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Swedish University of Agricultural Sciences
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Habitatval hos Gotlandsruss på åretruntbete

Karin Näslund

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Abstract
The constant decline of permanent pastures in Sweden has a negative impact on biodiversity. A multidisciplinary project is investigating if the endangered native Gotland pony could be used to keep and restore the biodiversity of permanent pastures and forests, on a minimal labour input, without compromising the ponies' welfare. This thesis is a part of that project, focusing on the ponies' resource utilisation. In May 2014 twelve one year old Gotland pony stallions were released into three enclosures of approximately 10 ha each, consisting of about 3 ha of lay and 7 ha of forest respectively. These enclosures were provided with man-made shelters and water troughs, but there were no supplementary feed given inside the enclosures during the year of the trial. To evaluate the ponies' preferences for different vegetation types the ponies were equipped with a GPS-collars. The shelters were equipped with movement sensitive cameras to monitor how and when the ponies utilized them. The results showed that the ponies favoured lay at almost all weather conditions, except when snow was covering the ground. Forest usage increased during the winter as feed got less available on the lay, and through out the year it was used more during the night than during the day. The shelters were used about 48 minutes a day throughout the year. They were used mostly during daytime in the non-vegetative season, but during the vegetative season there were no differences in shelter use between night and day. Most previous studies of shelter seeking behaviour were preformed in small paddocks with ad libitum feed for the horses, and resulted in a significantly higher shelter usage than seen in the present study. Presumably, the ponies spent a lot of time foraging, fulfilling their nutritional needs. Ad libitum fed horses have no need, and sometimes no possibility, to preform the same behaviours. This could be one of the reasons for the difference in shelter seeking behaviour in this study compared to the literature.

The Gotland Pony Project
This thesis is part of a larger project where Gotland Ponies are assessed as a tool in landscape preservation to improve biodiversity without compromising the animal welfare of the ponies. Because of their small size, 115-130 cm (SvRF, 2010) the Gotland ponies are expected to leave less damage to the ground layer than larger horses. They also have a natural ability to grow an early and thick winter coat (Jansson, 2014) and have low nutritive requirements, making it possible for them to thrive on pastures with a low nutritive value (SvRF, 2010). All of this, together with the fact that the Gotland pony is considered an endangered breed by the Swedish ministry of agriculture (SJV, 2007), and hence a need for an increased number of breeding animals, makes them an excellent candidate to se if this could be a new field of application for the Gotland pony in Sweden. When this project was initiated, SLU bought twelve one-year-old stallions from six different breeders in Sweden. Having all horses in the study of the same sex and age makes it easier to compare individuals within the group.

Introduction

Swedish Grazing Land

In Sweden, there is old saying ”äng är åkers moder”. It means that in order to harvest crops from your field you needed fertiliser, and fertilizer you got from your stalled animals during wintertime. To be able to stall animals during the winter, you needed winter feed, which you got from the meadow. So the size of your meadow in this way restrained the size of your cultivated land (Höök Patriksson, 1998). During the 19-century most livestock were still set to graze in the forests and other small patches of otherwise unusable grassland further away from the farm, as they had been doing for the last 6000 years in this part of Europe (Höök Patriksson, 1998). Often only calves and lambs were held to graze nearby the farms. The fields were naturally centred round the barns, shortening the route for the heavy and labour-consuming manure spreading. But during the agrarian revolution in the 19th century there was an increase in the human population, and new machinery and artificial fertilizers came along to disrupt the old traditions of meadows and cultivated fields. Many previously unploughed lays were trenched and transformed into fields for crops, in order to feed the increasing population. During the same time, the areal reformation of 1859 caused the previously collectively owned forest to be divided among the village farms, and a more modern type of forestry was starting to develop. As a consequence, animals were kept closer and closer to the farms, leaving the forest and the smaller patches of pasture on marginal land to reforest without grazing (Höök Patriksson, 1998).

