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The effect of blankets on horse behaviour and preference for shelter in Nordic winter conditions

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Abstract

Horses use human-made shelters actively during inclement weather, but the costs of building shelters may be high and owners use blankets or rugs on horses instead. The aim of the study was to investigate how wearing a blanket might affect the shelter seeking behaviour of horses under coastal arctic winter conditions. Could blankets make shelters redundant? During different winter weather conditions, seventeen horses had a full-neck blanket of their size put on and were released in a test paddock. There, horses were given free choice between staying outdoors, going into a heated shelter compartment or into a non-heated shelter compartment. An observer scored horse's location and behaviour using instantaneous sampling every minute for 1 h. Each horse was tested 2-12 days but only once per day. Detailed weather data (precipitation, wind and temperature) were continuously recorded by a weather station at the site. In general, horses with blankets still used the shelter and were observed inside in (mean per horse) 20.6 % of total observations. Horses spent more time inside shelters on days with rain and wind (39.7 % of tot obs) compared to on days with wind only (11.8 % of tot obs, P=0.05). Small coldblood horses were more active, spending more time in movement than large coldblood and large warmblood horses (P=0.01). In conclusion, wearing blankets reduced the impact of inclement weather, but did not make the shelter redundant for horses, under Nordic winter conditions.

Keywords: Equine, thermoregulation, inclement weather, preference, welfare.

Highlights

- The use of blankets on horses is comprehensive.
- During winter weather conditions, 17 horses dressed with a blanket were observed and their choice of staying outdoors, in a heated or in a non-heated shelter compartment was recorded.
- Horses spent more time inside shelters on days with rain and wind.
- We found breed type differences in activity and preference for heated or non-heated shelter.
- Wearing blankets did not make the shelter redundant for horses under Nordic winter conditions.

1. Introduction

The thermoregulation of domestic horses is an intricate interaction between physiological adaptions, behavioural changes and human management. This management may involve increased feeding, stabling in individual boxes, tiestalls or group housing with or without 24 hour access to outdoor areas.

In contrast to most other farm animals, sport horses often live under very controlled conditions. Studies show that the majority of horses in Europe are housed in single boxes and turned out in relatively barren paddocks with no shade or shelter, for most of the day (Bachmann and Stauffacher, 2002; Jørgensen and Bøe, 2010; Hartmann et al., 2015, 2017). In Nordic countries, the weather conditions set some premises and imply provision of additional feed in long winter months (normally from September to May). Although horses use human-made shelters actively during inclement weather (Mejdell and Bøe, 2005; Heleski and Murtazashvili, 2010; Snoeks et al., 2015), stable owners claim that the costs of building shelters are too high, and horse owners must conform to the facilities available at the stable where they seek livery services.

As temperatures fall and daylight decreases, horses grow a winter coat for increased protection (Morgan, 1997). Allowing the horse to grow a thick winter coat may be impractical for the owner because it takes more time to groom, and puts unnecessary heat stress on horses during exercise (Morgan et al., 2002). Varying between countries, 35-68 % of horse owners, therefore, practice clipping on a regular basis (Hartmann et al., 2017). A clipped horse will need extra protection from excessive heat loss and a German study revealed that more than ninety percent of clipped horses wore a blanket day and night (Steinhoff-Wagner, 2018).

In Sweden, 90.9 % of respondents stated that their horses used blankets during turnout, while the corresponding number in Norway was 83.7 %. In the same study, 96.1 % of clipped Swedish horses also wore blankets (Hartmann et al., 2017).

A rise in ambient temperature or increased sun radiation during the day may put unnecessary thermal load on the blanketed horse. The blanket interferes with the cooling effect of natural, physiological thermoregulatory mechanisms like skin blood vessel dilation and sweating (Curtis, 1983). Even a well-fitted blanket may over time induce pressure, causing skin chafing or sores (Clayton et al., 2010) and blankets in general impair social grooming (Höglund, 2015).

According to data on horses not wearing blankets, a shelter might provide sufficient protection against low temperatures and harsh winter conditions (Michanek and Ventorp, 1996, Autio and Heiskanen, 2005, Mejdell and Bøe, 2005; Jørgensen et al., 2016). Horses kept in 24 h outdoor housing systems should be offered access to shelter (e.g. Norwegian Food Safety Authorities, 20016). But horses that are taken into stables during night might still benefit from shelter, regardless of season, during turnout. To our knowledge, no studies have investigated how blankets would affect the horse's preference for shelter in different winter weather conditions. Furthermore, different breeds of horses have evolved to cope with very diverse environments and climatic conditions. The adaptations involve both different size and body conformation (Langlois, 1994), fat distribution and hair coat condition. No studies have documented how wearing a blanket will affect the impact of breed type and physiological traits on horse thermoregulatory behaviour.

