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The effect of weather conditions on the preference in horses for wearing blankets

Cecilie M. Mejdell[1], Grete H.M. Jørgensen[2], Turid Buvik[3], Torfinn Torp[2], Knut E. Bøe[4]*

1 Norwegian Veterinary Institute, Section for Terrestrial Animal Health and Welfare, P.O. Box 750 Sentrum, 0106 Oslo, Norway

2 NIBIO, Norwegian Institute for Bioeconomy Research, P.O. Box 34, N-8860 Tjøtta, Norway

3 Trondheim Hundeskole, Lauritz Jenssensgt 47, 7045 Trondheim

4 Norwegian University of Life Sciences, Department of Animal and Aquacultural Sciences, P.O. Box 5003, 1432 Ås, Norway

*Corresponding author, telephone: +47 67232678, email: knut.boe@nmbu.no

ABSTRACT

The use of blankets in horses is widespread in Northern Europe. However, horses are very adaptable to low temperatures and the practice is questioned because blankets may hamper heat dissipation at high temperatures and also disturb free movement. The aim of the current study was to gain information about horses' own preferences for wearing or not wearing a blanket under different weather conditions during the seasons. 10 horses usually wearing blankets and 13 horses usually not wearing blankets were kept outside in their paddock for 2 h during different weather conditions. Then, these horses were tested for their preference for wearing blankets (see Mejdell et al., 2016). When only considering air temperature and not the impact of other weather factors, the horses preferred to have the blanket on in 80 % and 90 % of the test at t < -10 °C in horses usually wearing and not wearing blankets, respectively. As air temperature increased, the preference for keeping the blanket on decreased and at air temperatures > 20 °C, the horses preferred to remove the blanket in all the tests. According to the statistical model, the probability for choosing to have a blanket on increased with increasing wind speed, and also precipitation increased the probability for choosing to have a blanket on. Sunshine however, reduced the probability for choosing to wear a blanket.

Key words: horse, thermoregulation, blankets, preferences, weather

1. Introduction

A survey among horse owners in Sweden and Norway showed that the use of blankets in horses is widespread (Hartmann et al., 2017). Among owners of warmblood riding horses, 96 and 97 % reported to use blankets on their horse in Norway and Sweden, respectively. This practice is surprising given the fact that horses are very adaptable to temperature variation, and that they thrive in tropical to subarctic climates (Cymbaluk, 1994). It is reported that cold acclimatized, adult horses had a lower critical temperature (LCT) of -15 °C (McBride et al., 1985) and that the LCT of acclimatized yearlings fed *ad lib* was -11°C (Cymbaluk and Christison, 1988).

The magnitude of heat loss from the body surface to the environment depends on body size and body conformation (i.e. body surface area relative to body mass), and insulation due to factors such as subcutaneous fat tissue and hair coat quality (Curtis, 1983; Cymbaluk, 1994; Langlois, 1994). A blanket will add to the insulation and hence reduce heat loss from the protected skin (e.g. Wallsten et al., 2012) which is advantageous at low air temperatures but disadvantageous at high air temperatures. A blanket will also protect the body against wind and help to keep the hair coat dry, reducing the cooling effects of wind and precipitation. On the negative side, a blanket may interfere with free movement and even a well-fit blanket may cause skin soreness (Clayton et al., 2010). It will also cover preferred sites for social grooming (Höglund, 2015). The abovementioned factors may indicate that horses have preferences that differ from what the owners think is best. Hence, the method developed by Mejdell et al. (2016) where horses use symbols to communicate their preferences, is suitable to reveal the horses' own preference for wearing a blanket during turnout.

The aim of the current study was to gain information about horses' own preferences for wearing or not wearing a blanket under different weather conditions during the non-grazing seasons in Norway. We hypothesized that most horses will prefer to wear a blanket during turnout in a paddock at low ambient air temperatures and at moderate air temperatures combined with rain and/or wind. At ambient air temperatures above +5 – +10 °C, most horses will prefer to be without a blanket.

2. Materials and methods

2.1. Methodology

We used the method developed by Mejdell et al. (2016) in which horses learn to communicate their preference by using symbols. By touching the appropriate symbol board with the muzzle, horses told the handler whether they wanted to wear a blanket or not (Figure 1). After the horses had passed the final learning criterion and training was deemed completed, the horses were included in studies aiming at testing the preference in horses for wearing, or not wearing, blankets at a wide variety of weather conditions.

