportunities for social interactions between horses are often limited in terms of frequency and lapse of time. In the case of opting for stable accommodation with individual paddock turn-out, tactile contact opportunities between own species are somewhat rare, even inexistent. One of the causes claimed by owners is their concern of the horses hurting each other. Having said that, the horse is a sociable species for which the possibility to socially interact has been demonstrated as necessary for its welfare [1] [2] [3] [4] and, moreover, that such possibility improved its relationship with man, making breaking-in, for example, easier [5 [6]. The aim of this study was thus to determine whether the case of an open stable partition (90-cm opening), enabling interactions between neighbouring horses, would encourage the expression of positive social interactions and would entail behavioural changes, compared with horses housed in a traditional stable without an open partition.

II. Material and methods

We compared the behaviour of 12 horses (5 females and 7 geldings aged between 7 and 18 years), housed in 9m2 stables overlooking a courtyard. Each horse was observed at random, 5 days in a stable with an open partition (hereinafter “with partition”), giving access to a fellow kind (Figure I), and 5 days in a stable without an open partition (hereinafter “without partition”).
In the “with partition” condition, each stable was randomly allocated to a same horse. Even-tempered pairs were thus formed. During the two days leading up to the observation phase, each pair was placed in contact with each other via a partition equipped with protective bars.

Each morning before being ridden and/or each afternoon before being turned out in individual paddocks, the horses were observed using the scan-sampling method. Observations by the same person lasted for 60-minute periods over three separate sessions. One single behaviour per horse was recorded per minute, i.e. 180 different behaviours recorded per horse, per day. The behaviours recorded are shown in Table 1.

The Statview 5.0 software was used for the statistical tests. We compared the various behaviours recorded in accordance with the two housing conditions: in a stable “with partition” and “without partition” (Wilcoxon non-parametric test). For the “with partition” condition, we also compared the positive social behaviours and the agonistic social behaviours of all the horses (Mann-Whitney non-parametric test).

<table>
<thead>
<tr>
<th>Behavioural categories recorded</th>
<th>Smell</th>
<th>Touch (ears pricked)</th>
<th>Mutual grooming</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive social behaviours</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agonistic social behaviours</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resting positions</td>
<td>Standing</td>
<td>Standing looking towards the door</td>
<td>Sternal or Lateral</td>
</tr>
<tr>
<td>Look</td>
<td>Towards the partition</td>
<td>Towards the door</td>
<td>Head overhanging the door (viewing the courtyard)</td>
</tr>
</tbody>
</table>

Table 1: Behaviour recorded

III. Results

In the case of an open partition, positive social behaviours (e.g. smell, touch and mutual grooming) were more often significantly expressed than agonistic social behaviours (e.g. threat, biting attempts and wall kicking) (p<0.01) (figure IIb). No injuries were observed throughout the study. Moreover, in the case of an open partition, horses spent significantly less time looking outside the stable (P<0.01) and less time resting in a standing position looking towards the door (P<0.01) than when without an open partition (Fig.2).

The results of this study not only highlighted the fact that horses are able to enjoy social interactions when housed in a stable, but also that this entails activity changes throughout the day, changes that seem somewhat positive, since linked to the presence of a fellow kind (e.g. resting whilst looking inwards, notably towards its neighbour via the open partition).
IV. Conclusion

Contrary to generally-accepted ideas, such expressed social behaviours between neighbouring horses are essentially of a positive nature as opposed to agonistic, which thus reduces the risk of accident. These results are important within a welfare perspective, whereby a partition allowing horses to freely express their natural behaviour could be a simple means to implement, in view of improving the living conditions of horses housed in stables. The set-up of this type of partition could thus be planned when renovating a stable block or when building new stables, and could be an asset for new businesses (e.g. livery stables) that place horse welfare at the heart of their preoccupations.