The aim of this experiment was to investigate how wearing a blanket would modify the shelter seeking behaviour of horses, and their preference for additional heat under Nordic winter conditions. We hypothesized that horses wearing blankets would be less affected by harsh weather conditions, compared to horses not wearing blankets in a comparable study. From this we predicted that horses wearing blankets would 1: use the shelter less, and 2: show different behaviours at the same winter weather conditions, compared to horses not wearing blankets. Furthermore, we predicted that the presence of blankets would mask or even remove any effects of breed type, body condition and hair coat quality on shelter preference and thermoregulatory behaviour.

2. Materials and methods

The present experiment represents a continuation of a very similar experiment done at the same facilities, in similar weather, on the same horses while not wearing blankets (Jørgensen et al., 2016).

The experiment was conducted during March, November and December 2014. The test facilities were built on the property of a medium sized livery stable (25-30 horses), in Sandnessjøen, located at the coast in the northern part of Norway (65°N), just south of the Arctic circle. Average annual temperature in the region is 6.7 °C (range -14 to 25 °C) and annual precipitation is 1001-1250 mm/year during winter (www.met.no).

2.1 Horses and management

Seventeen privately owned riding horses and ponies of different breeds and sex were included in the study, 8 horses in March and 15 horses in November/December 2014. Horses were healthy, in work and older than 1 year. Five of the eight horses tested in March were also used

in November/December. Horse information (e.g. age, breed, exercise intensity and blanketing routines) was collected by detailed questionnaires to the horse owners. All horses were accustomed to wearing blankets and wore blankets during periods with rain and wind. A few of the horses also wore blankets during rain and wind in summer. Horse height, weight and body condition scores (BCS) were recorded by a trained observer at the start of the observation period. Body weight was estimated using a standard weight estimation band (Höoks Hästsport AB, Borås Sweden) and body condition (points 1=emaciated to 9=obese, according to Henneke et al. (1983) was scored on six different body parts making an overall score for each horse. Findings ranged from BCS 3 to 7 (so no skinny and no very obese horses participated in the study). We created a new description of BC status by grouping the mean of scores from the six different areas of the body into five categories as follows: low= < 3.5; medium low= 3.6 – 4.5; medium= 4.6 – 5.5; medium high= 5.6 – 6.5 and high= > 6.5.

Hair coat samples were collected from a 3x3 cm area above the gluteal muscle using a small electric clipper. Hair samples were dried in a laboratory drying cabinet using permeable teabags, for 2 days at 50 °C. Then the hair samples were weighed on an electronic scale. Two horses tested in March had been clipped in autumn 2013, but we managed to collect a coat sample (0.2 and 0.3 grams). The hair coat samples were taken both in March and in November and for the five horses both attending spring and autumn/winter testing the hair coat sample actual weights varied within individual from – 0.6 to +1.2 g from spring to autumn. Based on hair coat sample weights, horses were assigned to one of three categories as follows: low= < 1 g, medium= 1 – 2 g and high= > 2 g.

Horses were grouped into five type categories according to the presence of warmblood (8) and coldblood (9) type characteristics (Langlois, 1994), height at the withers and estimated

body weights. The following criteria made the basis for breed type categories: ponies (height: ≤ 119 cm; body weight: 230-313 kg) = 2 individuals; small coldblood horses (120-149 cm, 234-464 kg) = 5 individuals; large coldblood horses (≥ 150 cm; 432-596 kg) = 2 individuals; small warmblood horses (120-149 cm; 372-402 kg) = 3 individuals; large warmblood horses (≥ 150 cm; 414-650 kg) = 5 individuals. Our categories based on the previous mentioned limits for height at the withers and body weight was therefore not strictly concurrent with the common height limits and standards for e.g. ponies and horses.

2.2 Shelter and paddock

Two identical experimental enclosures, each measuring 11 m x 11 m (121 m^2), were established in an open area using electrical fences in two heights. Inside the enclosures, there was a shelter with two separate compartments each measuring 3.7 x 3.6 m (13.3 m^2) (Figure 1). Horses in the experimental enclosures could not see each other, but they could see other horses more than 20 m away. Horses could not walk behind their own or the neighbouring shelter.