Figure 1 here

2.2. Horses and daily management

The same 23 horses that successfully had passed the training program and were able to communicate their preference for wearing blankets by using symbols (Mejdell et al., 2016) were included in the current studies. The horses were kept at one of two stables 1 kilometer apart at 63° N 10° E, close to the city of Trondheim, Norway. All horses were habituated to wear a blanket, but daily management routines varied among owners. Therefore, some horses were usually blanketed during daily turnout, others were usually not. All horses were actively utilized for riding purposes at different levels, and some horses were additionally used for pulling a carriage/sledge. During the night, horses were kept indoors in standard single boxes bedded with wood-shavings, and during daytime they were kept in outdoor paddocks in groups of 2 - 3 horses. Horses were fed hay or haylage three times per day. Concentrates were given twice daily (inside stable only) and the amount given was individually adjusted and dependent on type and intensity of work.

All horses were kept and handled according to Norwegian legislation (Animal Welfare Act, Directive on Horse Welfare, and Use of Animals in Research regulations), and horse welfare was never at stake during training or testing. These studies did not need any formal permit from the Competent Animal Research Authority but owners' consent was given for the horses which were included in the study.

2.3 Testing procedure

On each test day, the horses were turned out in their home paddocks with or without a blanket on according to the owners' routine practice, and stayed there for two hours. This was to allow the horses to adjust and become aware of the weather. Following the procedures reported in detail in

Mejdell et al. (2016), the individual horses were led one by one to an outdoor test arena. Two symbol boards were placed on the fence 3m in front of the horse. The horse was then unleashed and free to approach and make a choice. Horses which already had a blanket on could choose between keeping the blanket on ("no change" symbol) or to have it removed ("blanket off" symbol). Horses not already wearing a blanket could choose to continue to stay without a blanket ("no change" symbol) or to have a blanket put on ("blanket on" symbol). After making its choice about wearing a blanket or not, the horse was returned to the home paddock, and stayed there for at least one hour before the owner was allowed to move the horse.

2.4 Blankets and weather conditions

The blankets used were not standardized. Instead, the blanket used throughout the study was the one the owner normally would use under the prevailing weather condition, and it was adjusted to the individual horse. Most owners had several blankets which differed in insulation properties and waterproofness. For horses tested without a blanket on, and which signaled that they wanted to have a blanket put on, the blanket was pre-picked by the horse owners to be suitable for the current weather condition (e.g. waterproof in rain).

The air temperature (°C) and air velocity (m/s) was recorded by an electronic weather station (Silva ADC Summit, Silva®) on each location. Precipitation was categorized as no precipitation, light rain, heavy rain, sleet and snow and clouds were categorized as sunny (including partly sunny) or cloudy.

2.5 Study 1. Horses with blankets on

Study 1 included 10 privately owned horses: 8 geldings and 2 mares, 6 warmbloods (WB) and 4 coldbloods (CB), 4 clipped (2 WBs, 2 CBs) and 6 non-clipped horses (4 WBs, 2 CBs) usually wearing blankets. The mean age of the horses was 10.5 ± 0.9 years (range 5 - 13 years).

The horses were tested on 21 different days from early February to the middle of May in 2013 and 2014 with air temperatures ranging from – 15 to + 21 °C, wind speed from 0 to 14 m/s, sunny and cloudy weather, and on days with no precipitation, light rain, heavy rain, sleet and snow. The total number of tests were 124, in which 20 tests (16 %) on days with t >10 °C. Each horse were tested on average 12.4 times (range 6 - 17).

2.6 Study 2. Horses without a blanket

Study 2 included a total of 18 horses. Among these were 13 horses usually not wearing a blanket: 10 geldings and three mares, 4 WB and 9 CBs. None of these horses were clipped. In addition, another 5 horses (4 WBs and 1 CB), that had been included in the group for horses wearing blankets in the period of February to May, were in the following autumn, in agreement with the owners, routinely turned out without a blanket. Two of these horses had been clipped the previous winter season, but were left unclipped this autumn. The mean age of the horses was 9.6 ± 0.7 years (range 3 – 16 years).

147 The horses were tested on 37 different days during the period from early February to the middle
148 of December with air temperatures ranging from – 16 to + 23 °C, air speed from 0 to 14 m/s,
149 sunny and cloudy weather, and on days with no precipitation, light rain, heavy rain, sleet and
150 snow. The total number of tests were 231, whereof 82 (35 %) on days with t > 10 °C. Each horse
151 was tested on average 12.8 times (range 8 – 29).

152

153 **2.7 Statistical analyses**

154 The statistical model used was a generalized linear mixed model (Proc Glimmix, SAS Institute
155 Inc., Cary, NC, USA). We used a binary response variable called *test*. In study 1, horses that
156 usually wore a blanket, the variable *test* was set equal to 1 when the horse chose to stay
157 unchanged, that is to keep the blanket on. In study 2, horses that usually did not wear a blanket,
158 the variable *test* was set equal to 1 when the horse chose to stay unchanged, that is without
159 blanket. We modelled the probability P (*test* = 1) and tried different models with different
160 explanatory variables.