Dairy cows has been the predominant grazer in Sweden (SJV, 2005), but as the cows keep getting more efficient, leaving higher yields per kilo feed, less cows are needed to maintain the production. One of the side effects caused by this decline in grazing animals is a decrease in permanent pastures in Sweden from 2 million ha in the year 1800 (Höök Patriksson, 1998) to 440.000 ha in the year of 2002 (Nordberg, 2015). Without grazing, pastureland can lose up to 50 % of its biodiversity in 24 years (Persson, 1984). At the same time, biodiversity is in a constant decline in the whole of Western Europe (Wallis De Vries et al., 1998). Permanent pastures can house up to 700 different vascular plants, which is more than any other type of farm land (Höök Patriksson, 1998). Thus, to preserve and restore these pastures with unique biodiversity, grazing animals are of the uttermost importance (Wallis De Vries *et al.,* 1998).

The Gotland Pony

Man has used the Gotland pony for more than 5000 years, making it one of the oldest horse breeds in Europe. But, in the middle of the nineteenth-century, farm structures were changing in Sweden due to the areal reformation, and on the island of Gotland this event had a negative effect on the Gotland pony population. When the forest changed from joint to private ownership, the former large herds of wild Gotland ponies decreased (Erixon, 2014). In addition, the ponies were by some considered a pest and were therefore hunted by the people on the island (SJV, 2013). In the 1880s a squire in Klinteby, Gotland started the first stud farm with Gotland ponies, and the first studbook was opened in an attempt to revive the breed. The breed was still small in numbers, and in the 1950s, the risk of inbreeding was so high that two welsh pony stallions were imported to save the Gotland pony (Erixon, 2014). In 1984 the *Swedish gene bank* decided that the Gotland pony was to be included among the native livestock breeds, which Sweden should monitor and protect from extinction. The Swedish Board of Agriculture consider the Gotland pony to be especially important to save, since it is the last small horse of peasant type in Sweden. It is of great importance to maintain all their useful traits (SJV, 2007), such as their small size (115-130 cm) their hardiness with an early winter coat setting and that they are easy breeders (SvRF 2010). Despite the recent increase in number of horses in Sweden (Jansson, 2014) there are only about 5-600 Gotland pony mares, and just over 100 Gotland pony stallions (SvRF, 2010) in breeding, which is too few to ensure a healthy genetic variation within the breed.

Horse Grazing Compared to Other Grazers and their Effects on the Landscape

Horses can graze between 14-17 hours per day (Cosyns *et al.,* 2001; Duncan, 1980). They are strictly grazers with a preference for grasses (*Poaceae)* (Cosyns *et al.,* 2001), Konik pony diets can consist of up to 86 % grasses (Cosyns *et al.,* 2001) and the diet of Camargue ponies have ben found to consist of up to 90% grasses (Putman *et al.,* 1987). Horses can be very selective grazers when given the opportunity, but when little feed is available, they seem to only maximize their feed intake not selecting for quality (Duncan, 1983). Compared to ruminants, horses differ in their way of grazing. They have anterior teeth in both upper and lower jaw (Pehrson, 1994) making it possible for them to graze closer to the ground than cattle for instance, and this also allows them to gnaw bark from trees, preferably broad-leaved trees. Horses also defecate in a more aggregated way than cattle (Karlsson, 2014), and having a more selective grazing pattern, they leave un-grazed patches of grass. These toilet-patches could benefit nitrogen favoured plant species, giving a certain character to the pasture vegetation (Karlsson, 2014; Pehrson, 1994). Horses, compared to cloven-hoofed animals have no rumen restricting their eating capacity, making them suitable for grazing overgrown pastures with grasses in later stages of development (Pehrson, 1994).

Challenges for Free Ranging Horses

Weather - the Need for Shelter From Both Sun and Rain?

