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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