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Research

The effect of shelter design on shelter use by Icelandic horses in the winter period

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ABSTRACT

Little is known about the effect of shelter design on sheltering behavior in horses. This study investigates shelter use by Icelandic horses kept outdoors 24 hours a day during the winter in Denmark and whether shelter use and levels of fecal cortisol metabolites (FCMs) are affected by (1) the number of entrances (1 vs. 2) and (2) a partition inside the shelter. The effects of weather conditions on shelter use are also investigated. Thirty-two Icelandic horses participated in the study. The horses were pastured in 8 groups of 4 horses, and each group had access to a shelter (30 m^2), which in the first study period (5 weeks, Dec-Jan) had either 1 or 2 entrances (n = 4 groups per treatment). In the second study period (5 weeks, Jan-Feb), all shelters had 2 entrances and half were equipped with a partition inside the shelter (n = 4 groups per treatment). Infrared cameras were placed inside all shelters for recording of shelter use. Feces were collected weekly during the last 3 weeks of each study period. We found that groups with 2 entrances to their shelter used the shelters significantly more than groups with only 1 entrance (% pictures with at least 1 horse inside, median [25;75%]: 2 entrances: 12.6 [7;20] vs. 1 entrance: 3.0 [2;4], $P = 0.029$). In addition, horses with 1 entrance had significantly increased FCM levels (ng/g, mean ± SE: 2 entrances: 6.8 ± 0.5 vs. 1 entrance: 10.0 ± 1.2, $P = 0.019$). The partitions did not affect shelter use or FCM levels. In both study periods, the shelters were used mainly at night (light vs. dark hours: $P < 0.001$), and daily average temperatures below zero degree Celsius increased shelter use. We conclude that entrance conditions are crucial to the use of shelters by Icelandic horses during winter.

Introduction

Horse breeds such as Icelandic horses and Shetland ponies are generally expected to tolerate lower ambient temperatures than warmblood breeds without being in risk of cold stress (Langlois, 1994). Cold resistance depends on the combined effect of the individuals' own heat production and its insulation by the fat tissue and fur coat. However, wind and rain lowers the insulating effect of the fur coat and increases heat loss (Schutz et al., 2010). Accordingly, outdoor-wintered animals increase their use of protected areas during times with precipitation, lower temperatures, and increased wind speed (horses: Heleski and Murtazashvili, 2010; Mejdell and Bøe, 2005; Snoeks et al., 2015; beef cattle: Graunke et al., 2011; Van laer et al., 2015). Thus, animals kept in areas with limited natural protection against wind and rain may benefit from a well-designed shelter to mitigate the risk of cold stress. Although the temperature in a shelter may be equivalent to the outside temperature, the shelter protects against the cooling effects of wind and precipitation and can ensure dry lying areas (Mejdell and Bøe, 2005). A mathematical model predicted that cold resistance could increase by 20% in horses with access to a shelter (MacCormack and Bruce, 1991, cited in the study by Cymbaluk, 1994 and Snoeks et al., 2015). Cold stress responses can include reduced lying time, increased adrenocortical activity, and decreased white blood cell numbers, which may indicate impaired welfare (cattle: Van laer et al. 2014; Webster et al., 2008).

According to national legislation, horses kept outdoors 24 hours per day during the winter must be in good health and body condition and have access to a shelter. The minimum shelter size should be (2 × horse height at withers)^2 per horse for the first 4

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horses, whereas there are no specific requirements for shelter design including entrances. There is a lack of controlled experiments on shelter use by horses during the winter, and the extent to which horse breeds such as Icelandic horses actually use artificial shelters is only sparsely investigated. Mejdell and Bøe (2005) investigated shelter use by a single group of 40 Icelandic horses and found that the horses spent most of their time outdoor (70% of the recordings). The recordings were carried out manually in the evening (16-24 hours, i.e., no recordings during most of the night), which may have influenced the results. It was further reported that the use of the shelter increased with decreasing temperature and increased rain and wind. The authors concluded that minimum temperatures of −31°C did not appear to challenge the thermoregulation of Icelandic horses that were acclimatized to cold weather and had free access to feed and a shelter. Autio and Heiskanen (2005) also recorded a single horse group's use of an indoor area in Finland and found that the horses (n = 10 weanlings, Finnish cold-blood and American Standardbred) stayed inside 43% of the observation time, and that their behavior, for example, time spent eating and huddling, did not change as the temperature dropped from 0°C to −20°C.