More then 80 % of the Swedish horse population are still kept in box stalls, at least some part of the day, and around 20 % of the Swedish horses have access to a shelter in their paddocks (SJV, 2012). Horses that spend more than 18 hours a day outdoors during the non-vegetative season should, according to Swedish animal welfare legislations, have access to a man made shelter to protect them from wind and precipitation. The shelter should have at least three walls, and the opening should normally be directed to the south (DFS, 2007). The shelter seeking behaviour (SSB) of horses has been assessed by many scientists showing that horses make use of shelters, especially during wet weather conditions (Autio, 2008; Brosäter & Peterhoff, 2013; Duncan, 1985; Heleski & Murtazashvili, 2010; Mejdell & Bøe, 2005; Michanek & Ventorp, 1996; Nilsson, 2006). In common for most of these studies were that there was no natural protection against harsh weather in the trial paddocks, hence the only protection was the provided shelters. In more natural conditions horses can use the forest as a shelter during harsh weather conditions (Tyler, 1972). A Californian study (Holcomb *et al.,* 2014) points out that horses that have access to a shaded area during hot summer days not only uses, but prefers the shade. In this study the horses were kept one by one in very small paddocks (74 m^2) of which half were covered by a roof providing shade. During this time the horses spent 7.1 % more time in the shade than out in the sun. However, there seem to be differences amongst breeds when it comes to shade preferences. Were the former study used Thoroughbreds and Quarter horses, another study by Heleski and Murtazashvili (2010) compared Draft horses with Arabians. They found that Draft horses spent 16 % of their time in the shelters during hot (> 39° C) and sunny weather compared to 0 % for the Arabians. In cold (< -7° C) weather, the proportions were the opposite, only 7 % of the Draft horses sought shelter in cold weather, compared to 69 % in the Arabian horses. The sun did not seem to affect the Arabians in the same way as the heavier Draft horses, presumably because of their constitutional differences. New Forest ponies, which constitution wise may be more like a small Draft horse than an Arabian have also been seen to prefer shade in hot and sunny days. They often sought shade from 9-10 in the morning until the late afternoon during sunny weather, with only short detours for grazing and drinking (Tyler, 1972).

If pastures are provided with shelters, water troughs or fencing, it can be of great importance where these facilities are situated, for example both cattle and sheep have been seen to alter their grazing behaviours according to these (Putfarken et al. 2008). Items such as water troughs and salt blocks are recommended to be mobile in order to decrease any damage caused by trampling (Pehrson, 1994).

Seasonal Adaptation and Time Budget

Free ranging horses in different environmental conditions seem to differ in their seasonal adaptation to different vegetation types and variations in feed availability (Putman *et al.,* 1987; Duncan, 1983; Girard *et al.,* 2013). In a study made on free ranging Konik ponies, Cosyns (*et al*, 2001) saw no changes in grazing pattern or biomass intake during the year of the study. A reason for the absence of seasonal change could be their overall strategy of feeding on the most nutritious plants, consequently generating a fat reserve during the vegetative season. This reserve could then be used during the winter when feed is scarce, and of poor nutritive quality. Shetland ponies have been found to lose up to 20 % of their weight during the winter season when kept on pasture with no supplementary feeding (Lamoot et al, 2005). During that time their body condition score (BCS) dropped from 4.6 to 2.4 on the scale made by Carroll & Huntington in 1988 (*et al.,* 2012).

The ponies of New Forest breed have been found to change their preference for some vegetation types during the year, whilst the usage of other vegetation types remained unaffected by seasonal changes. The driving factor in this seem to be the foraging behaviour, where wet areas were used mostly during the summer, woodlands were used mainly during the winter and improved grasslands were used equally throughout the year (Putman *et al.,* 1987). Similar patterns have been observed among sheep and cattle, avoidance of wetlands during wet weather and avoidance of dry patches during dry whether (Pehrson, 1994). However, Duncan (1983) split it up even further, and found that the horses of Camargue had separate areas in which they feed and areas where they preformed other, non-feeding behaviours. These horses avoided flooded areas for non-feeding behaviours, preferring land with as little vegetative cover as possible. This was probably a result of insect avoidance, thus this preference was seen only during the warmer months of the year, from April to October.

During the colder months they didn't discover any pattern comparing time spent in feeding and non-feeding areas.

During snowy conditions, horses can paw away the snow to obtain the underlying vegetation. This is found more often as the snow gets deeper, but in shallow snow, or in places already pawed from excess snow horses have been found to feed directly through the snow, pushing it away using their muzzle (Salter and Hudson, 1979). During the winter horses can expand their diet to roots and rhizomes of plants like *Epilobium hirsutum* and *Urtica dioica* (Cosyns *et al.,* 2001). During the late nineteen seventies, the French scientist Patrick Duncan studied free ranging Camargue horses and saw that feed quality and biting flies were the two most important factors effecting the Camargue horses time budget. Rain on the other hand had only a minimal effect, prolonging the time that the horses spent standing resting (Duncan, 1985). Foraging behaviours were preformed 51- 63 % of their time, lowest for adult (intact) males during spring and summer, and highest for yearlings during autumn and winter (Duncan, 1980).

