SCIENTIFIC PAPER

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Lying Behavior in Horses in Relation to Box Size

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ABSTRACT

To analyze if horses' lying behavior is influenced by the size of their lying area, 8 horses were kept, first, in a large box—(2.5 × height of the horse)^{2}m^2—and then in a small box—(1.5 × height of the horse)^{2}m^2—or vice versa. After a 5-day adaptation period, the lying behavior (frequency and duration of sternal and lateral recumbency, rotating behavior just before lying down, and rolling behavior just before getting up) was observed from video recordings on 3 consecutive nights. The results showed that the duration of sternal recumbency was significantly longer in the large boxes than in the small boxes (P = .002). Furthermore, box size exerted an influence on the frequency of the rolling behavior shown before getting up, but box size was not the only factor affecting this behavior. We conclude that observations of the resting behavior of horses are necessary to make recommendations for the minimal size of stalls for horses.

Keywords: *horse, box size, sleep, recumbency, rolling behavior, welfare*

INTRODUCTION

In contrast with other farm animals, horses are often housed in old buildings. In addition, the size of modern riding horses is increasing. As a result, the size of the boxes in which most horses are kept is relatively small. According to Danish recommendations, the box area measured in m^2 should be at least twice the height at the withers squared, and the shortest side of the box should be at least 1.5 times the height at the withers. Recommendations in other European countries are similar. In the UK, the British Horse Society recommends a box size of 3.6×3.6 m. In Sweden, the Swedish Board of Agriculture recommends that the minimum area for a small horse should be 8.0 m^2, the shortest side being 2.35 m, and for a large horse 9.0 m^2, the shortest side being 2.5 m. For horses higher than 1.7 m at the withers, the area in m^2 should be at least 1.8 times the height at the withers squared. However, all of these recommendations are based on practical experience rather than systematic observation of the behavior of horses, particularly their lying behavior.

Pedersen et al[1] conducted an experiment on the influence of bedding material on the time horses spend recumbent. The experiment revealed that most of the horses made a rolling behavior before getting up. It was suggested that this behavior is due to difficulties in getting up, possibly because of too small a box size. Except for a brief note in Waring,[2] this rolling behavior before getting up has, to our knowledge, not been previously described. Therefore, the question is raised whether the behavior is normal or whether it is a result of too small a box size. If so, the behavior could possibly be used as an indicator of how big a box should be to allow normal resting behavior in horses. In addition, the rolling behavior increases the risk that the horse gets stuck against the box wall, a condition that is rare but can be fatal.

The number of studies on equine sleep is limited. The main focus has been on the entity of sleep and its effect on the behavior of the horse or on the effect of the behavior of the horse on its sleep.[3] Although many studies have examined sleep in animals, its purpose is still unclear. Some studies suggest that sleep might serve as a thermoregulatory function,[4,5] that it plays a role in memory consolidation,[6-8] permits vigilance recovery,[9] conserves energy,[4,10] and is a restorative process.[10] These studies also show that short-term deprivation of sleep will lead to an increase in total sleep time during recovery.

These and other studies make it obvious that systematic observations are necessary to ensure that horses

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are able to perform normal sleeping behavior, and to obtain an optimal amount of sleep, when reconsidering the recommendations for the minimal box size for horses.

The objective of the study was to analyze the effect of the box size on the lying behavior of horses and to observe whether the frequency of the rolling behavior before getting up is influenced by the size of the box. Based on video recordings, the duration and frequency of sternal and lateral recumbency of 8 horses kept both in a small and in a large box were calculated and the behavior before lying down and getting up was observed. Since determination of sleep necessitates electroencephalographic recording, particularly determination of slow wave sleep and rapid eye movement sleep (REM), observations in the current study were limited to body position rather than the occurrence of sleep.

MATERIALS AND METHODS

The study was done at Søborggaard Horse Centre in the northern part of Sealand (Denmark) from October 2003 to February 2004.

Animals

Eight riding horses of various breeds were used in a crossover study. The horses varied in height and stature. All horses were experienced with individual housing. They were fed oats daily according to exercise and body condition. Hay, straw, and water were given ad libitum. During the study, the horses took part in the daily program at the horse facility and were thus exercised for approximately 1 hour a day and let out on pasture for a minimum of 6 hours each day.