Heleski and Murtazashvili (2010) included 7 groups of mainly Arabian horses (n = 3-12 horses per group). The study aimed to relate shelter use to weather conditions (Michigan), and it was reported that the use of shelters was highly variable and especially precipitation and wind increased the use of shelters. The authors further noted that some horses were less likely to use shelters, possibly due to social relationships within the group (Heleski and Murtazashvili, 2010). In addition, Ingólfsdóttir and Sigurjónsdóttir (2008) investigated use of roofless shelters in 5 groups of Icelandic horses and reported that only 1 group, which consisted mainly of subadults, used the shelter to some extent. Recently, Snoeks et al. (2015) conducted a large field study on 426 horses (123 cold-blood and 303 crossbred) on 166 different pastures and reported a high overall use of artificial shelters (48% of the observations) and that the use of artificial shelters increased on days with low (winter) and high (summer) temperatures and on rainy days. There are no published studies investigating the effects of shelter design and entrance conditions on shelter use by horses.

This study aims to investigate the effects of (1) the number of entrances (1 vs. 2), and (2) a partition inside the shelter on the use of shelters and level of fecal cortisol metabolites (FCMs) in groups of Icelandic horses, kept outdoors 24 hours per day during winter. An additional objective was to investigate the effect of temperature, wind speed, and precipitation on the use of shelters in areas without access to protection by natural vegetation. We hypothesized that 2 entrances and shelter partitions would result in increased shelter use. We further expected increased wind and precipitation to increase shelter use.

Materials and methods

Thirty-two privately owned female Icelandic horses participated in the study. They were transported to an experimental farm 2 weeks before the study and allocated to 8 groups with three 2-year old horses and 1 adult horse (9-16 years) per group. Each group was pastured (0.6-1 ha) 24 hours with access to a shelter (5 × 6 m, corresponding to national legislation on size requirements). A layer of straw (approximately 0.3 m) was provided on the ground in each shelter. Feed (hay/hay silage) was provided 25-30 m from the shelters by placing a bale (approx. 250 kg) on the ground. A new bale was provided when the horses had eaten most of the previous and/or contaminated remains with feces/urine. Water and minerals were available *ad libitum* in each paddock. The horses received no concentrates during the study period. There were no trees or bushes that could provide natural shelter within the paddocks.

Experimental design

The study was conducted as 2 separate experiments due to the limited number of horse groups: in Experiment 1 (Dec-Jan, 5 weeks), we investigated the effects of entrance conditions (1 vs. 2 entrances, each 1.5 m wide; Figures 1 and 2A and B). In Experiment 2 (Jan-Feb, 5 weeks), all shelters had 2 entrances and the effect of a partition (2 m long, 1.2 m high) was investigated (partition vs. no partition; Figure 4A and B). Data were collected in the last 3 weeks of each experimental period, allowing for a 2-week habituation period to the shelter design.

Recordings

Shelter use was monitored by the use of game cameras (Black IR Trail Camera, ScoutGuard), set to take a photo every 10 min. From these photos, we subsequently recorded the number and identity (where possible) of horses inside each shelter as well as their activity (lying, standing). Two days per week during the light hours (Mondays and Wednesdays, 9-15 h), we conducted direct observations of horse behavior (Table 1) and position in the paddock (Table 2) using scan sampling, every 30 min (12 scans per horse per day, i.e., a total of 72 scans per horse during each 3-week period).

Fresh feces were collected from each horse once per week in the last 3 weeks of each experimental period. FCMs were analyzed as a measure of adrenocortical activity (Möstl and Palme, 2002) with an 11-oxoetiocholanolone enzyme immunoassay previously described in detail by Palme and Möstl (1997) and successfully validated for horses (Möstl et al., 1999).

Body condition was assessed twice (once in each experimental period) on a 1-9 scale (Henneke Body Condition Score, Brady et al., 2014; Henneke et al., 1983). Social relationships were assessed twice using a limited resource test, which has previously been used to assess social rank in horses (Christensen et al., 2012). For the test, 2 feed containers were placed in the paddock and successful displacements were recorded. This method has been found to have a high agreement with social rank based on recordings of undisturbed social interactions (validated in Ahrendt and Christensen, 2012; Rørvang, 2014).

Data on daily temperatures, wind speed, and precipitation were available from a local database belonging to Aarhus University, located approximately 10 km from the study site. In addition, temperature loggers (iButton DS1923; Maxim Integrated, San Jose, CA) were placed inside the shelters (1 per shelter) at 2 m height, obtaining the shelter temperature (°C) every hour throughout the experimental period.

Data analysis

The cameras were not entirely precise, for example, some took a photo approx. every 10 minutes and 30 seconds, resulting in differing numbers of total photos from the 3-week data collection periods. As a consequence, we calculated shelter use in 2 ways: (1) the percentage of the total number of photos with at least 1 horse in the shelter (i.e., taking the difference in total number of photos into account) and (2) the total number of horse recordings on the photos (1 photo can include up to 4 horses). Unfortunately, it was not always possible to determine the ID of the horses on the photos (e.g., dark photos and/or if only a part of the horse was visible; Experiment 1: 16% of recordings and Experiment 2: 7.5%, ranging from 1% to 43% of recordings within groups). Because of this missing ID, we considered data on individual shelter use to be inaccurate and data