Insects and Parasites

During summer, avoidance of biting flies is of great importance to the horses when selecting grazing areas (King, 2002). Duncan (1985) found that horses decreased their feeding time by 2.5 hours a day in early summer, most likely as an effect of horseflies and midges. Biting flies can also interrupt horses feeding bouts, stressing them to do more walking and passive standing instead of grazing (Mayes & Duncan, 1986) even though passive standing also have been observed to decline with an increasing numbers of biting flies (Duncan, 1985). A recent Swedish study found a negative relationship between wind speed and shelter-seeking behaviour during summer. The horses seemed to prefer to be outside the shelter if possible, but used it when it was less windy as an escape from the biting insects (Hartmann *et al.,* 2015).

The New Forest ponies in New Forest, Hampshire have both been seen to avoid grazing close to their own latrine, especially during the summer months in a study by Putman *et al.,* (1987), whilst Tyler (1972) who also studied the ponies of New Forest saw almost no coprophobic behaviour. The only exception was when they were resting in shady places; they then left the group and walked a few yards before defecating. In a French study Fleurance et al. (2007) saw that horses avoided grazing within one meter from horse faeces, and always avoided tall grass in favour of a shorter sward. They saw it as an interaction between the will to optimize the nutritional intake, whilst avoiding the risk of consuming infectious larvae. Results like this were also found by Fleurance (*et al*, 2005), whom concluded that horses favour swards with high nutritional values, while avoiding the risk of parasitic infections.

Aim of Thesis

The aim of this thesis has been to investigate the movements and shelter-seeking behaviour (SSB) of extensively kept Gotland ponies, to assess how they utilise their available recourses during the vegetative and the non-vegetative season within one year, in relation to time, weather and vegetation. Location data from the ponies was collected using GPS collars, and data about their SSB was obtained using camera traps inside the shelters. The year of the study was divided into vegetative and non-vegetative seasons using the recommendations in the Swedish animal welfare legislations.

Material and Method

This study was conducted during one year using twelve one-year-old Gotland pony stallions kept under free ranging conditions in three enclosures of about 10 ha each, consisting of fresh coniferous forest and unimproved lay.

Study Area

The experimental site was situated in Krusenberg, about 14 km south of Uppsala, Sweden, 35 m above sea level. The temperature varied over the year between -13.5° and 33.3° C, and maximum precipitation during 24 hours was 26.8 mm (Table 1). The study area was surrounded by forest to the northeast and by open landscapes in the southwest. The enclosures were designed to contain both lay and forest and their size was based on the lays' predicted yields, with the forest as a bonus area since there are no previous records of its feed contribution (Table 2).

Table 1. Weather at Krusenberg study site from 1 May 2014 to 1 May 2015

		Vegetative season		Non-vegetative season	
Variable	**Unit**	**Mean**	**Range**	**Mean**	**Range**
Wind speed	m/s	1.82	0 – 6.62	2.63	0 - 7.71
Temperature	°C	2.73	-2.79 - 33.3	1.08	-13.5 – 15.71
Precipitation	mm/day	0.1	0 - 26.8	0.06	0 - 2.9
Snow depth	cm	-	-	12.65	0 – 27

The lay in enclosure 1 and 2 was natural rangeland, earlier grazed by cattle. In enclosure 1 it contained 58 % grasses (*Poaceae*), 10 % yarrow (*Achillea millefolium*) and 7 % dandelions (*Taraxacum*), and in enclosure 2 it contained 57 % grasses (*Poaceae*) 14 % yarrow (*Achillea millefolium*) and 10 % dandelions (*Taraxacum*). The lay in enclosure 3 had previously been used for forage production and contained 47 % dandelions (*Taraxacum*), 26 % grasses (*Poaceae*) and 5 % white clover (*Trifolium repens*). The amount of grass (*Poaceae*) in the forest varied, the forest in enclosure 1 contained 11 %, and in enclosure 2 it contained 21 % and in enclosure 3 it contained 12 %. Enclosure 2 and 3 also contained semi forest, which contained 36 % grasses (*Poaceae*). There have been no prior experiments of this kind with horses in Sweden; therefore the carrying capacity for year-round pasture is unknown. The animal density during this study was between 60 – 80 kg/ha.