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References


Organisms

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Abstract

The aim of this study was to examine the influence of a horse’s living conditions in relation to its welfare, to its personality and to its learning ability, as well as to the safety of handlers. In order to do so, two batches of 10-month old foals were kept for 12 weeks, in either control (N=9) or enriched (n=10) living conditions. The “control” batch lived in a stable on wood shavings with 3 meals a day, each foal being turned out individually every other day for one hour in a paddock. The “enriched” batch lived in a stable on straw bedding and was confronted with many types of stimulation, such as new objects, different smells or even a varied diet. It was turned out to pasture at night as a herd. Back in the stable, the “enriched” batch neighed significantly less, demonstrated less aberrant behaviour, with less alert and ears-back positions, and tended to rest more often lying down. Their personality was also modified, since they became less emotional, more trusting of man and were less wary of tactile stimulations. They were also easier to handle and express less defensive reactions. And finally, they were more efficient when confronted with complex learning tasks. Such enrichment thus improves welfare, reduces emotivity in young horses, increases the learning ability and reduces dangerous behaviour towards human.

Keywords: enrichment; stereotypies; behavioural reactivity; human-animal relationship; accidents; learning; housing

I. Introduction

The living conditions of the Equus ferus caballus, or domestic horse, are often far removed from those out in the wild. Indeed, whereas a horse out in the wild will spend 60 to 80% of its time feeding itself on the move [1], a domestic horse is more often housed in confined stables, being turned out daily for short periods and essentially fed a concentrated diet with dry forage. Such conditions can cause a number of abnormal behaviours, including stereotypies that affect between 5.2% and 32.5% of the equine population [2, 3]. Other abnormal behaviours [pawing the ground or licking the walls and bars], qualified as “aberrant” behaviour, and which may evolve into stereotypies, have been highlighted in young horses housed in stables, as opposed to those living out in a grassy field [4]. Not only such abnormal behaviour may be considered as indicators of disquiet, but may also induce non-negligible consequences for the owner as regards the sale price or the potential loss of the animal’s performance [5].
Several studies have enabled to identify environmental enrichments for horses living in a stable, with the aim of overcoming such problems. Such enrichments concern the diet, the social environment, the structure of the buildings and the provision of sensorial stimuli. Diet enrichments serve to increase the time horses spend eating, whilst stimulating their taste buds. In order to do so, it is possible to vary flavours and diet formulae [6], or to use systems for progressively dispensing feed and set up in different places around the stable [7]. Social enrichments serve to bring the horse into contact with fellow playmates. Several studies have shown that the fact of keeping animals in a herd, whether during weaning [4, 8, 9] or in training [10, 11], enables to reduce any aggressive behaviour towards man, as well as the appearance of abnormal behaviour. Concerning stable layout, the size and choice of bedding will affect a horse’s welfare, notably as regards its resting attitude [12, 13]. To end, many research teams proposed adding various sensorial stimuli to the surroundings. These are known to stimulate the exploratory behaviour [14], to enhance a state of quiet [15] or to reduce stress [16]. However, generally-speaking, the effect of these enrichments has only been tested individually, and often only on a single parameter (i.e. either on stereotypies, or on the safety of handlers, for example). The aim of this study was thus to observe the impact of the simultaneous set-up of several environmental enrichments in relation to diet, to the social environment, to the building structure and to the provision of various stimuli, for the purpose of proposing a comprehensive programme for use in situ. Moreover, we studied said impact using several parameters at the same time: stress and welfare, in addition to personality (fearfulness, gregariousness, etc.), reactions when handled and learning ability. In order to do so, we placed one group of yearlings in “control” living conditions and another group in “enriched” living conditions. The living conditions of the first group were directly inspired from common equestrian practices: individual stable accommodation, no enrichments, wood-shavings’ bedding and limited daily turn-out. For the second group, a fully enriched programme was set up, inspired from prior studies described in literature. Our assumption is that this programme would enable to improve the welfare of horses, to reduce their reactivity and to enhance their learning ability, while making them safer and easier to handle.