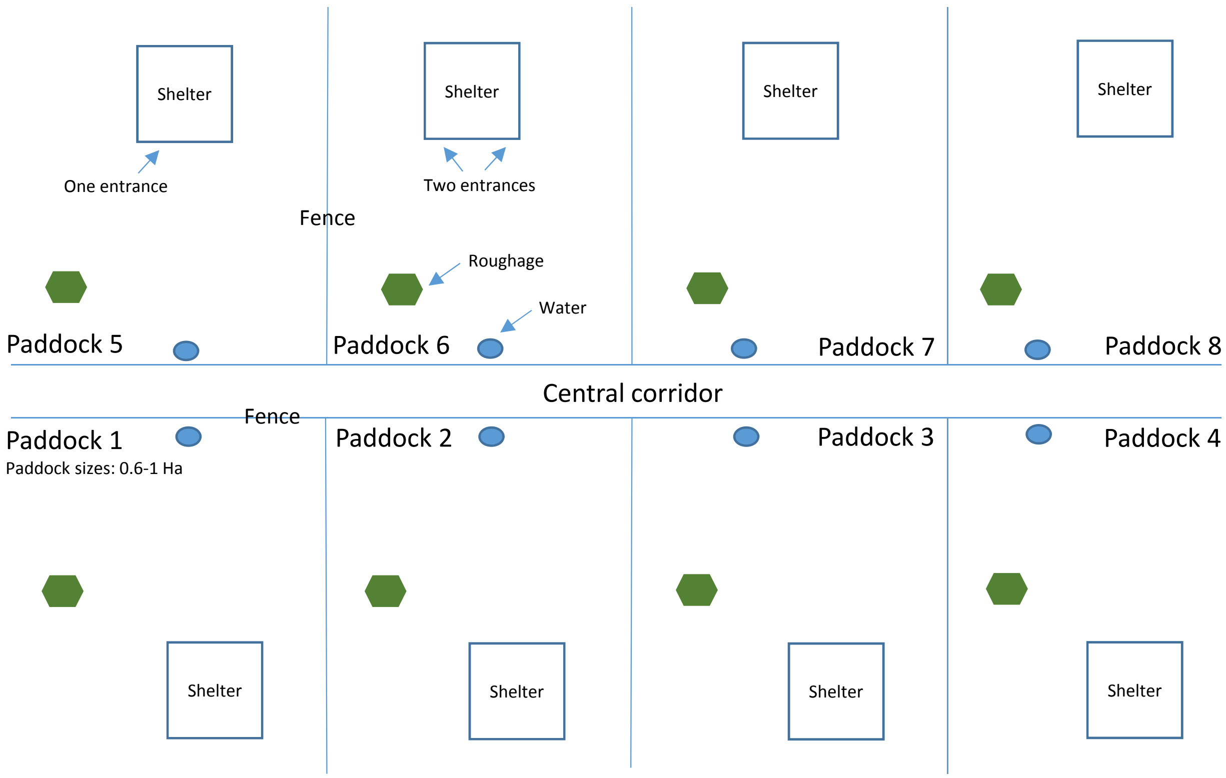

Figure 1. Illustration (not to scale) of the experimental design in Experiment 1 (1 vs. 2 entrances). Shelters were placed with the opening toward the north, as the wind was known to rarely come from this direction. Feed was available approx. 25-30 m from the shelters. In experiment 2, all shelters had 2 entrances, and the shelters in paddocks 1, 2, 7, and 8 had a short partition inside the shelter.

are therefore analyzed at group level as explained below, including the "nn" (i.e., no ID) recordings. Data on individual shelter use are only included as descriptive data and to estimate correlations.

The response variables "shelter use" (a: percentage of photos with at least 1 horse inside, and b: the total number of horse recordings), "activity in shelter" (frequency of lying or standing), "behavior on pasture" (freq. of eating, standing, locomotion, lying, social), and "position in the paddock" (freq. of open paddock, in shelter or by shelter) as well as "FCM" (calculated as the average of the obtained samples per individual) were analyzed for an effect of treatment (1 vs. 2 entrances in Experiment 1 and partition vs. no partition in Experiment 2) in a t-test (for data with normal distribution and variance homogeneity, presented as means ± SE), or a Mann-Whitney *U*-test (data presented as medians [25;75% quartiles]; SigmaPlot 12.0, https://systatsoftware.com).

Correlations between shelter use and weather conditions (temperature, wind speed, and precipitation) were investigated using Spearman correlations (SigmaPlot 12.0, https://systatsoftware.com).

Results

Experiment 1: 1 versus 2 entrances

Weather conditions

During the first experimental period, the weather conditions were rather wet, windy, and warm compared to usual Danish winter conditions (Table 3). Only 3 days were free from precipitation (0 mm). The average temperatures inside the shelters were 0.5°C-1°C warmer than the outdoor temperatures and the average shelter temperature during Experiment 1 was 6.2 ± 0.3°C.