(*Figure 1 here*)

The shelter was made of wood with corrugated metal plates on the roof. The indoor wall height in the compartments was 2.5 m and each of the door openings were 1.27 m wide and 2.35 m in height. A light was installed in both compartments together with an infrared heater (ALF 14 terrace heater 1400 W). The infrared heater was turned on in one of the compartments at the time. The compartments to be heated were randomly changed between observation days, to prevent bias from horses choosing compartments based on preferred position, rather than the presence of radiation heat. Infrared radiation heats the objects in its

188 path and has little impact on air temperature inside the shelter compartments in general, due to
189 their open design.
190
191 **2.3 Test procedure**
192 Horses were trained to enter both compartments in the shelter as described in Jørgensen et al.
193 (2016). All test days started from morning (8 o'clock) and lasted until daylight faded around 2
194 to 3 p.m. Horses were fed their normal ration of feed, then fitted with a standard full neck
195 blanket (Heimer Budget, 200 gr fill[1] and 600 denier[2]) of their size and turned out into their
196 home paddock. After two hours, the test horse was led into the experimental enclosure and
197 observed there for one hour before it was led back to the home paddock. Feed was not
198 available in the experimental paddock or in shelters.
199
200 **2.4 Behavioural observations**
201 The horses were observed in the experimental enclosure by a trained observer for 1 h per day.
202 The observer was positioned so that she could see both horses and enclosures at the same
203 time. Each individual horse was observed from 2 to 12 days (median: 8) under different
204 weather conditions. Horses to be tested each day was randomly chosen. The total number of
205 observation hours was 132. Using instantaneous sampling at 1min intervals, horse behaviours
206 were scored from an ethogram of mutually exclusive behaviours (Table 1). The observer also
207 noted where the horse was located, using 3 location alternatives: 1) outside in paddock, 2)
208 inside heated shelter compartment, 3) inside non-heated shelter compartment.
209
210 (*Table 1 here*)

[1] Medium thick blanket with a fill material of 200 gr/m^2 material.
[2] Denier means weight per unit length (linear density) measure of a continuous filament or yarn. The lower the denier number, the finer the material (Business Dictionary online). Here, the denier number means that the outer layer has a medium course thread weave, making it durable with water repelling properties.

2.5 Weather parameters

Data on weather factors were automatically recorded by a weather station (ITAS) on an hourly basis. Sudden changes in precipitation or temperature were noted by the observer, so they could be crosschecked against data from the weather station. The weather station was located 15 m from the shelters and saved data of wind (direction and speed), precipitation (i.e. rain, sleet or snow) and air temperature. During the experimental period, the average temperature was 1.3 °C (range -8.7 to 8.1 °C); the average precipitation was 0.17 mm per hour (range 0.0 to 3.9 mm/h) and average wind gust speed was 1.6 m/s (range 0.02 – 8.2 m/s). Weather conditions were later categorized into eight weather categories as described in table 2.

(Table 2 here)

Another variable was created by combining weather categories without precipitation (1 – 4) for 'dry', and weather categories with precipitation (5 – 8) for 'wet' weather. A further variable describing weather extremes as 'mild' was created by combining Categories 1 and 2, and 'harsh' by combining Categories 7 and 8. Data from Categories 3-6 were excluded and a new dataset made the basis for analysis of weather extremes.

2.6 Data analysis

The effects of weather and type on use of shelter and behaviour were investigated using a mixed model of analysis of variance with the following class variables: 'weather category' (1-8); 'horse type category' (1-5) and 'horse' (1-17) as class variables. BCS and hair coat sample weights were included as covariates in the model. The denominator degrees of freedom were

computed using the Satterthwaite's approximation. 'Horse' within 'horse type category' was specified as a random effect.

The effect of 'dry' or 'wet' weather on use of shelter was tested using a similar model with the following class variables: 'horse', 'horse type category' and 'wet or dry weather' (0, 1). The effect of BCS categories and hair coat sample weight categories were also tested using a similar model with the following class variables: 'horse', 'horse type category', 'BCS category' and 'hair coat sample weight category'.

The same model was applied for testing differences between weather extremes: 'mild' and 'harsh' weather including the interaction effect between weather extreme (mild/harsh) and horse type category (1-5) in the model. A Tukey Kramer test for least square means was applied for testing differences between means within class variables.

The correlation between actual BCS's (mean over all body parts per horse and year) and use of shelter was investigated using a Spearman correlation test (PROC CORR Spearman command) for each location and behaviour separately. The same test was performed for the correlation between hair coat sample weight and use of shelter.

The data analysis for this paper was generated using SAS software, Version 9.4 of the SAS System for Windows 6.2.9200 Copyright © 2002-2012 SAS Institute Inc. SAS and all other SAS Institute Inc. product or service names are registered trademarks or trademarks of SAS Institute Inc., Cary, NC, USA.