II. Material and methods

A. Animals

The study was conducted at the INRA (National Institute for Agronomic Research-Nouzilly) on 19 Welsh pony foals aged around 10 months, give or take a month (average height at withers: 10.3 hh or 1.08 m). They were all reared together, up until the start of the study: out at grass in the summer and in open stabling in the winter. The experiment lasted 12 weeks (Figure 1), during which the foals were separated into 2 batches: one batch was housed in “control” living conditions (N=9) with another batch housed in “enriched” living conditions (N=10). Handling and presence by man was the same for both batches. All had free access to water due to the automatic troughs installed in each stable.

B. “control” living conditions

The foals were housed individually in 1.6 x 3.5 m² stables on wood shavings. They were turned out in individual paddocks three times a week for 1 hour. Although unable to make any physical contact, they could see, hear and smell each other. They were fed 1 kg pellets morning and evening placed in the mangers, with 2 kg hay at midday placed in nets.
C. “Enriched” living conditions

From Monday to Friday, 9 a.m. to 4 p.m., the foals were housed individually in 4 x 5 m² stables on straw bedding. They were then turned out to grass until the next morning. They were fed 3 meals a day. The morning and evening meals were comprised of any one of the following: 500 gr nuts, 500 gr bran, 80 gr carrots, 70 gr apples or 50 gr alfalfa pellets. Different flavours were added to these meals [garlic, fenugreek, caraway seeds, banana, cherry and oregano]. They were placed either in the manger hidden under a pile of hay, in a bucket with a detachable lid, or scattered around the straw bedding. At midday, they were given two different types of hay constituting 2.1 kg, split into 700-gr portions and placed into 3 different coloured nets and dispatched in 3 different places. Each food type was presented and distributed haphazardly over time. In order to further enhance their environment, brushes were fixed to the walls at head and croup level. Every week, 6 different new objects (plastic bottles, tarpaulin, chord, etc) were placed in the stables or out in the field. Once a week, a perfume device was hung in each stable (a hole-punched bottle, containing a compress steeped in 2 ml varied essential oils). Classical or country music was played in the barn for 1 hour every day. To end, the foals were taken three times a week to a new place for 20 minutes (stables or paddocks containing different unknown objects).

D. Behavioural observations in the stable

For the first five weeks of the experiment, the foals were observed via scan samplings from Monday to Friday, between 9 a.m. and 4.30 p.m. Recordings were made every 5 minutes for 1½ hours in order to cover all time slots. Neighing could be heard, just as were observed alert positions (neck held high with head turned towards the point of interest), aberrant behaviour (smelling/licking the stable bars or walls, pawing the ground, kicking the walls and repeated head nodding), lying down to rest and the adoption of an ears-back stance.

E. Personality tests

Personality tests were carried out 5, 12 and 23 weeks after the start of treatment, which enabled to measure 5 personality dimensions: fear, tactile sensitivity, gregariousness, reactivity in relation to humans and the level of activity. For more information on methodology, please refer to Lansade & Simon [17]. After 5 weeks of treatment, a handler-reaction test was carried out in order to assess a foal’s behaviour when haltered and lead out.

F. Learning

Ten learning sessions were conducted between the 6th and 11th week. The instrumental task of the horse consisted of touching a target in response to a command given by an experimenter in view of obtaining a food reward. Two experimenters alternatively carried out the tests. In the first phase (A+, B+), the two experimenters rewarded the horse as of when it correctly touched the target in response to a command. In the “Go/No-go” phase (A+, B-), only experimenter A rewarded the horse, whilst the other (B-) never reinforced.

G. Statistical analyses

Groups were compared with each other via Mann Whitney non-parametric tests or by a dual proportional comparison “z” test.

II. Results

A. Behavioural observations in the stable

During the first week, the “control” foals neighed far more than the “enriched” foals (U=22; P=0.04). From the second week onwards, less than 20% of the foals neighed, thereby preventing any statistical comparison. Throughout these 5 weeks (Figure 2), the “control” foals were more often on the alert than the “enriched” foals. They also demonstrated more aberrant behaviour and lied down less often. Finally, as of the 3rd week, the “control” foals were more often seen with their ears back than the “enriched” foals.
B. Personality tests