161

162 The final statistical model was

163 $$p_{ijktv} = P(test_{ijktv} = 1 \mid H_j) = \frac{e^{\beta_0 + \alpha_i + \beta_1 \cdot t + \beta_2 \cdot v + H_j}}{1 + e^{\beta_0 + \alpha_i + \beta_1 \cdot t + \beta_2 \cdot v + H_j}} \quad (1)$$

164

165 where $test_{ijktv}$ is observation k for horse j, in situation i (cloudy and no precipitation, cloudy with
166 precipitation, or sunny with no precipitation), at temperature t (°C), and wind v (m/s). The H_j's
167 are random variables assumed to be independent and normally distributed with expected value 0
168 and common variance (σ_H^2 unknown parameter). The α_i's, β_0, β_1, and β_2 are unknown

parameters. The estimates of all unknown parameters are given in Table 1. By putting the H_j's equal to their expected value zero, we got estimates $\hat{p}_{ijktv}$ by replacing the parameters in (1) by their estimates. For a given situation, *i*, the estimates $\hat{p}_{ijktv}$ can then be calculated in different ways as a function of temperature, *t*, and wind, *v* (Figure 3). For example, for a given probability *p*, situation *i*, and wind speed *v*, the estimate for the temperature *t* which gives $P(test = 1) = p$ can be calculated from (1) as

$$t = \frac{\ln\left(\frac{p}{1-p}\right) - \left(\beta_0 + \alpha_i + \beta_2 \cdot v\right)}{\beta_1} \qquad (2)$$

when α_i, β_0, β_1, and β_2 are replaced by their estimates in table 2.

Table 1 here

3. Results

3.1 Horses with blankets

On average, the horses preferred to keep the blanket on in 66.2 % of the tests. WB horses preferred to keep the blanket on in 62.7 % of the tests whereas the CB horses preferred to keep the blanket on in 71.4 % of the tests. The two clipped horses preferred to keep the blanket on in 76.6 % of the tests, whereas horses with an intact haircoat preferred to keep the blanket on in 59.3 % of the tests. The variation among individual horses was however considerable. Two of the 10 horses (Katug, a clipped WB and Mario, a non-clipped CB) always wanted to keep the blanket on, but these two horses were not tested at air temperatures above + 5 °C. Another horse (Remosa, a non-clipped WB) preferred to keep the blanket on in only 36.4 % of the tests.

When only considering air temperature, and not the impact of other weather factors, the horses preferred to keep the blanket on in 80 % of the test with t < -10 °C (Figure 2). As air temperature increased, the preference for keeping the blanket on decreased and at air temperatures >20 °C, the horses preferred to remove the blanket in all the tests.

Figure 2 here.

Focusing on wind speed, the horses' preference in general for keeping the blanket on increased with increasing wind speed (Figure 3). At fresh (8.0 – 10.7 m/s) and strong (10.8 – 13.8 m/s) breeze, the preference for keeping the blanket on was 100 %.

Figure 3 here.

On days without precipitation, the horses preferred to keep the blanket on in 59 % of the tests, whereas on days with rain or rain showers the horses wanted to keep the blanket on in all the tests. Interestingly, on days with snow or sleet, the horses chose to keep the blanket on in just 59 % of the tests.

Two specific test days serve to illustrate the warming effect of sun radiation. On February 16th, a cloudy day with -1 °C without wind or precipitation, all four tested horses preferred to keep the blanket on. On March 14th, a sunny day with -5 °C and no wind or precipitation, four of the six

tested horses asked for the blanket to be removed. It was noted several times during the study that horses wearing blankets became sweaty under the blanket on sunny days.

When focusing on specific test days without wind and rain, all the WB-horses preferred to keep the blankets on whereas only half of the CB-horses preferred to keep the blanket on (Table 2). At a test day with moderate air temperatures (5 °C) half of the horses preferred to keep the blanket and at a test day with high air temperatures (20 °C) all horses preferred to remove the blanket. At a test day with gentle breeze (3.4 – 5.4 m/s) and moderate air temperatures (5 °C), half of the horses preferred to keep the blanket. However, when the horses were exposed to both wind and rain, all horses preferred to keep the blanket on. The difference between WB-horses and CB-horses was small.

Table 2 here.