Boxes

The 4 boxes that were used in the experiment were placed in a semi-open barn and were built to match the horses. Because of the variation among the horses in height at the withers, 2 sets of boxes were made, 1 for the larger horses (approximately 155 cm high at the withers) and 1 for the smaller horses (approximately 145 cm high at the withers; Table 1)—1 set consisting of 1 large and 1 small box. A large box was defined as $(2.5 \times \text{the height of the horse})^2 m^2$ and a small box as $(1.5 \times \text{the height of the horse})^2 m^2$.

During a pilot test, a horse housed in the small box damaged a box wall because of lack of space. The measurements for the box were changed to prevent further accidents. It was decided to keep 1 side at 1.5 times the height at the withers and thus enlarge the box only by lengthening 1 side. Table 1 shows the final measurements of the boxes.

The open sides of the barn faced a courtyard and a paddock in which horses from a loose housing system were kept. The walls in the boxes were approximately 1.5 m high, which allowed the horses to have contact with at least 1 other horse and to see the other horses taking part in the experiment at the same time. Each box was equipped with a videocamera and infrared lights.

Table 1 Size and area of the boxes

Box	Horses	Box Size	Measurements	Area
1	Group 155 cm	Large	3.9×3.9 m	15 m^2
2		Small	2.2×2.8 m	6.2 m^2
3	Group 145 cm	Large	3.65×3.65 m	13.1 m^2
4		Small	2.2×2.2 m	4.7 m^2

Experimental Design

Four of the horses were observed, first, in a large box (group LS), and the other 4 horses were observed, first, in a small box (group SL). The observations were continuous and based on time-lapse video recordings (continued sampling, 12 frames per second) made via a multiplexor from 22:00 hours to 07:00 hours over a minimum of 3 consecutive nights. The horses were housed in the box for a minimum of 5 nights before the observations started. The frequency and duration of sternal and lateral recumbency, and the behavior just before lying down (rotating behavior) and getting up (rolling behavior), were recorded. Sternal recumbency lasted from the time the hindquarters of the horse touched the ground until lateral recumbency started or until the horse got up. Lateral recumbency lasted from the time the horse's head and neck touched the ground and lasted until they were raised again. Rotating behavior was defined as the horse lowering its head and walking around in a circle. Rolling behavior was defined as the horse lying down in lateral recumbency and moving up on its back.

To analyze if there was a correlation between performing the rolling behavior and the configuration of the horse, the circumference of the chest (girth measure) and abdomen (measured at the widest point) was measured, apart from the height of the horse at the withers.

Because of technical difficulties, some of the recordings progressed for more than 3 days so that more than 3 nights of observations were made for some of the horses. All usable observations were included in the results.

STATISTICS

For the statistical analysis, SAS was used. Because the data set was not normally distributed, it was transformed to normality with a Box-Cox transformation, with $\gamma = 0.3$ for the statistical analysis. The statistical program Proc Mixed was used for analysis with this model. To test for correlations between the occurrence

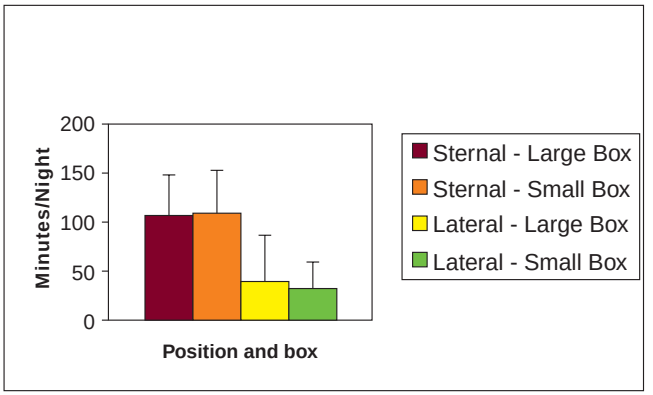

Figure 1: Mean ± SD total time spent in sternal and lateral recumbency per night for each box size. Data shown are non-transformed data.