By week 5, the “enriched” horses were significantly less afraid than the “control” horses: they were less concerned by an unknown object and were faster to eat under the sudden test. During the test showing reactions to humans, they seemed to better trust man and accepted a halter more quickly. They reacted less to the tactile sensitivity test and they also perform less defensive reactions during the man-handling test (Table 1). At week 12, the “enriched” horses were again less afraid than the “control” horses: they would make more contact with any new object, were less concerned by it and were faster to eat when tested passing over an unknown surface. They more often trusted a passive human and accepted a halter more quickly. They reacted less to the sensitivity tests (Von Frey filaments and stifle-haunch joint stimulation). At week 23, the “enriched” horses were also less afraid and were less reactive to tactile stimuli than the “control” horses: they would make significantly more contact with any new object, were much less concerned by it, were faster to eat when tested passing over an unknown surface and reacted less to the tactile sensitivity test (hip-stifle joint stimulation). Regardless of the test period, the two groups failed to differ in terms of gregariousness or locomotion.

<table>
<thead>
<tr>
<th>Dimension and Variable measured</th>
<th>Week 5</th>
<th>Week 12</th>
<th>Week 23</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fearfulness</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of contacts with novel object</td>
<td>NS</td>
<td>$M_E = 8.5 \ (7.25 - 11.75)$</td>
<td>$M_E = 11.5 \ (8.25 - 16.5)$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$M_S = 4 \ (0 - 6)$</td>
<td>$M_S = 3 \ (0 - 9)$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$U = 18, P=0.02$</td>
<td>$U = 22.5, P=0.05$</td>
</tr>
<tr>
<td>Number of glances at novel object</td>
<td>$M_E = 2 \ (1.25 - 3.75)$</td>
<td>$M_E = 4 \ (2.25 - 4.75)$</td>
<td>$M_E = 1 \ (0.25 - 2.75)$</td>
</tr>
<tr>
<td></td>
<td>$M_S = 9 \ (6 - 10)$</td>
<td>$M_S = 10 \ (8 - 13)$</td>
<td>$M_S = 8 \ (7 - 9)$</td>
</tr>
<tr>
<td></td>
<td>$U = 12.5, P=0.007$</td>
<td>$U = 5, P=0.001$</td>
<td>$U = 4.5, P=0.009$</td>
</tr>
<tr>
<td>Latency to eat during novel area test (s)</td>
<td>NS</td>
<td>$M_E = 14.5 \ (11-19.5)$</td>
<td>$M_E = 23.5 \ (19.25-75.75)$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$M_S = 180 \ (180-180)$</td>
<td>$M_S = 180 \ (39-180)$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$U = 7.5, P=0.001$</td>
<td>$U = 16, P=0.01$</td>
</tr>
<tr>
<td>Latency to eat during suddenness test (s)</td>
<td>$M_E = 45(33-160.25)$</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>$M_S = 180 \ (140-180)$</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$U = 21.5, P=0.04$</td>
<td></td>
<td></td>
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<tr>
<td><strong>Gregariousness</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of neighs during social isolation test</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>
**Locomotor activity**

| Number of sectors crossed | NS | NS | NS |

**Tactile sensitivity**

| Response to von Frey filaments | NS | $M_E = 1 \ (1 - 1.5)$ | $M_S = 2.5 \ (2 - 3)$ | U = 14, P=0.01 | NS |

| Reaction to stifle haunch axis stimulation | $M_E = 2.18 \ (1.49 - 2.82)$ | $M_S = 5.5 \ (4 - 7.42)$ | $U = 16; \ P=0.01$ | $M_E = 2.02 \ (1.56-2.87)$ | $M_S = 5.25 \ (3.75-5.74)$ | U=9, P=0.003 | $M_E = 1.37 \ (1.15-1.69)$ | $M_S = 2.67 \ (2.5-3.67)$ | U=12, P=0.006 |