According to the statistical model, at air temperatures < - 10 °C the estimated probability for the horses to prefer to keep the blanket on was almost 1.0 (Figure 4), regardless of other weather conditions. At an air temperature of -10 °C and no wind, the probability for preferring to keep the blanket on was reduced to 0.95, 0.90 and 0.80 at weather conditions with cloudy sky and no precipitation, cloudy sky with precipitation and sun respectively. When air temperatures further increased, the probability for preferring to keep the blanket on decreases, especially at sunny conditions, whereas the difference between cloudy conditions with and without precipitation was small. At 20 °C, however, the probability for preferring to keep the blanket on was very low

234 regardless of weather conditions. Wind had only a small impact on the probability for preferring
235 to keep the blanket on at low temperatures, but a large effect at temperatures > - 10 °C.

236

237 **3.2 Horses without blankets**

238 On average, the horses preferred to have a blanket put on in 58.6 % of the tests. WB horses
239 preferred to have a blanket put on in 67.5 % of the tests whereas the CB horses preferred to have
240 a blanket put on in 51.6 % of the tests. The variation among individual horses was however
241 considerable. One horse (Alto, WB) preferred to have a blanket put on in 87.5 % of the tests
242 whereas another horse (Maibrun, CB) preferred to have a blanket put on in only 22.2 % of the
243 tests.

244

245 When only considering air temperature, and not the impact of other weather factors, the horses
246 preferred to have a blanket put on in 90 % of the test at t < -10 °C (Figure 2). As air temperature
247 increased, the preference for having a blanket put on decreased and at air temperatures >20 °C
248 horses preferred to stay without a blanket in all the tests.

249

250 When only considering wind, the horse's preference in general for having a blanket put on
251 increased with increasing wind speed (Figure 3). At fresh (8.0 – 10.7 m/s) and strong (10.8 –
252 13.8 m/s) breeze, the preference for keeping the blanket on was 100 %.

253

254 On days without precipitation, the horses preferred to have a blanket put on in 43 % of the tests,
255 whereas on days with rain the horses wanted a blanket on in 85 % of the tests. Furthermore, on

256 days with snow or sleet, the horses chose to have blanket put on in 75 % of the tests. To illustrate
257 the effect of sun radiation, two specific test days without wind and precipitation were selected.
258 On March 16th, a sunny day with -13 °C, two of six horses preferred to stay without a blanket. In
259 contrast, on December 9th, a cloudy day with -15 °C, all 12 horses preferred to have a blanket put
260 on.

261

262 When focusing on specific test days without wind and rain, all the horses preferred to have a
263 blanket put on at a test day with low air temperatures (-14 °C) (Table 2). When the air
264 temperature increased to 10 and 23 °C, the vast majority preferred to stay without the blanket. At
265 a test day with fresh breeze and moderate air temperature, nearly all horses preferred to have a
266 blanket put on, and at a test day with both rain and wind, the vast majority of the horses preferred
267 to get a blanket on. The difference between WB-horses and CB-horses was small.

268

269 According to the statistical model, at air temperatures near -20 °C the estimated probability for
270 the horses to prefer to get a blanket on was almost 1.0 (Figure 4), regardless of weather
271 conditions (precipitation or sun). At an air temperature of -10 °C and no wind, the probability for
272 preferring to have a blanket put on was reduced to 0.80, 0.95 and 0.65 at weather conditions with
273 cloudy sky and no precipitation, cloudy sky with precipitation and sun, respectively. When air
274 temperatures further increased to + 10 °C, the probability for preferring to have a blanket put on
275 decreased markedly, especially at sunny conditions, a little less for cloudy conditions without
276 precipitation and the least with cloudy conditions with precipitation. At + 20 °C however, the
277 probability for preferring to have a blanket put on was 0.00, regardless of weather conditions.

Wind had only a small impact on the probability for preferring to keep the blanket on at low temperatures, but a large effect at temperatures > - 10 °C.

It is interesting to notice that horses tested without blankets in cloudy weather without precipitation and wind reached probability score 0.5 (meaning that the choice of being with/without a blanket is 50/50) at -2°C whereas horses tested with blankets reached score 0.5 at 6 °C (Figure 4). Thus, horses tested with blankets needed higher temperatures to ask for a change, compared to horses without a blanket.

4. Discussion

Overall, horses with blankets preferred to keep the blanket on in 66.2 % of the tests whereas horses without blankets preferred to have a blanket put on in 58.6 % of the tests, and the weatherfactors air temperature, wind speed, solar radiation and precipitation all influenced the preference for blankets. The fact that the horses preferred to have a blanket on in the majority of the tests, implies that the horses did not feel uncomfortable *per se* when wearing a blanket, and thus do not support concerns raised by Clayton et al. (2010) and Höglund (2015).