Table 2 Estimated durations of average sternal and lateral recumbency, in minutes per position. Data shown are values after the Box-Cox transformation

Group	Position	Large Box	Small Box	*P* Value
All Horses	Recumbency	10.4	8.5	.002
	Sternal	13.8	12.1	.02
	Lateral	6.8	5.4	.06
Group LS	Sternal	12.6	11.2	.15
	Lateral	7.1	5.3	.07
Group SL	Sternal	15.1	11.9	.05
	Lateral	5.3	5.0	.59

Table 3 The sum of rolling behavior over all 3 nights in each horse according to treatment

	Box Size		
	Small	Large	Small
Horse B	0	0	-
Horse D	4	0	-
Horse F	0	3	-
Horse G	4	4	-
Horse A	-	0	3
Horse C	-	0	0
Horse E	-	3	7
Horse H	-	5	9

of the rolling behavior and the horses' height at the withers, girth, and abdomen, a Spearman rank correlation test was done.

RESULTS

Lying Behavior

The mean total duration of recumbency of each horse per night was 140 minutes in the large box and 135 minutes in the small box (Fig 1). When the estimated average duration of lying episodes was analyzed (ie, after transformation of the data set), there was a significant difference between the large box and the small box (P = .002; Table 2), in that the horses spent more time recumbent in a large box. When lying was divided into sternal and lateral recumbency, it was found that the horses spent significantly more time in sternal recumbency when kept in a large box (P = .02). The estimated average duration of episodes in lateral recumbency tended to be longer in the large box (P = .06; Table 2).

The data set was further divided into 2 groups according to whether the horses were tested first in a large box and then in a small box (Group LS = large to small box) or vice versa (Group SL = small to large box). As shown in Table 2, for the horses that were first observed in a small box, the estimated average duration of sternal episodes was significantly longer in the large box (P = .05). For the horses that were first observed in the large box, the estimated average duration of lateral episodes tended to be longer in the large box compared with duration of lateral episodes in the small box (P = .07; Table 2).

Rolling Behavior

The rolling behavior was observed at least once in 6 of the 8 horses. The total frequency of rolling behavior according to treatment of the horses—that is, whether the horse was kept first in a small box and then in a large box or vice versa—is shown in Table 3.

Horses that were kept first in a large box performed the rolling behavior 13% of the time when getting up after a recumbent period in the large box (Table 4). After they were moved to a small box, they performed the rolling behavior 33% of the time when getting up after a recumbent period. The horses in Group SL performed the rolling behavior approximately 11% of the

Table 4 Mean ± SD frequency of getting up and percentage of the occurrence of rolling behavior

	Frequency of Getting Up per Night		Percentage of Getting Up With Rolling Behavior per Night	
	Large Box	Small Box	Large Box	Small Box
All horses	3.8 (±1.3)	4.0 (±1.5)	11.9%	21.5%
Group LS	3.4 (±1.5)	3.8 (±1.5)	13.1%	32.8%
Group SL	4.1 (±1.2)	4.1 (±1.6)	10.8%	11.6%

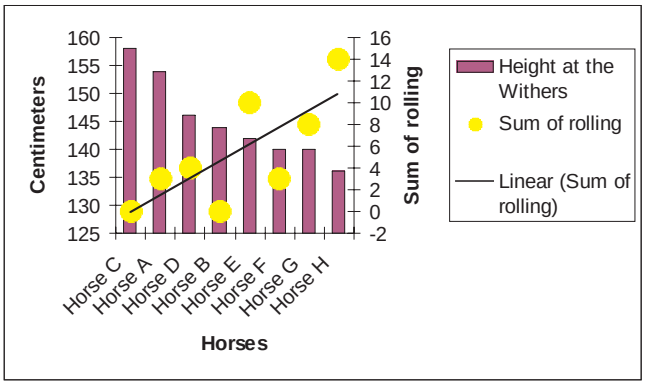

Figure 2: Rolling behavior compared with height at the withers.

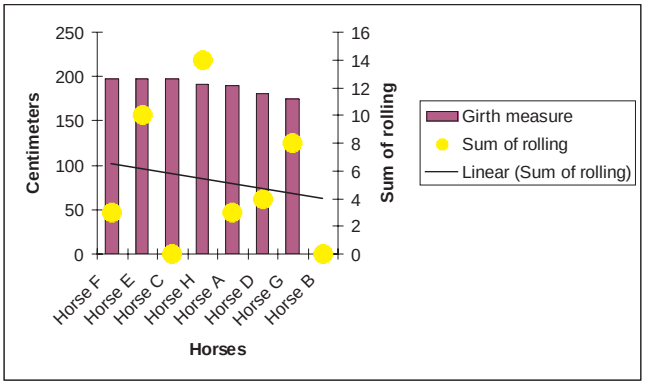

Figure 3: Rolling behavior compared with girth measure.