**Reactivity to humans**

| Number of contacts with passive human | $M_E = 10.5 \ (9.25-14.75)$ | $M_S = 2 \ (0 - 9)$ | U =14, P=0.01 | $M_E = 10 \ (8 - 12.75)$ | $M_S = 4 \ (0 - 4)$ | U =19.5, P=0.03 | NS |

| Latency to put halter (s) | $M_E = 8(8-8)$ | $M_S = 23(13-37)$ | $U=10; \ P=0.001$ | $M_E = 8(8-8)$ | $M_S = 12(8-14)$ | U=15, P=0.003 | NS |

| Number of defensive reactions | $M_E = 0 \ (0-0)$ | $M_S = 4 \ (2-4)$ | U=1; P<0.0001 | Non tested | Non tested |

Table 1 : Medians (interquartile) of the variables of personality as a function of the experimental group and test session (5, 12, or 23 weeks after the beginning of the treatment). E: EE-treated horses, S: Standard horses, Mann-Whitney tests, NS: Non Significant

### C. Learning tests

All horses attained the success criteria during the 1st phase of learning (6 successful trials out of 7 consecutive trials using experimenter A+ and B+ for each), regardless of the group. Likewise, the success rates among the two groups failed to differ between the two experimenters (A+ and B+), which was expected. On the other hand, during the “Go/No-go” phase, all the horses came up to par, although the “enriched” horses showed a higher success rate when using experimenter A+, which compensated the horses, than when using experimenter B-, which never compensated them (i.e., the median (interquartile) for the success rate using A+ = 88 (49-95), while that using B- = 65 (50-80); hence Z=2.12 and P=0.028), whereas no significant difference was observed in the control group.

### III. Discussion

The aim of this study was to better grasp the impact of living conditions on the welfare of young horses, on their personality, on their learning ability and on their relations with man. Concerning the effect on stable welfare, the “enriched” foals neighed less, were less often on alert and showing aberrant behaviour, and were more often seen lying down than the “control” horses. As of the 3rd week, they were seen less with their ears back. These different results illustrate reduced stress and improved welfare in foals living in ‘enriched’ conditions [4, 18].

The enriched environment also clearly modified the horse’s personality in the long term, particularly as regards the dimensions of fear, reactivity to human and sensorial sensitivity. The “enriched” horses proved to be less emotional during any “sudden” or “novel” tests (i.e., object or new surface testing), which confirms the numerous prior results [19]. However, the “enriched” environment also reduced reactions of avoidance in relation to tactile stimuli and to human presence. Such changes thus reflect broader effects than those normally observed with regard to anxiety. In the “enriched” horses, all of these observations seem to reveal a more positive perception of the environment, whether concerning potentially frightening stimuli (new or sudden stimuli) or non-frightening stimuli, such as tactile stimuli or that relating to human presence. Surprisingly, the effects regarding fear and sensitivity persisted for at least 3 months after completion of the treatment, despite both groups of horses having been turned back out together to grass. Even though personality is relatively stable when horses are constantly housed in the same environment [20-23], we illustrate
here that a radical change in environment, such as an enriched environment as of the early age, can modify personality in the long term. Finally, as regards the learning ability, the “enriched” horses revealed better performances in the complex “Go/No-go” task. Such better performances could be the consequence of their change in personality. By becoming less fearful and more trusting of man, the “enriched” horses would be more attentive and less inclined to differentiate between the commands given by the experimenters during the “Go/No-go” phase, which would make them more efficient.

In the current day, many horses are housed in living conditions similar to the “control” conditions stated in our study: alone in the stable for most of the time with little change in diet and fast to ingest. The study that we have conducted shows that a horse’s welfare may be significantly improved by offering a multitude of enrichments, whether sensorial, social or cognitive. It is thus possible to conciliate stable management, while observing the welfare of the horse. Moreover, such living conditions enable to reduce emotivity in horses and to facilitate handling. In terms of safety, this is a major argument when recommending such types of enrichment. In parallel to this type of experimental study, a pilot project carried out on a Thoroughbred stud has illustrated that this enrichment programme was indeed feasible in practice and further enabled to reduce the stress of the horses when taken to the Sales, while at the same time promoting the safety of both horse and handler. All these results clearly indicate the importance of setting up this type of enrichment in practice.

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and group kept horses. 5th International Conference of the Society for Equitation Science.

Organisms

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