Air temperatures

At air temperatures between -10 and 0 °C there was a considerable variation in the preference for blankets (the horses chose to wear a blanket in 40 – 80 % of the tests), whereas at air temperatures < -10 °C, the horses chose to wear a blanket in 80 – 90 % of the tests. This

corresponds well to the results of McBride et al. (1985) who found that the lower critical temperature (LCT) of adult, cold acclimatized horses was -15 °C. In the cool zone the animals try to minimize heat loss (Curtis, 1983), and wearing a blanket will absolutely reduce the heat loss.

The large variation in the preference for wearing blankets in the temperature interval -10 to 0 °C is probably due to the fact that other parameters like wind and precipitation was not considered here. When air temperatures increased to +10 - +20 °C, the vast majority of the horses wanted to be without a blanket, and at air temperatures > 20 °C, in fact all horses preferred to stay without a blanket. Under these conditions, the horses actually need to increase their heat loss, and wearing the blanket will of course counteract this. These results imply that the widespread use of blankets even at high temperatures (Hartmann et al., 2017) is negative for the horse thermoregulation and that horse owners actually lack basic knowledge of horse thermoregulation and heat production.

Wind and precipitation

Rain and wind will indeed increase heat loss from the animal (Monteith and Mount, 1974; Hillmann, 2009) and several studies show that horses increase the use of shelter in windy and rainy conditions (e.g. Mejdell and Bøe, 2005; Jørgensen et al., 2016). This corresponds well with the present results. Further, the effect of precipitation of snow/sleet on the preference for wearing a blanket was less pronounced than for rain, which is in accordance with findings on shelter

seeking behaviour in Mejdell and Bøe (2005). The authors suggested that the reason for this could be that snow does not melt easily on a thick hair coat, and hence the skin did not get wet.

At low ambient air temperatures the horses' heat loss will be higher, even without the impact of wind or precipitation. Hence, the horses will have a stronger preference for wearing a blanket regardless of wind speed and precipitation. However, at increasing temperatures, there was an increasing impact of wind speed and precipitation on blanket preferences.

At air temperatures > 20 °C it is likely, although outside the range of the statistical model, that the horses will prefer to stay without a blanket even at high wind speeds. At such high temperatures the wind will actually contribute to maximize heat loss, and hence be viewed as positive (Curtis, 1983; Hillmann, 2009).

Solar radiation

At very low air temperatures, the additional heat gained from solar radiation had apparently no effect on the preference for wearing blankets, but at air temperatures from -10 ° and up to +10 °C, the effect of solar radiation on preference for wearing blankets was very clear. At ambient temperatures from 10 to 20 °C with sunshine, the effect of wind speed on the preference for wearing blankets was less. It was noted that horses sometimes became sweaty underneath the blanket. A blanket will hamper the physiological mechanisms for heat dissipation from the skin such as vasodilation and sweating (Curtis, 1983).

Effect of habituation to wearing blankets

Horses tested with a blanket (study 1) or without a blanket (study 2) seemed to have slightly different temperature points for when the probability for signaling a change reached 0.5. One explanation for this may be that horses usually not wearing blankets generally become more habituated to the cold. It is obvious, but important to emphasize, that horses not wearing blankets will be more susceptible to the cooling effects of wind, precipitation (McArthur and Ousey, 1996) and air temperature (McBride et al., 1985; Morgan, 1998). Solely because of this, it is reasonable that horses without blankets make choices at quite different thresholds than horses already wearing a blanket. Hence, horses probably do not ask for a change unless feeling uncomfortably hot or cold, and the thermal comfort zone for horses is relative wide (Morgan, 1998).

Individual differences

Although CBs are expected to be more cold resistant than WBs (Langlois, 1994), we did not find any overall difference in the preference for blankets shown by WBs and CBs. However, there were individual differences. Actually, one CB horse (Alto) which routinely did not wear a blanket, usually asked for it. It is known that geriatric horses may have problems fine-tuning the temperature-exchange with their surroundings. Increased susceptibility for overheating during exercise, due to age related alterations in physiological mechanisms important for thermoregulation are for example documented (McKeever et al., 2010). Knowing that also hair coat quality (Brosman and Paradise, 2003 a,b; Innerå et al., 2013; McGowan et al., 2010) and the

fat thickness change with age (Superchi et al., 2014), age is an important individual factor to be considered.

There are good reasons to believe that clipped horses, which are deprived of the insulating properties of an intact hair coat (Morgan, 1998), will prefer to wear a blanket. However, there were too few clipped horses in the present study to test the effect of clipping on blanketing preferences. Future studies should therefore focus on the effects of age, body condition and hair length on the preference for blankets and also the effect of type of blanket.

We conclude that horses stabled at night and kept in paddocks during the day, show clear preference for wearing a blanket under harsh weather conditions, such as low ambient temperatures (well below 0 °C) and even moderate temperatures (+5 to +10 °C) in combination with rain and/or strong wind. When the temperature exceeds 10 °C, very few horses chose to wear a blanket.