Shelter use

Data on shelter use are presented in Table 4. Shelter use was analyzed as the percentage of photos from each camera where at least 1 horse was inside a shelter (i.e., accounting for the varying number of photos per camera) and partly as the total number of recordings of horses inside each shelter (i.e., the actual number of horses on the photos). There were a higher percentage of photos with at least 1 horse inside for groups with 2 entrances (Figure 2C). A similar result was obtained for the total number of horse recordings in the shelters (2 entrances: 467 [255;907] vs. 1 entrance: 111 [90;127], MWU: $P = 0.029$).

Horses in both treatment groups used the shelters significantly more at night (number of horse recordings/hour, 16-08 (dark hours): 9.9 [6;33] vs. 8-16 (light hours): 1.7 [0;4], $P < 0.001$). There was no treatment effect on the activity inside the shelters (e.g., percentage of horses in the shelter that are lying, 2 entrances: 48 ± 8.3 vs. 1 entrance: 55 ± 9.9, $P = 0.61$).

There were large individual differences in shelter use. For example, the old mare in group 2 was not observed in the shelter at all during Experiment 1, whereas the horse with the highest number of recordings in the same period was identified inside the shelter on 377 photos (a young horse in group 3). In general, young horses appeared to use the shelters more than older horses (recordings in shelter/horse; old mares (n = 8): 21 [4;61] vs. young mares (n = 24): 40 [20;70]). These data should be used with caution, however, due to the number of recordings (16%) where horse ID could not be determined.

Shelter use correlated positively with the amount of precipitation ($n = 21$, $r_s = 0.5$; $P = 0.02$) and outdoor temperature ($n = 21$, $r_s = 0.6$; $P = 0.004$). Wind speed did not correlate with shelter use.