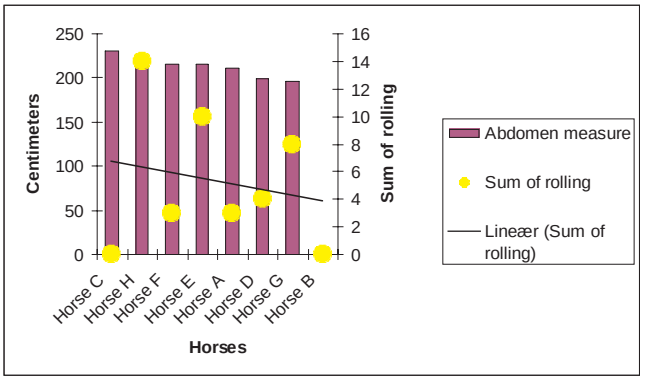

Figure 4: Rolling behavior compared with abdomen measure.

time, and there was no change in the occurrence of the behavior when the horses were moved from a small to a large box (Table 4).

When plotting the horses' height at the withers (Fig 2), girth measure (Fig 3), and abdomen measure (Fig 4), we found no tendencies for correlations between the performance of the rolling behavior and girth and abdomen measures, but there was a correlation between the behavior and height at the withers. A Spearman rank correlation test revealed a significant negative correlation ($\alpha \leq 0.05$) between height at the withers and the rolling behavior, meaning the smaller horses performed the behavior more often than the larger horses.

DISCUSSION

The results of our study show that horses are recumbent for a longer time in the large boxes than in the small ones. Although the difference is small, it was found to be statistically significant ($P = .002$; Table 2). Furthermore, box size exerts an influence on the rolling behavior shown before getting up. When examining the treatment (ie, from small to large box or vice versa), it was revealed that the horses that are moved from a large to a small box perform the rolling behavior almost 3 times as often in the small box, whereas there is no change in the frequency in the horses that are moved from a small to a large box (Table 4).

Lying Behavior

The time the horses spent recumbent observed in this study lies within the range of what other studies have found. Also, the duration and frequency of lying bouts are within what others have observed.[1,3,10-17]

The fact that horses spend more time recumbent in larger boxes than in smaller ones has been shown in other studies. In a comparison of individual and group confinement, Glade[14] observed that changing the size and shape of the enclosure affected the time horses spent recumbent. Glade's method of study varied greatly from ours in that he used daytime observations of foals in a climate very different from ours. In a study of 4 different loose housing systems containing a separate area for recumbence, Zeitler-Feicht and Prantner[17] found that social rank affected the time spent in recumbency and that an insufficient area in which to lie reduces the resting time.

When total recumbency was divided into sternal and lateral recumbency, we found that the horses spent more time in sternal recumbency in the large box than in the small one. A similar result was reported by Zeitler-Feicht and Prantner.[17] Glade,[14] however, found that more time was spent in sternal recumbency in a smaller enclosure than in a larger one. In addition, Glade[14] and Zeitler-Feicht and Prantner[17] found that horses spend more time in lateral recumbency in a large enclosure than in a small one. In our study, there was only a tendency for a similar result. The difference in the results can well be caused by the differences in the experimental design, since it has been documented that the design can affect sleeping behavior to a large extent.[3,10,12,18] Another reason for discrepancy in results

may be the small number of animals used in our study. With a small number of test animals, the individual differences have greater influence on the variation than with a large number of test animals.

The variation due to individual differences may also be the reason for the results from the different treatment of the horses. For the horses that were kept first in a large box and then in a small box, the time spent in sternal recumbency did not differ between the boxes, but the time spent in lateral recumbency showed a tendency to be longer in the large box (Table 2). Horses kept first in a small box and then in a large box spent significantly more time in sternal recumbency in the large box. There was no difference in the time spent in lateral recumbency between the large box and the small box (Table 2).