Table 2. Size and proportions of vegetation types in hectare and percentage within each enclosure

	Lay		Forest		Semi Forest		Total
Variable	**Ha**	**%**	**Ha**	**%**	**Ha**	**%**	**Ha**
Enclosure 1	2.7	20	10.7	80	0	0	13.4
Enclosure 2	3.3	32	5.8	56	1.3	13	10.3
Enclosure 3	2.7	28	6.8	70	0.2	2	9.7
Total	8.7	26	23.3	70	1.5	4	33.4

Each enclosure was equipped with a 4 x 4 m shelter (Cover all Europe GmbH, Groß Lüdershage, Germany) situated on the lay (marked in red in Figure 1). The shelters were put on bare ground without any bedding material, but during the spring of 2015 the shelters were lined with rough gravel, as the ground became soaked during damp weather conditions.

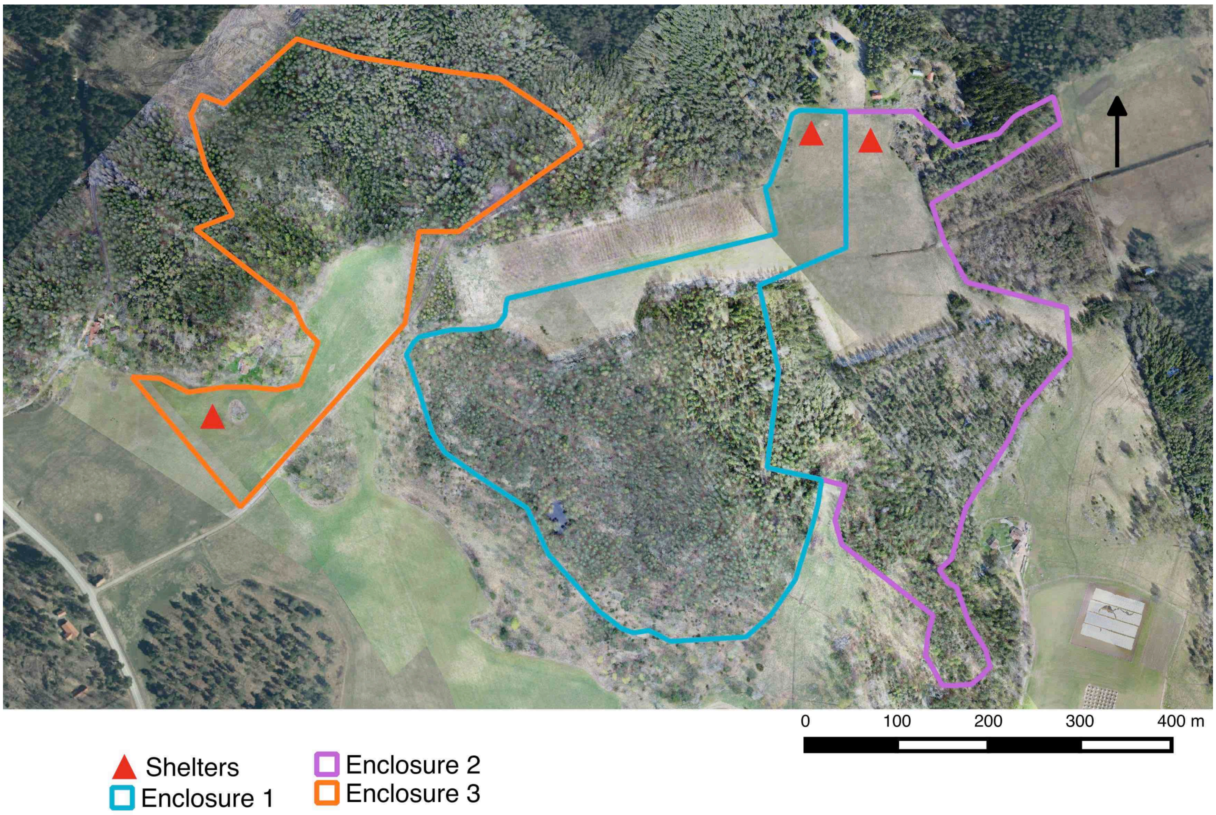

Figure 1. Map of enclosures with shelters marked in red.