3. RESULTS

3.1 Use of shelter

Regardless of weather, horses spent more time outdoors than indoors (mean per horse: 79.3% of total observations, ranging from 3.3-100%, see table 3). The weather conditions had, however, a significant impact on time spent outdoors, ranging from 60.3 % on days with wind, rain and air temperatures $\geq$ 0 °C to 88.2 % on days with air temperatures $\geq$ 0 °C, no rain but with wind (Table 3 and Table 4). No effects of wet (categories 5-8) or dry (categories 1-4) weather were found for time spent in shelter ($F=1.2$; $P=0.27$).

(*Table 3 here*)

Time spent outdoors decreased significantly from 85.2 % on days with mild temperatures, without precipitation or wind (weather category 1-2) to 63.6 % on days with harsh weather (weather category 7-8), ($F=3.8$, $P=0.02$). Horse type category did not influence the use of shelter (Table 4).

Hair coat sample weights ranged from 0.7 to 4.7 g and the ponies (mean ± SD, 4.5 ± 0.1 g) and coldblood horses (2.2 ± 0.6 g) had thicker hair coats with higher sample weight than warmblood horses (1.1 ± 0.4 g). The model covariate on actual haircoat sample weight per horse and observation tended towards an effect on the mean proportion of time spent outdoors per horse (Table 4). This was supported by a tendency for a correlation between hair coat sample weight and proportion of time spent outdoors (Table 4).

Horses with a high body condition score (BCS) were more frequently observed outdoors compared to horses with medium and medium high body condition scores (BCS category medium: 73.4 ± 4.0 %; medium high: 74.9 ± 4.7 %; high: 89.4 ± 3.1 %) ($F=3.8$; $P=0.022$).

Horses with medium low body condition scores were however observed outdoors the most (91.1 ± 1.9 %).

3.2 Heated vs. unheated shelter

The mean time spent in the heated compartment and unheated compartment of total time spent in the shelter was 61 % and 39 %, respectively. Three of 17 horses chose the heated compartment more than 50 % (range 53.7 to 66.0 %) of the time spent in the shelter. Only one horse preferred the non-heated compartment more than 50 % of the time spent in shelter (95 %). Even though weather conditions apparently had no significant effect on time spent in the heated compartment, the general use of shelter increased with wetter, colder or more windy weather (Table 3).

An interaction effect between horse type category and extremes within weather was discovered. Especially large coldblood horses seemed to change from staying outdoors in mild and dry weather (weather categories 1 and 2) to using both heated and non-heated compartments in harsh weather with precipitation and wind (weather categories 7 and 8) (Figure 2). Small coldblood horses reduced their time spent outdoors with 25.1 % as weather conditions changed from mild to harsh (Figure 2). The interaction between horse type and weather characteristic (mild or harsh) tended towards significance ($F=2.0$; $P=0.060$).

(*Figure 2 here*)

The correlation between hair coat sample weight and proportion of time spent in heated compartment tended towards significance (Table 4).

(Table 4 here)

3.3 Horse behaviour

The most common behaviour observed was 'stand relaxed' (Table 3). On days with mild weather (≥ 0°C) and no precipitation, but wind, horses tended to spend less time moving (4.8 ± 1.9 %) compared to days with temperatures below zero and snow (13.2 ± 2.6 %; F=2.0; *P*=0.06). The behaviour 'stand tense' was only observed on days with no precipitation or wind and 'shiver' was never observed (Table 3).

Small coldblood horses were more often observed moving (18.5 ± 2.8 %) in the experimental pen compared to ponies (3.9 ± 0.8 %), large coldblood (4.9 ± 0.8 %), large warmblood (7.6 ± 1.0 %) or small warmblood horses (11.0 ± 2.0 %) (Table 4).

The correlation between body condition scores and the behaviour moving tended towards significance (Table 4), indicating that fatter horses moved more around (BCS category 2: 5.4 ± 1.6; BCS category 3: 9.0 ± 1.1; BSC category 4: 9.8 ± 1.8; BCS category 5: 10.2 ± 1.9 % of tot obs).

4. DISCUSSION

4.1 Use of shelter

Contrary to what we predicted, we found that blanketed horses still used the shelter and increased the use on days with harsh weather (precipitation combined with wind). One Nordland/Lyngen horse was observed only 3.3 % of total observations outdoors on a day with rain/sleet and wind (weather category 7). Regardless of weather, horses in the present experiment were mostly observed outdoors (79 %), and spent more time outdoors than horses

not wearing blankets (64 %), as found by the authors in a comparable study on the same premise (Jørgensen et al., 2016). The increased use of shelter during harsh weather conditions with a combination of rain or snow and wind, is in agreement with results from similar studies (Jørgensen et al., 2016; Snoeks et al., 2015).