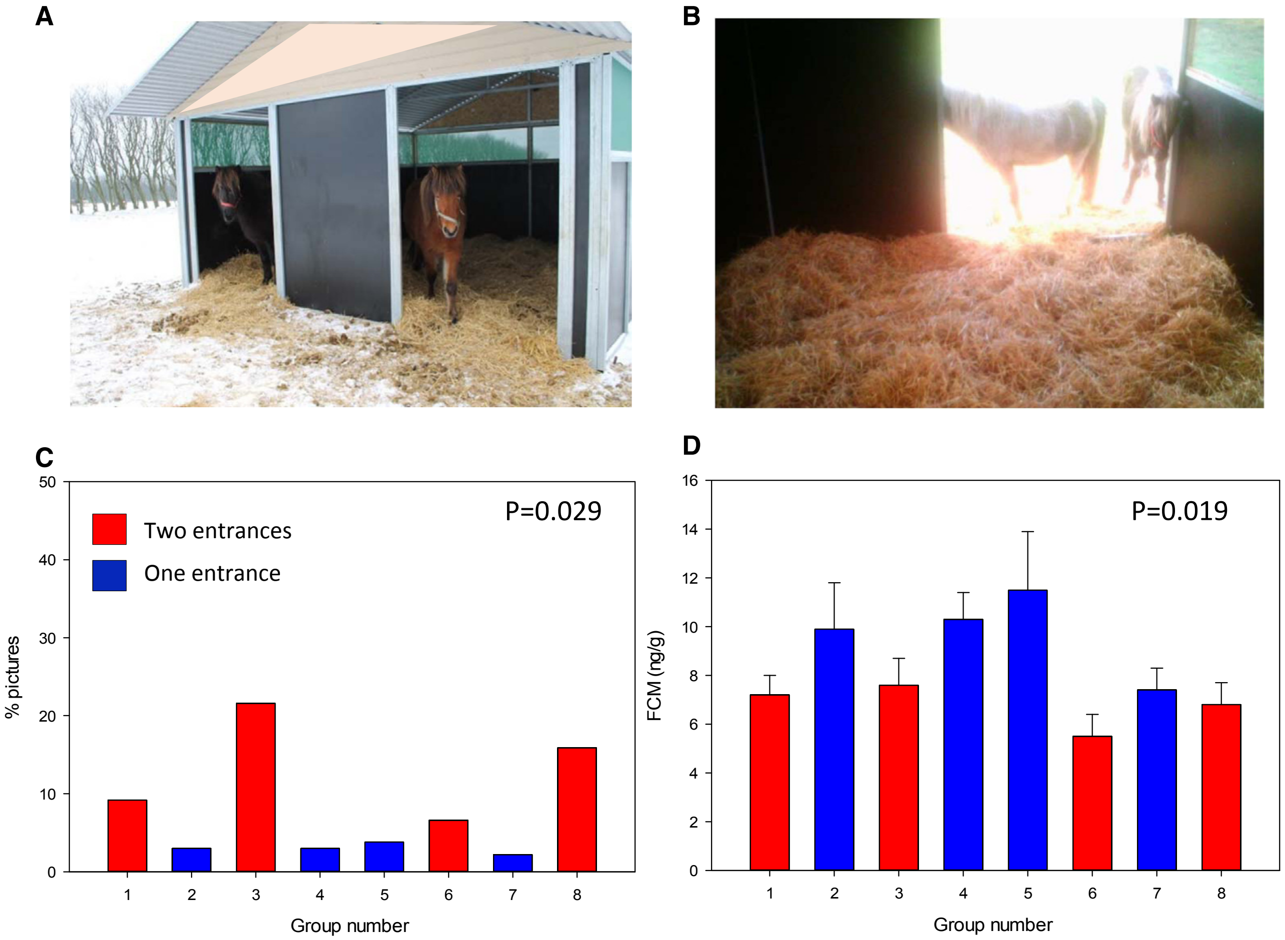

Figure 2. Shelter use was significantly higher in shelters with 2 entrances (A) than with 1 entrance (B), shown as percentage of photos with at least 1 horse inside for each of the 8 groups (C). Levels of fecal cortisol metabolites (FCMs, ng/g, mean ± SE per group) were significantly lower in horse groups with 2 entrances (D).

Behavior during day light

There was no treatment effect on the behavior of the horses during the light hours. Eating accounted for more than half of the recordings (%, 2 entrances: 53 ± 2.1 vs. 1 entrance: 55 ±2.4, $P = 0.52$). "Standing" was the second most frequent behavior with 15%-33% of recordings per group, whereas lying, locomotion, and social interactions were recorded only in 1-18 scans out of the total of 288 scans per group. The horses mainly stayed on the open pasture (66%-95% of all recordings per group) in the area with hay/hay silage, and there was no treatment effect.

FCM levels, body condition score, and social relationships

Groups of horses with only 1 entrance to their shelter had a higher level of FCMs compared to groups with 2 entrances (Figure 2D). Individual use (i.e., the total number of times a horse was recorded inside) did not correlate with FCM levels, but the results should be treated with caution due to the large number of recordings (16%) where horse ID could not be determined. The horses had a body condition score above average (BCS: 6.0 ± 0.1; 6 = "moderately fleshy"), and there was no difference between the treatment groups. Since almost all horses obtained BCS 6 and only a few BSC 5 or 7, there was not sufficient variation to investigate any potential effects of BCS on, for example, FCM levels. The limited resource test showed that in all groups, the older mare displaced all the young horses and monopolized 1 of the 2 feed buckets (Figure 3). There were no successful displacements of the older mares by young horses in any groups. The 3 young horses shared access to the other feed bucket, that is, there were no successful displacements between them in most groups. In a few groups, one of the young horses attempted to displace one or both of the other young horses, but since this was inconsistent, it was not possible to calculate differences in social rank between the young horses.

Figure 3. The Limited Resource test, in which feed containers are placed in the paddock and successful displacements between the horses recorded, has been previously used to estimate social rank in horses. The adult mares monopolized a feed container in all groups, whereas the young horses shared access to the other container.