It is not surprising that 2 treatments give different results, but since the results for the group of horses going from a large to a small box tended to show a decreasing amount of time spent in lateral recumbency, one could expect that the group of horses going from the small to the large box would show the opposite result. Since this was not the case, however, it can be assumed that it is a different experience for the horse to change environment to a smaller area than to a larger area.

Ruckebusch[18] found that when changing to a new environment, horses had a period of a few days when recumbency did not occur. When rats were prevented from sleep by electric shocks, they ignored the treatment after 2 to 3 days, but when the same rats were placed in a new enriched environment, they stayed awake for 4 to 5 days.[19] Obviously, animals need some time to adjust to a new environment, but it is not certain that the same period of time is needed for different types of changes, as in the case of our study.

To our knowledge, no studies have been conducted on the time needed for a horse to fully adjust to a change from 1 box to another. In our study, the horses were introduced to the test boxes 5 nights before the video recording, so they could adjust to the new box. It is uncertain whether the horses adjusted more easily to 1 box size than to another and whether the time for adjustment had any effect on the results.

It is well documented that following sleep deprivation, an individual will compensate for the lost sleep by increasing sleeping time when given the opportunity over a period of a few days.[5,12,20,21] This effect, however, was not seen in our study, probably because the rebound effect (if any) occurred during the 5 nights of adjustment the horses had before video recordings were made.

The fact that the group of horses going from a small to a large box spent the same amount of time in lateral recumbency in both boxes indicates that the horses were able to cover their need for REM sleep in the small box, since REM sleep is accomplished only in lateral recumbency.[3,10,22] Others disagree that REM sleep is accomplished only in lateral recumbency.[10,23] It must also be noted that since our study included only nighttime recordings, it is impossible to say whether daytime rest changed during the study.

The fact that the study was carried out in a semiopen barn could have influenced the results. In a semiopen barn, weather conditions play a greater role than in a closed barn or stall. Since horses are flight animals, sounds and wind conditions can have had an effect on the results if the horses were disturbed or startled by sudden sounds or blasts of wind.[3,10]

The horses in this study did not have difficulty lying down in sternal position, but it was observed that if a horse had obtained a sternal position near or against the wall, it could have difficulty proceeding to a lateral position. This occurred more frequently in the smaller boxes than in the larger ones. If a horse is unable to position itself in a comfortable lying position owing to lack of space, it may be disturbed in its sleep and the lying bouts could possibly be shortened. To compensate, it is possible that the horse would increase the number of bouts per night. Such an increase was not found in our study. Since the recordings were done only during the night, it is possible that the horses compensated by resting more during the daytime.

The longer time spent in recumbency in the larger box could be interpreted as a sign of greater comfort for the horse.[3,10,12,18,23] More time spent in recumbency probably means increased sleeping time as well. More sleep may improve conditions for animals, especially animals that are exposed to a high level of stress or training, such as horses used in sport competitions.[3,6-8,24-26] Although the difference found in our study was statistically significant, it is questionable whether it is enough to have any welfare implications for the horses.

Rolling Behavior

The rolling behavior sometimes shown by horses just getting up was observed by Pedersen et al[1] while studying the influence of bedding on the time horses spend recumbent. In their study, 13 out of 16 horses performed the behavior, and the bedding material (straw or wood shavings) did not appear to have an effect on the behavior. It was suggested that the horses performed the behavior to move away from the box wall or corner, so that they were able to perform the forward movement while getting up. This suggestion is based on observations that some horses walked around the box as an initial preparation to lying down and thus ended up lying down against the wall. The suggestion is further based on the fact that some horses were observed moving away from the wall or corner while they were rolling on their back.[1]

In the current study, it was observed that before a period of rest, the horses would walk around the box, "grazing" the bedding material. When going into drowsiness, the horse simply stopped the grazing behavior and stood still wherever it was situated in the box. After a period of drowsing or sleeping, the horse then assumed sternal recumbency. It was also observed that most horses turned around from .5 time to 1.5 times before lying down.

The observations made by Pedersen et al[1] indicate that the horses have some sort of preference for a suitable lying area in the box, while our observations indicate a more randomized selection of a lying spot. To our knowledge, no studies have been conducted specifically on this topic, so both options will be considered in the following discussion.