The present study found no effects of wet or dry weather on time spent outdoors. This may reflect the water repelling and protective properties of the blanket. Looking at days with no wind and rain (weather catogory 1 and 2), low air temperatures *per se* apparently had no effect on time spent outdoors. But, horses tended to spend less time outside on days with wind combined with snow. Both wind and snow/rain will increase the animal's heat loss (Curtis, 1983), and several studies have shown that the use of shelter increases in inclement weather (cattle: Van lar et al., 2014, horses: Mejdell and Bøe, 2005, Snoeks et al., 2015, Christensen et al., 2018), thus supporting our findings.

In another study, horses were trained to communicate their preferences for wearing blankets during different weather conditions (Mejdell et al., 2016, 2019). No horses in that study indicated that they preferred to wear blankets in sunny spring and summer weather, and most asked for a blanket in chilly weather with rain and wind. However, irrespective of the pre-determined blanketing routines of the horse owners, some horses preferred to wear blankets on days with 6-9°C and rain and wind, while others did not. This reflects individual difference that even the owners could not anticipate (Mejdell et al., 2016). Detailed analyses of the choices made in different weather conditions have later revealed that individual horses have different thresholds for when they choose to get a blanket on (Mejdell et al., 2019).

Horse type differences in hair coat characteristics were as expected: thicker (heavier) hair coats with longer hairs on ponies and coldblood horses, compared to on warmblood horses. In the present experiment, the heaviest hair coat sample weighed 4.7 g dried and belonged to a sportpony, while the lightest hair coat sample (not from a clipped horse) weighed 1.1 g dried and belonged to a large warmblood Mecklenburger horse. Similar type differences in hair coat characteristics have been found by Autio (2008), and might be explained by general adaptations of the types to the climate where the breeds have lived and adapted (Langlois, 1994). Such type adaptations also include a thicker layer of subcutaneous fat for insulation. Our results showed that horses with a higher body condition score were observed more often outdoors. This may indeed be a reflection of increased insulation against the cold.

The effects of hair coat thickness on shelter use are difficult to explain, as both horses with low and horses with high hair coat sample weights were observed to use the shelter more than horses with medium haircoat sample weights. In the study without blankets, a much clearer effect was found, where horses with a thicker haircoat spent more time otudoors (Jørgensen et al., 2016). Disregarding the fact that the hair coat of horses wearing a blanket most certainly will not be fully raised by eventual piloerection, a full set of winter coat underneath a medium thick winter blanket might significantly affect the total surface insulation of the horse (Morgan, 1997).

4.2 Heated vs. unheated shelter

Of the total time spent inside the shelter, horses in the present experiment chose the heated compartment in 61.2 % of the occasions. This is in fact more than horses without blankets (53.7 %) (Jørgensen et al., 2016). The general preference for the heated compartment could be explained by the need for drying the body parts not covered by the blanket. If horses became

wet on their head, it might feel uncomfortable and horses could prefer shelters with radiation heat to dry up. Another explanation could be that the blanket became wet all the way through and horses sought heat because they felt cold. This was however never the case. The blankets were new, and kept all horses dry during the experiments relatively short duration. It might also be that blankets shielded the heat radiation so that the heated and non heated compartments felt equally comfortable to stay in. Since the heat was turned on randomly in one of the two compartments, and changed from one observation day to the next, any effects of preferred shelter compartment (left or right) should not be present.

4.3 Horse behaviour

On days with mild weather (≥ 0°C) and no precipitation, but wind, horses spent significantly less time walking compared to days with temperatures below zero and snow. This is opposite to what has been found in Finnish yearlings, where increased wind speeds were correlated with an increase in horse movement (Autio, 2008). Horses in the present experiment were in general adults, and wind will disturb the horse's sense of hearing, which might make an inexperienced yearling restless, while an experienced adult horse might reduce activity and trust their other senses. The increased moving observed on days with low temperatures (≤ 0 °C) was not significant for non-blanketed horses (Jørgensen et al., 2016). Cymbaluk and Christison (1988) reported that yearlings increased their play activity during cold weather conditions.