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Table 1. Estimates and standard errors for unknown parameters in the statistical model.

Parameter	Study 1 (with blanket)		Study 2 (without blanket)	
	Estimate	Standard error	Estimate	Standard error
β_0	– 0.3239	0.4473	1.2417	0.6265
$\alpha_{\text{cloudy, no precipitation}}$	1.3510	0.6439	– 0.7685	0.6329
$\alpha_{\text{cloudy with precipitation}}$	0.9594	0.5639	– 3.0337	0.6670
$\alpha_{\text{sunny, no precipitation}}$	0		0	
β_1	– 0.1710	0.0403	0.2070	0.0329
β_2	0.2313	0.0851	– 0.3183	0.0724
σ_H^2	0.5023	0.6077	1.9791	1.1600

Table 2. Proportion of WB and CB horses preferring to stay with or get a blanket on (study 1 and 2) on a selection of test days with different weather types.

	Air temp. °C	Wind (m/s)	Precipitation	WB	CB
Study 1	-15	Calm (0 – 0.2)	No	6/6	2/4
	5	Calm (0 – 0.2)	No	3/6	1/2
	20	Calm (0 – 0.2)	No	0/5	0/3
	5	Gentle breeze (3.4 – 5.4)	No	3/3	2/2
	5	Strong breeze (10.8 – 13.8)	Rain/rainshowers	5/5	3/3
Study 2	-14	Calm (0 – 0.2)	No	7/7	5/5
	10	Calm (0 – 0.2)	No	0/6	1/5
	23	Calm (0 – 0.2)	No	0/6	0/8
	6	Fresh breeze (8.0 – 10.7)	No	7/8	5/9
	10	Moderate breeze (5.5 – 7.9)	Rain	7/8	6/9

Legends to figures

Figure 1. A horse without blanket in the choice situation, touching the board with the “blanket on” symbol.

Figure 2. Effect of air temperature on the preference for keeping/having a blanket put on.

Figure 3. Effect of air speed on the preference for keeping/having a blanket put on.

Figure 4. Probability of different weather conditions on the preference for blankets.

Figure 1.

499 Figure 2.

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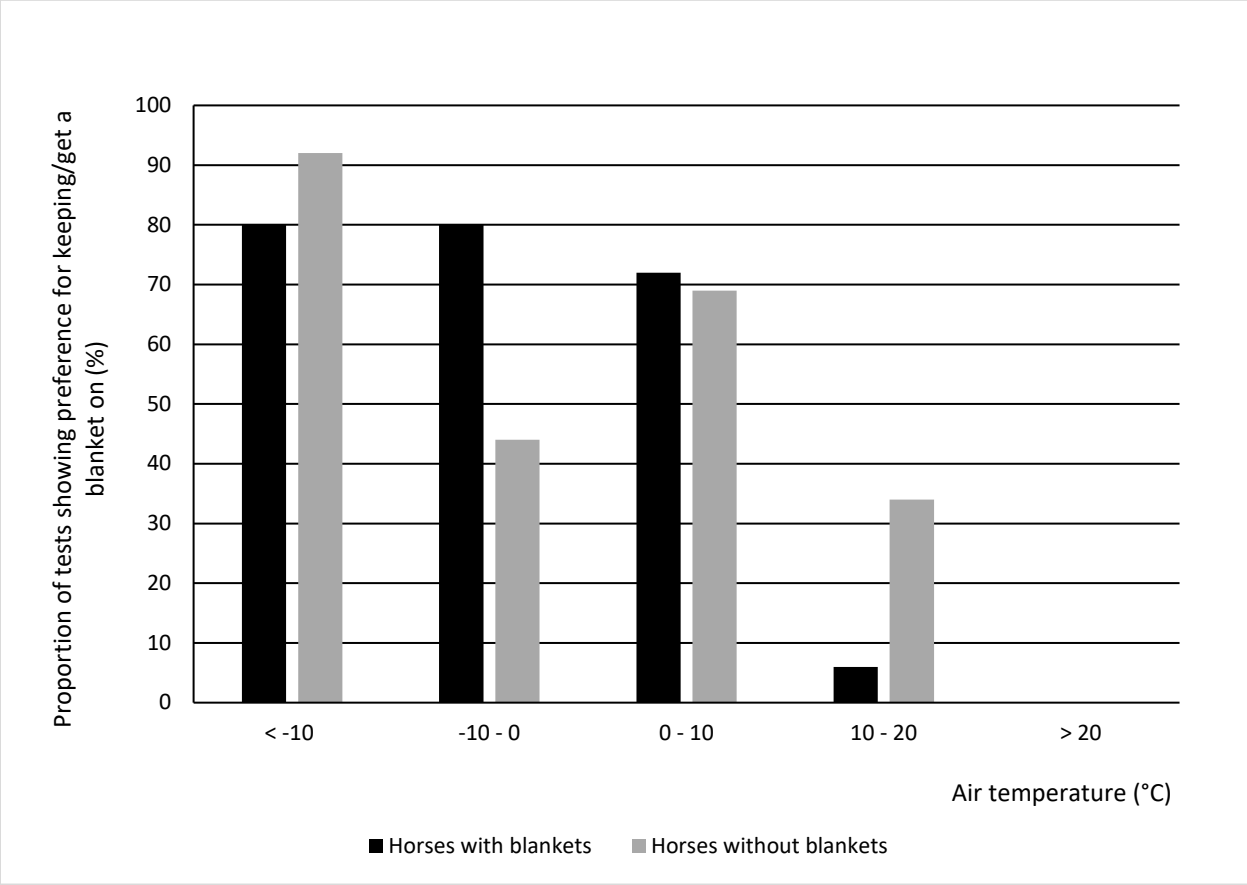