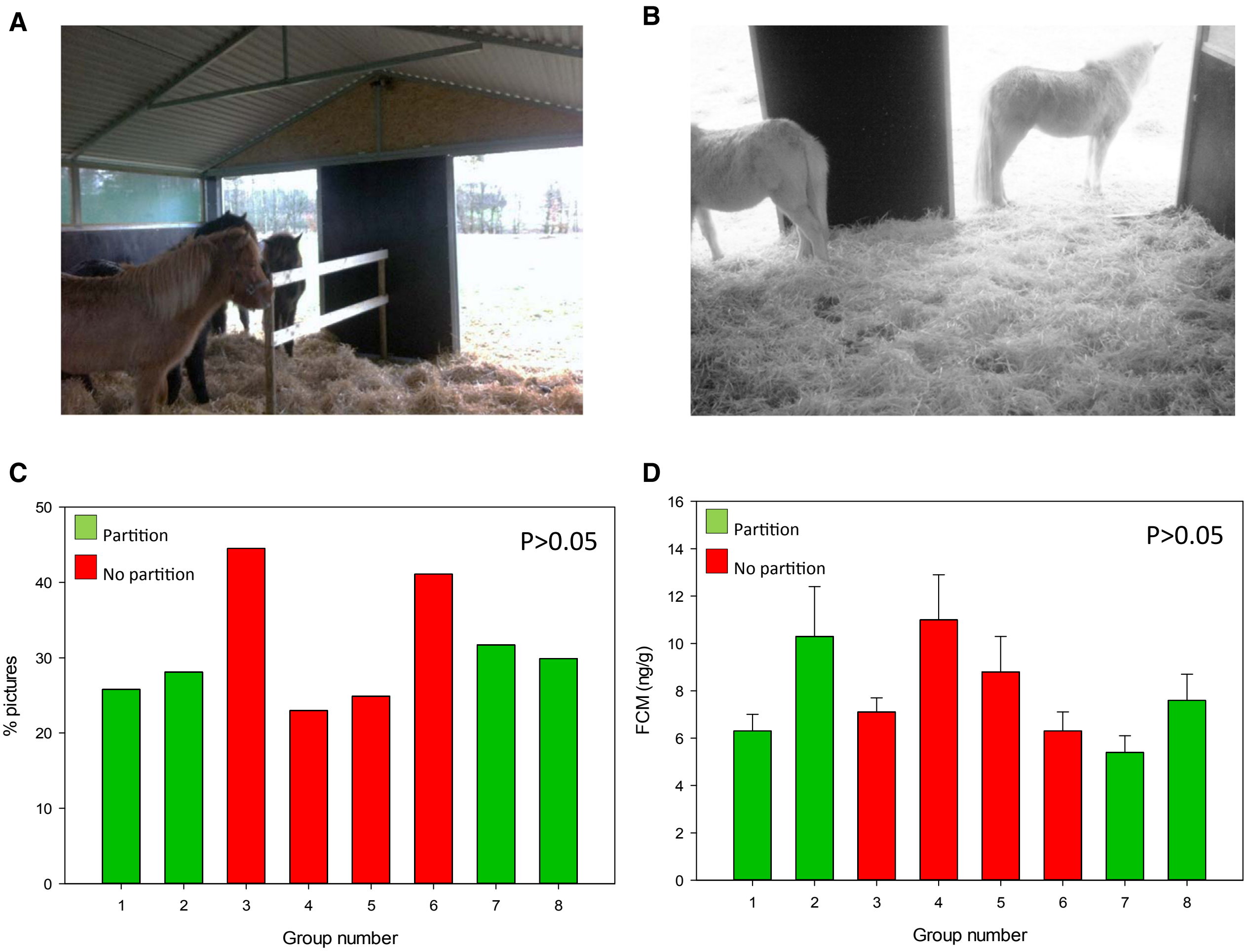

Figure 4. Shelter use did not differ between shelters with 2 entrances and a partition (A) compared to shelters with no partition (B), shown as percentage of photos with at least 1 horse inside for each of the 8 groups (C). Levels of fecal cortisol metabolites (FCMs, ng/g, mean ± SE per group) also did not differ between treatments (D).

Experiment 2: partition versus no partition

Weather conditions

The average weather conditions in the second experimental period are shown in Table 3. Six days had average temperatures below zero degree Celsius. Seven days had no precipitation and 11 days less than 1 mm. The daily average shelter temperature was 1°C-1.5°C warmer than the outside temperature, and the average shelter temperature was 2.9 ± 0.6°C.

Shelter use

There was no treatment effect on shelter use measured as the percentage of pictures where at least 1 horse was inside (Figure 4C). The same result was obtained for the total recordings of horses in the shelters (partition: 1565 ± 230 vs. no partition: 1704 ± 399, P = 0.77). The horses were lying on more than half of the recordings, with no treatment effect (%, partition: 53 ± 3.6 vs. no partition: 57 ± 4.2, P = 0.47). The shelters were mainly used during the dark hours (number of horse recordings/hour: 16-08 (dark hours): 86 [68;139] vs. 8-16 (light hours): 4 [2;11], $P < 0.001$).

The horse with the lowest number of recordings in the shelter in Experiment 2 was an old mare in group 1 (6 recordings), whereas the horse with the highest number of recordings was a young horse in group 6 (701 recordings). Young horses appeared to use the shelters slightly more than old horses (recordings in shelter/horse, old mares [n = 8]: 301 ± 91 vs. young mares [n = 24]: 397 ± 37). Again, the data should be used with caution, due to the number of recordings (7.5%) where horse ID could not be determined.

The horses used the shelters more on days where the average 24-hour temperature was below zero °C (recordings of horses in the shelters/day, ≤0°C (6 days): 778 ± 20 vs. ≥1°C (15 days): 560 ± 33, $P < 0.001$). There was a positive correlation between shelter use and wind speed (n = 21, $r_s = 0.5$; $P = 0.02$), whereas precipitation did not appear to affect shelter use during Experiment 2.

Table 1
Ethogram used for scan sampling of behavior

Behaviour	Description
Eating	Chewing hay/hay silage or grazing
Standing	Standing still for more than 3 seconds
Lying	Sternal or lateral lying for more than 3 seconds
Locomotion	Walking or running (any gait)
Social	Interaction with other horses (groom, play, aggression)
Other	Behavior not included above, for example, rolling, scratching

Table 2
Position of the horses recorded during scan sampling

Position in paddock	a. In shelter b. By shelter (<3 m all sides of shelter) c. Open paddock

Table 3
Overview of weather conditions during the 2 experimental periods

Experiment	Temperature (°C)	Precipitation (mm)	Wind speed (m/s)
Experiment 1 (Dec-Jan)	5.4 ± 0.3 [2.7 to 8.3]	3.5 ± 0.8 [0 to 15.9]	5.5 ± 0.3 [2.4 to 8.3]
Experiment 2 (Jan-Feb)	1.8 ± 0.6 [−3.6 to 5.8]	2.4 ± 0.8 [0 to 11.6]	5.7 ± 0.3 [2.4 to 9.9]

Average daily measures: mean ± SE and range [min-max]; temperatures measured at 2 m, precipitation at 1.5 m, and wind speed at 10 m height.