The small coldblood horses in the present experiment were more often observed moving around compared to large coldblood or large warmblood horses. Small horses have a larger surface to body mass ratio (e.g. Bligh, 1998) which is disadvantageous in a cold climate, because of heat loss from the skin. Moving around means muscle work, in which 80% is heat

production. Thus, increased moving could be a result of smaller horses feeling cold and activating their muscles for heat (Curtis, 1983). Feeding influences metabolism and thus heat production, and the larger warmblood horses were on a richer diet than the average small coldblood horses. Furthermore, warmbloods have the genetic fat deposit distribution, hair coat characteristics and body conformation adapted to a warmer climate (Langlois, 1994), which is very different compared to coldblood horses. These factors will, in broad sense explain much of the breed type differences found.

As predicted, the presence of a blanket masked many of the breed type effects on thermoregulation found in the study on horses without blankets (Jørgensen et al., 2016). Still, the interaction between horse type category and weather extremes on horse use of shelter indicate that the blanket was not enough to protect horses at inclement weather conditions. This may again be explained by the slight differences in thermal comfort that individual horses have displayed in the study by Mejdell et al (2019).

The behaviour moving might on the other hand be interpreted as an expression of normal behaviour, whereas animals feeling cold save energy and reduce activity (Cattle: Wassmuth et al., 1999). In the present study, horses with a high BCS also tended to be moving more. This finding is discussed in the previous experiment on horses without blankets (Jørgensen et al., 2016). Whether horses reduce or increase activity when feeling cold is thus a difficult conclusion to draw. Maybe they do both, but at different ends of their thermoneutral zone.

4.4 Limitations of the study

Using privately owned horses made us unable to control how many of each horse type and age group we could use. Great efforts were made to standardize the test conditions, to reduce

surrounding noise and distractions and at the same time keep the environment, feeding routines and training as familiar as possible. We made sure that all horses were thoroughly habituated to the test facilities. Each horse was also exposed to the given weather factors for two hours at the test days, wearing a standard blanket, before behavioural recordings started. In general, preference tests may have generic limitations because we do not know how strong any preference is, i.e. how important it is for the horse to seek shelter or to make use of the heated compartment. Neither did we test whether horses preferred to have access to a shelter over wearing a blanket.

5. Conclusion

Horses wearing blankets still used shelter, and increased their use of shelter on days with rain and wind. Wearing blankets also masked previously documented effects of horse type on shelter seeking behaviour, but there still seem to be breed type differences in general activity outdoors. Further studies should investigate the effect of different types of blankets (thickness and waterproof properties) on horse behaviour and sheltering preferences.

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Legends to tables

Table 1. Ethogram with description of horse behaviours observed during tests.

Table 2. Weather categories and number of observations per category.

Table 3. Horse use of shelter and behaviour according to different weather conditions. Numbers are given in mean ± standard error and the number of one-hour observation periods per weather category is indicated above each column.

Table 4. Statistical models of associations between weather, horse type, body condition score (BSC), hair coat sample weight, horse behaviour and voluntary selection of location. Only covariates with significant effects within the mixed model are listed.

570 **Tables**

571

572 Table 1

573

Behaviour	Description
Stand relaxed	Standing in a relaxed body posture, may also have eyes closed and be asleep
Sniff	Stand or walk with nose close to or in contact with ground. May nibble at snow or sniff the ground
Stand tense	Standing with fore feet and hind feet closer together. Head low. Body tense. Tail tucked in between hind legs
Shiver	Stand or move slightly with involuntary muscle shivering. Mostly shaking in the large muscles of the hindquarters but may also show muscle shivering in other body parts
Moving	The horse moves around, walking or running
Others	Lie on the ground, rolling, eliminative behaviours or scratching against shelter wall

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576 Table 2

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Weather category	Description	Number of observations
1	> 0 °C, no wind, no precipitation	30
2	≤ 0 °C, no wind, no precipitation	38
3	> 0 °C wind[3], no precipitation	10
4	≤ 0 °C wind, no precipitation	14
5	> 0 °C no wind, precipitation[4]	0
6	≤ 0 °C no wind, precipitation	12
7	>0 °C, wind and precipitation	16
8	≤ 0 °C, wind and precipitation	12
Sum		**132**

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[3] Wind was defined as present when maximum wind speeds observed reached 5 m/s.

[4] Precipitation was defined as present on days with more than 0.1 mm per hour.