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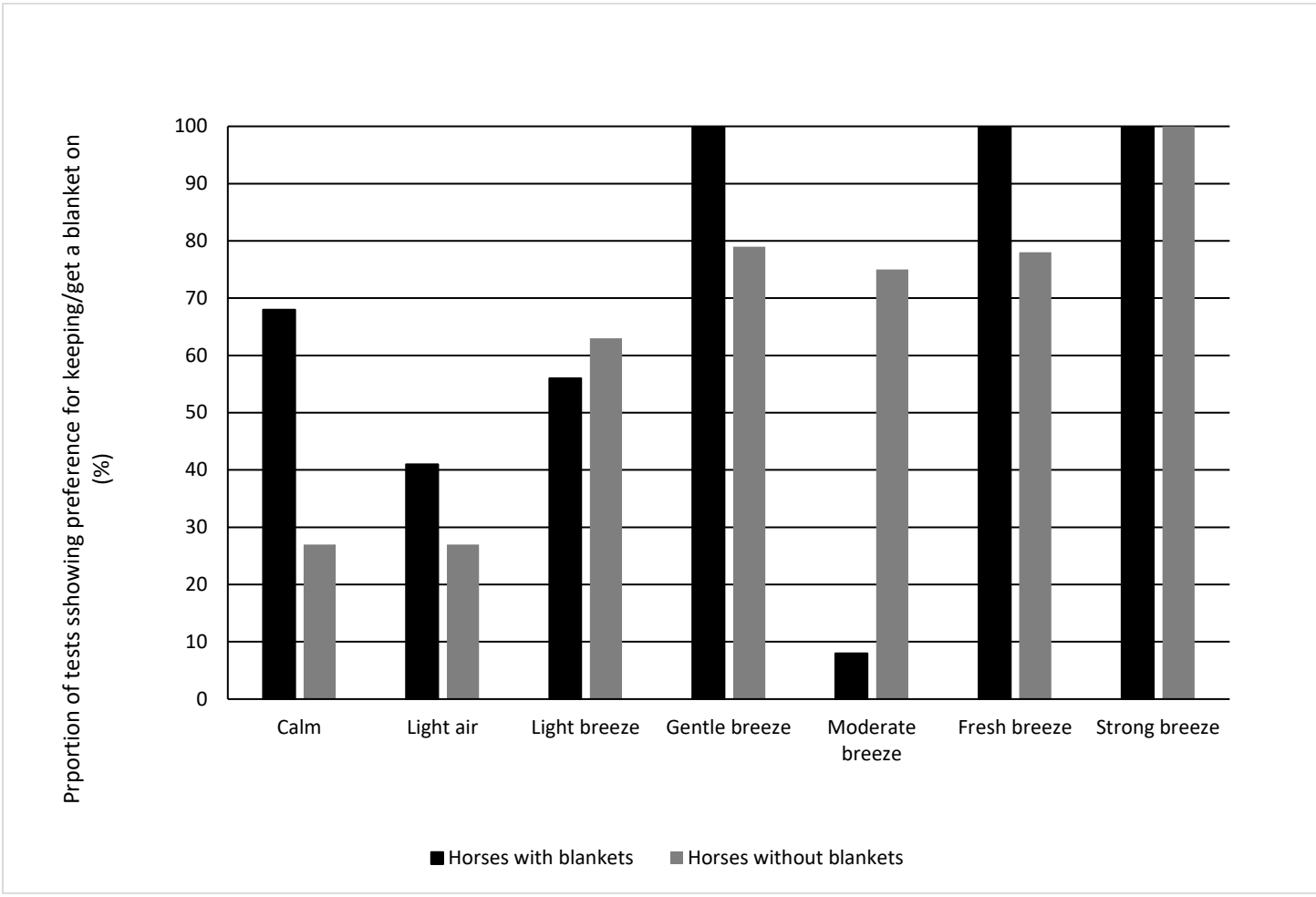
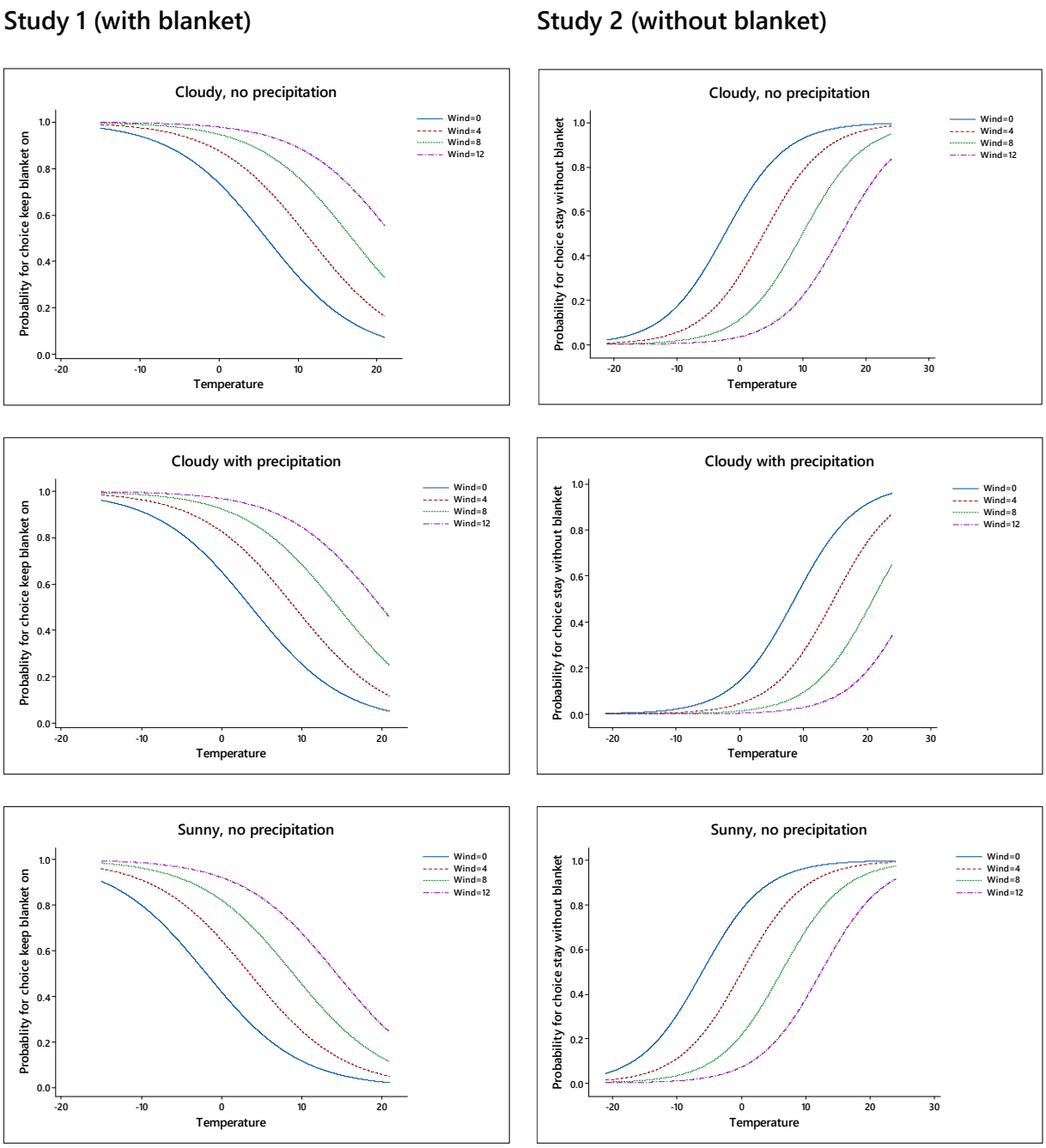
Figure 3.


Prportion of tests sshowing preference for keeping/get a blanket on (%)
100
90
80
70
60
50
40
30
20
10
0
Calm
Light air
Light breeze
Gentle breeze
Moderate breeze
Fresh breeze
Strong breeze
Horses with blankets
Horses without blankets

510 Figure 4.



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