Behavior during day light

Behavior during the day did not differ between the treatment groups. Eating accounted for more than half of the recordings (%, partition: 54 ± 5.2 vs. no partition: 56 ± 3.3, $P = 0.76$). "Standing" accounted for 40%-64% of the recordings per group, whereas lying, locomotion, and social behavior were only recorded 1-18 times/group. The horses mainly stayed in the open paddock, close to the hay/hay silage (%, partition: 87 ± 5.2 vs. no partition: 85 ± 5.3, $P = 0.78$).

FCM levels, body condition score, and social relationships

There was no treatment effect on FCM levels (Figure 4D). There was a weak, negative correlation between the total number of individual recordings in the shelter and FCM levels ($n = 32$, $r_s = -0.37$; $P = 0.035$) and between the total number of recordings where a horse was lying inside and FCM levels ($n = 32$, $r_s = -0.42$; $P = 0.017$). Again, the results on individual use should be interpreted with caution due to the 7.5% of recordings where horse ID could not be determined. The average body condition score was 5.2 ± 0.1, that is, the horses had lost weight since the scoring in Experiment 1, but lack of variation did not allow for an investigation of associations with shelter use or FCM levels. The social relationships did not change from Experiment 1, that is, the older mares still displaced all the young horses from the feed, whereas the social relationship between the young horses was less clear.

Discussion

Our results show that entrance conditions to a shelter matter. Despite potentially providing a higher degree of protection from the wind, shelters with only 1 entrance were used significantly less than the more open shelters with 2 entrances. This effect may be caused by horses avoiding to enter the shelter in fear of being trapped if a higher ranking horse enters. In addition, horses may be generally reluctant toward entering areas with limited visibility, which has also been reported for cattle (Van laer et al., 2015). The shelters had a natural inflow of light through a net in the upper third part of the 3 sides (Figure 2A) but a free view of the environment was limited to the shelter entrances. Increased visibility can be obtained through using shelters with a full open side (as, e.g., in the study by Heleski and Murtazashvili, 2010)—at the expense of the degree of protection against weather conditions provided by the shelter. The relatively high use of the shelters during Experiment 2, where at least 1 horse was inside the shelter on 25%-45% of the photos (Figure 4C), suggests that 2 entrances may provide an adequate balance between free view of the environment and weather protection. However, further studies are required to investigate preferences for shelter openness in interplay with the degree of protectiveness offered by the shelter. In addition, this experiment did not investigate the possible association between behavioral lateralization in horses (Austin and Rogers, 2014) and side (left/right) preferences for shelter entrances, which could potentially have affected shelter use in shelters with only 1 entrance.

All the participating horses were experienced with group housing from their home environment and yet there was a large variation in sheltering behavior. We aimed to study individual use but this was not always possible due to problems with identification on the photos, resulting in individual shelter use being underestimated for some horses. In Experiment 1, the individual number of recordings varied from 0 to 377, while in Experiment 2, individual use varied from 6 to 701 recordings. The young horses appeared to use the shelters more than the older horses, which may be related to young animals having a higher "lower critical temperature" (McBride et al., 1985; Ousey et al., 1992; Van laer et al., 2014) or a higher need for lying than adult animals (Köster et al., 2017; Raabymagle and Ladewig, 2006). The reason for including an adult mare into each group was to ensure a difference in social status within the groups. As expected, the older mares displaced all the younger horses during the Limited Resource test, and thus, they could be assigned a higher social rank than the younger horses. The social relationship between the horses is especially interesting in groups with only 1 entrance where a higher-ranking individual may block the entrance to the shelter. However, the older, higher-ranking mares in the 4 groups with only 1 entrance had a lower number of recordings inside the shelter than the younger horses but obviously could still have prevented the young horses from entering by staying near the entrance. By contrast, the young horses tended to share the food resource during the Limited Resource test, rather than attempting to displace each other. This behavior may also transfer to the shelter as a resource, and shelter use is likely more affected by agonistic interactions in groups of adult horses.