579 Table 3.
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Number of 1H obs. periods	(132)	(30)	(38)	(10)	(14)	(12)	(16)	(12)
Means ± SE % of tot. obs. **Location**	**Overall**	**> 0 °C**	**≤ 0 °C**	**>0 °C and wind**	**≤ 0 °C and wind**	**≤ 0 °C and snow**	**>0 °C, wind, rain**	**≤ 0 °C, wind, snow**
Outdoors	79.4 ± 2.2	85.9 ± 2.9	84.5 ± 3.2	88.2 ± 3.8	71.3 ± 6.7	86.5 ± 6.5	60.3 ± 10.0	67.0 ± 10.0
In heated compartment	12.6 ± 1.7	11.3 ± 2.7	9.7 ± 2.5	8.6 ± 2.3	14.7 ± 4.3	10.9 ± 6.7	19.5 ± 7.6	18.6 ± 8.8
In non-heated compartment	8.0 ± 1.4	2.8 ± 0.7	5.8 ± 1.7	3.2 ± 1.9	14.0 ± 4.9	2.6 ± 0.7	20.2 ± 8.0	14.4 ± 7.1
Means ± SE % of tot. obs. **Behaviour**	**Overall**	**≥ 0 °C**	**≤ 0 °C**	**≥ 0 °C and wind**	**≤ 0 °C and wind**	**≤ 0 °C and snow**	**≥ 0 °C, wind, rain**	**≤ 0 °C, wind, snow**
Stand relaxed	72.8 ± 1.5	70.3 ± 3.0	71.7 ± 2.7	77.2 ± 8.1	78.1 ± 2.7	64.3 ± 4.3	77.3 ± 5.2	75.7 ± 6.3
Sniff	14.8 ± 1.1	14.8 ± 2.1	15.4 ± 2.0	14.3 ± 5.4	14.4 ± 1.8	16.4 ± 2.5	10.6 ± 4.7	17.8 ± 5.0
Stand tense	0.04 ± 0.03	0.06 ± 0.06	0.09 ± 0.09	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Moving	8.9 ± 0.8	11.4 ± 1.9	8.6 ± 1.3	4.8 ± 1.9	4.6 ± 1.3	13.2 ± 2.6	10.2 ± 3.0	5.8 ± 1.8
Other behaviours	3.2 ± 0.6	3.4 ± 1.1	4.2 ± 1.6	3.7 ± 2.2	2.8 ± 1.6	6.1 ± 2.8	1.9 ± 1.3	0.7± 0.5

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Table 4.

Mixed model				
Fixed effects	**Response variable**		**F-value**	**P-value**
Weather category (8)	Location	Outdoors vs indoors	2.2	0.05
		Heated vs. non-heated	0.5	NS
	Behaviour	Stand relaxed	1.2	NS
		Sniff	0.9	NS
		Moving	2.0	0.06
Horse type category (5)	Location	Outdoors vs indoors	1.7	NS
		Heated vs. non-heated	0.7	NS
	Behaviour	Stand relaxed	1.5	NS
		Sniff	0.8	NS
		Moving	4.7	0.01

Effects of covariates within the mixed model				
	Response variable	**Covariate**	**F-value**	**P-value**
Location	Outdoors vs indoors	Hair coat	3.6	0.06
Behaviour	Stand relaxed	Hair coat	3.5	0.07
	Moving	Hair coat	3.1	0.09

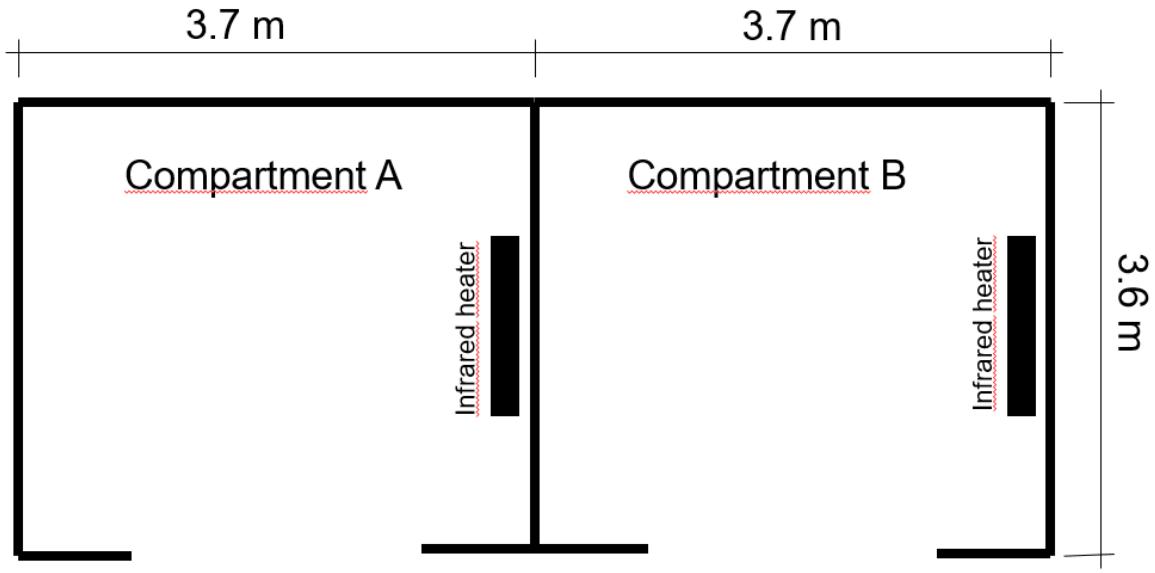
Spearman correlations				
			Spearmans ρ	**P-value**
Hair coat sample weight	Location	Outdoors	0.14	0.09
		Heated	-0.17	0.05
		Non-heated	-0.04	NS
Mean body condition score	Behaviour	Stand relaxed	0.01	NS
		Sniff	-0.08	NS
		Moving	0.16	0.05