In our study, the rolling behavior was performed by 6 out of 8 horses, and the behavior occurred in both the large box and the small box. The rolling behavior occurred in 11.9% of the episodes when the horses got up in the large box and 21.5% in the small box (Table 4). This result seems to be in coherence with the suggestions mentioned earlier, since the walls and corners are closer to the horse in a smaller box than in a larger box. Therefore, if the horse lies down at random after grazing the bedding material in a small box, it will end up lying close to the wall or corner more often than in a larger box, consequently leading to more rolling in a smaller box than in a larger one.

If the horse does not lie down at random but prefers a certain part of the box, the walls or corners will still be closer to the horse in the small box than in the large box, and it will still lead to more rolling behavior in the small box than in the large one.

When the results are examined separately for Groups LS and SL, a different picture emerges. When going from a large box to a small box, the percentage of getting up initiated by rolling behavior increased from 13.1% to 32.8% (Table 4). When going from a small box to a large box, the percentage did not change (10.8% and 11.6%, respectively).

If horses lie down at random, the ones in the large box have a larger area to graze, so when lying down, there is a good possibility that they are able to turn toward the middle. When going from the large box to the small box, the chance of ending up lying near the wall or corner is greater, if the horse has not adapted to the smaller area. This change could increase the number of situations where rolling might be necessary. With the opposite change the box area is increasing, so that the horses might be accustomed to avoiding the walls or corners. Consequently, since the horse still occasionally ends up lying against the wall or corner, the number of situations where rolling might occur stays the same.

If the horse prefers a certain part of the box, the preferred area in a large box—for example, the center—will be larger and easier to maneuver in than in a small box. When going from a larger box to a smaller box, it is possible that the horse will find it more difficult to acquire a suitable recumbency position, and situations where rolling behavior might occur will be more frequent. In contrast, when the change is from a small box to a large box, the horse might be accustomed to avoiding the walls or corners. This interpretation indicates that the horses in Group LS did not adapt to the small box during the 5 days before the observation period.

When using the Spearman rank correlation test to check if girth or abdomen measures or height at the withers were correlated with the rolling behavior, it was found that there was no clear correlation between girth or abdomen measures and rolling behavior. There was, however, a significant correlation between height at the withers and rolling behavior, indicating that the shorter horses performed the rolling behavior more often than the taller ones.

If the rolling behavior somehow helps the horse get up, it seems that a taller horse would perform the behavior more often than a smaller horse. On the other hand, smaller horses are often stockier than taller horses and may therefore perform the rolling behavior not only to maneuver away from the wall, but also as a technique to get the rising act started in a forceful way.

Age and gender could be other factors affecting the rolling behavior, a possibility that could not be analyzed in our study.

It is possible that the rolling behavior before getting up serves several purposes once it has been learned. If the triggering factor of learning is lack of space, and the horse learns to perform the behavior as a way to maneuver away from a corner or wall, it might learn that the rolling eases getting up or that it in some way is comfortable to perform the behavior (as humans stretch in bed before getting up).

A final possibility is that the rolling behavior is an abnormal behavior. According to the definition of abnormal behavior described by Houpt,[27] the rolling behavior can be categorized as abnormal behavior since it has not been observed (or at least described) in wild or free-ranging horses and therefore may represent an attempt to adjust to the artificial and restricted environment forced upon the animal. It is not a stereotyped behavior, however, since it is not a stylized, repetitive, or functionless motor response or sequence, as defined by Kiley-Worthington.[28]

CONCLUSION

We conclude that box size affected the lying behavior of horses in that they spent more time recumbent in a large box than in a small one. Although the difference was statistically significant, it was found to be so small that it is questionable whether it has any implications for the horse. We further conclude that box size was a

factor that affected the occurrence of the rolling behavior before getting up and that the change was more pronounced in horses that went from a large box to a small box than vice versa. Although box size exerts an influence on the rolling behavior before getting up, however, it does not seem to be the only factor affecting the behavior.

Further research is needed on the subject to investigate if lack of space is the triggering factor for learning this behavior and to identify other affecting factors, to establish whether the absence of the behavior is a valid indicator of optimal box size.

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