Furthermore, our results showed that the level of FCMs was higher in groups of horses with only 1 entrance. This may reflect a thermal stress response because these horses were more exposed to precipitation and wind as previously reported in cattle (Tucker et al., 2007; Webster et al., 2008). Other factors that potentially could cause this effect are agonistic interactions around the shelter entrance and reduced lying time in horses with a lower shelter use. The horses were lying down on approximately half of the recordings in the shelters, whereas lying behavior was rarely observed on pasture. This result suggests that horses entered the shelters when motivated to lie down or that being inside the shelter on the straw bedding induced lying behavior. There were no treatment differences in lying behavior reflecting that although the horses used shelters with 1 entrance less, they were equally likely to lie down once inside. Because we did not record behavior on the pasture during the dark hours, we cannot from this study

Table 4
Distribution of photos with 0, 1, 2, 3, or 4 horses inside the shelters with 1 or 2 entrances during Experiment 1 (3 weeks in Dec-Jan)

Group	Number of entrances	Total pictures	Number of horses on photo				
			0	1	2	3	4
1	Two	2751	2498	203	42	8	0
2	One	2751	2668	48	31	4	0
3	Two	2730	2141	288	199	93	9
4	One	2940	2852	76	12	0	0
5	One	2793	2688	86	16	2	1
6	Two	2751	2569	134	42	6	0
7	One	2856	2793	43	17	3	0
8	Two	2667	2243	243	164	16	1

conclude if horses with reduced shelter use also had reduced total lying time. However, previous studies suggested that horses and cattle mainly lie down inside (Mejdell and Bøe, 2005; Redbo et al., 2001; Tucker at el., 2007). Horses can rest while standing but REM sleep requires that they lie down (Pedersen et al., 2004). Reduced lying time caused by a lack of suitable resting areas with a dry and soft surface may therefore be a potential welfare problem for animals kept outside during winter if they are not ensured access to dry lying areas. Similarly, Webster et al. (2008) concluded that in cows, cold and wet conditions could have either directly resulted in elevated glucocorticoid levels, or indirectly via a reduction in lying time (Fisher et al., 2002). By providing dairy cows with shelter, the time spent lying down increased and FCM concentrations decreased (Tucker et al., 2007). Further studies that include automatic registration of lying behavior would be valuable to further explore the welfare of horses kept outside during winter.

We found a positive correlation between shelter use and precipitation in Experiment 1. This result is in accordance with previous results in horses (Heleski and Murtazashvili, 2010; Mejdell and Bøe, 2005) and cattle (Redbo et al., 2001). There was also a positive correlation between shelter use and temperature which may relate to a coincidental, strong positive correlation in temperature and precipitation during the experimental period. In Experiment 2, the ambient temperature was significantly lower than in Experiment 1 and the horses used the shelters significantly more, when the average daily temperature was below zero degrees Celsius. There was a positive correlation between shelter use and wind speed, which corresponds to results for cattle, where low temperatures in combination with high wind speed caused the animals to seek shelter (Graunke et al., 2011). In contrast to Experiment 1, precipitation did not correlate to shelter use during the second experiment, which likely reflects that due to the lower temperatures, a part of the precipitation was snow. In accordance with the observation in the study by Mejdell and Bøe (2005), snow did not melt on the horses' backs due to their thick winter coats and therefore did not lead to the same heat loss as rain.

The partitions that were used in this study did not affect shelter use, nor FCM levels. Perhaps, the 2 entrances already ensured access to the shelter for all horses and the partition did not further decrease monopolization of the shelter entrance. It is possible, however, that differently shaped or sized partitions could have had a different effect, and the influence of shelter partitions in horse groups with a higher level of agonistic interactions deserves further study.

We further found that the horses mainly used the shelters during the dark hours. Mejdell and Bøe (2005) also reported that Icelandic horses used shelters more in the evening (22-24 h: 47% of the horses were inside) compared to the afternoon (16-18 h: 14% inside). Similarly, a recent study on beef cattle found that cattle predominantly used shelters during the dark hours (Fogsgaard and Christensen, 2018). The study also reported that the available space per individual was important as increasing space allowance from 4 to 6 m^2 for an adult individual ($\geq$500 kg) caused a significant increase in the use of shelters (Fogsgaard and Christensen, 2018). According to the current legislation, the available space per Icelandic horse was 6.8 m^2 in the present study, and shelter use is therefore not expected to be limited by lack of space per se. Further studies on the influence of space and the preference for natural versus artificial shelter in horses are needed. This study was conducted on Icelandic horses, which are generally expected to be more cold resistant than warmblood horses, and it would be interesting to further explore the cause of the increased cortisol levels, and whether it relates to thermal stress or is caused by other factors such as decreased lying time and aggression over the shelter as a resource.

In conclusion, when only 1 entrance was provided, we found a reduced use of shelters and a higher level of fecal cortisol metabolites in groups of Icelandic horses. A partition in the shelter neither affected shelter use, nor levels of cortisol metabolites.

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Ethical considerations

The study conformed to the "Guidelines for ethical treatment of animals in applied animal behavior and welfare research" suggested by the ethics board of the International Society of Applied Ethology (http://www.applied-ethology.org/). According to national legislation, no ethical permission was required for the experiments.

Conflict of interest statement

The authors declare no conflicts of interest.

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