Legends to figures

Figure 1. Sketch showing the enclosures and shelters with two compartments and infrared heaters in each room. The heaters were turned on in one compartment per shelter, at a time. Sizes given in millimetres.

Figure 2. Use of shelter per class of horse type and effects of mild (weather category 1 and 2) or harsh weather (weather category 7 and 8). Numbers of observations per weather extreme are given in parenthesis.

Figure 1.


3.7 m
3.7 m
Compartment A
Compartment B
Infrared heater
Infrared heater
3.6 m

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639 Figure 2.

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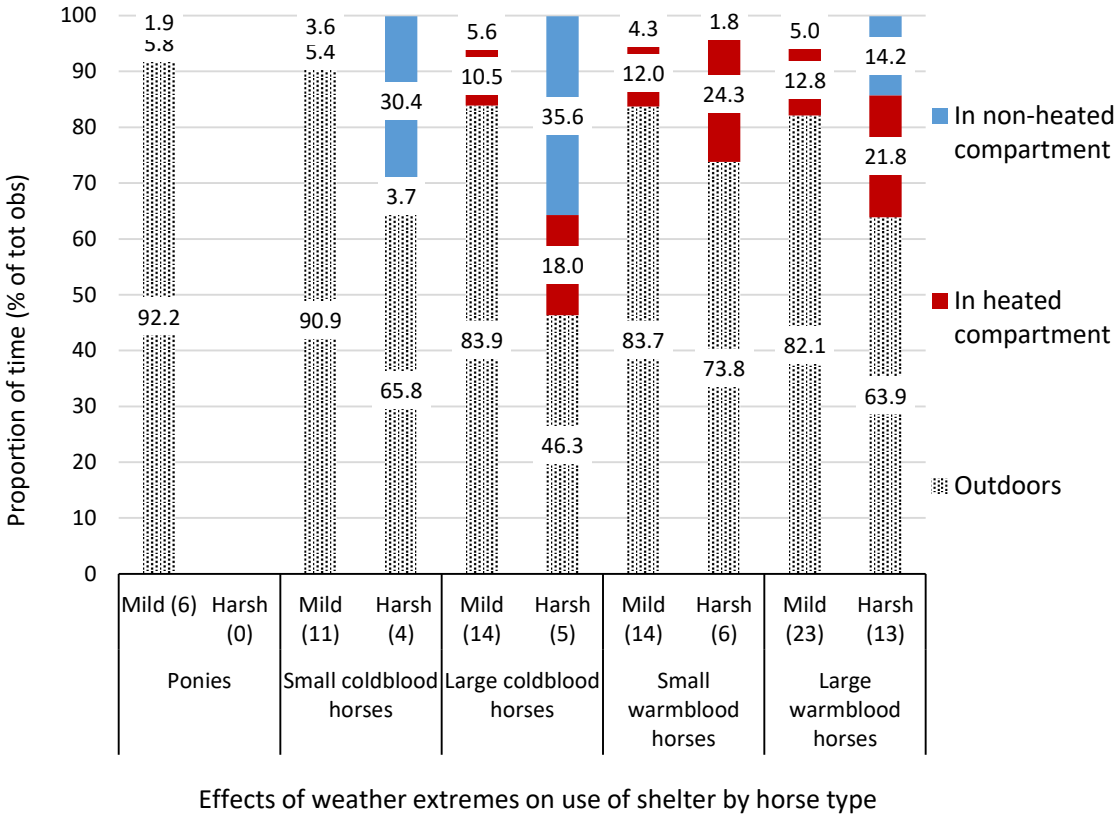

641 Effects of weather extremes on use of shelter by horse type