Shelter Usage

The shelters were equipped with camera traps (Z-AIM AB, UM565), placed in the far left corner of the shelter to cover as much of the space inside the shelter as possible. These cameras took a picture as soon as something moved within its range, continuously photographing once every minute for as long as something was moving. These cameras were also equipped with infrared sensors, making it possible to take black and white photographs even during the dark hours. The shelter pictures were analysed by visual inspection, and divided into three classes, 1 for when at least one pony had more than two feet inside the shelter, 0 when there were no or less than two pony feet in the shelter, and NA for time periods when the equipment for some reason were malfunctioning. The bursts of minutes that were classified as used (1s) were then summarised together with the first timestamp from the burst using an inverse cumulative sum.

Habitat Selection

Between one and three ponies per enclosure were always fitted with a GPS collar (Followit Lindesberg AB, Tellus) that registered and stored the ponies' positions every 15 minutes during the experiment. Ten out of twelve ponies were at some point fitted with a GPS collar. The GPS data was first sorted to eliminate positions with low locational accuracy by removing positions with a DOP <= 2, and positions without 3D accuracy. All spatial computations were performed in Q-GIS (2.8.2-Wien).

Vegetation Data

A botanical plot inventory of the enclosures was conducted between the 2 and the 20 May 2014, before the ponies were introduced to the enclosures. The inventory plot locations were predetermined in a systematic random design, placing a plot at every 35 m using Q-GIS. Each plot was 15 m^2 measured as a circle, and its location was identified using a handhold GPS (Garmin® GPSmap 62st). Each plot was marked using an orange coloured wooden stick put in the ground, except for sites where it was not possible to put down a stick, then the plot were marked using orange spray paint. The exact GPS positions of each plot were noted for further inventories. The height of the vegetation was measured on the north side of the wooden stick (or spray marking) using a Rising Plate Meter, a rectangular drop disk of wood (20 * 20 cm) on a graded metal stick. The ground flora was examined at the same spot as the height was measured, covering the same area as the wooden disk, using Fältflora (Ursing, 2013) All identified species were noted, along with their visually assessed coverage in percentage. All trees within the 15 m2 circle from the stick were recorded, and up to three specimens of every species closest to the stick were measured for diameter, height, and marks from browsing and gnawing. These trees were divided into three height classes, class 1 for trees < 3 m, class 2 for trees between 3-5 m and class 3 for trees > 5 m. The plots were also checked for dead wood and faeces, were species and number of faecal groups was recorded. The plots local vegetation type were defined using Lantmäteriets (www.lantmateriet.se) predefined chart of vegetation classification, adding one extra class of "semi forest". This class included forest areas that were dominated by a deciduous forest with a large proportion of grass in the ground coverage, which probably could contribute with a larger feed value than the other forest types. The information obtained in the botanical and vegetation type inventory was used to make a vegetation map for the enclosures. The inventory plots were mapped upon aerial-photos in GIS, were they were used to make polygons of all the different vegetation types (Fig 2a). For spatial analysis, these vegetation types were then classified into three categories: lay, forest and semi forest (Fig 2b). Lay was predefined as cultural land in the definition system used, semi forest were, as previously mentioned made up for this project, and forest included all of the remaining vegetation types of forest: coniferous forest on lichen-dominated areas, coniferous forest on dry areas, dry-fresh coniferous forest, fresh coniferous forest, fresh coniferous forest on wet areas, coniferous forest on wet areas, mixed forest on mires, broad-leaved forest, broad-leaved forest in wet areas and mires. In both classifications the shelter-areas were made into a separate class, in order to separate them from the rest of the lay where the shelters were situated. The ground coverage of the enclosures was also photographed once every second week from fixed points along the fence.

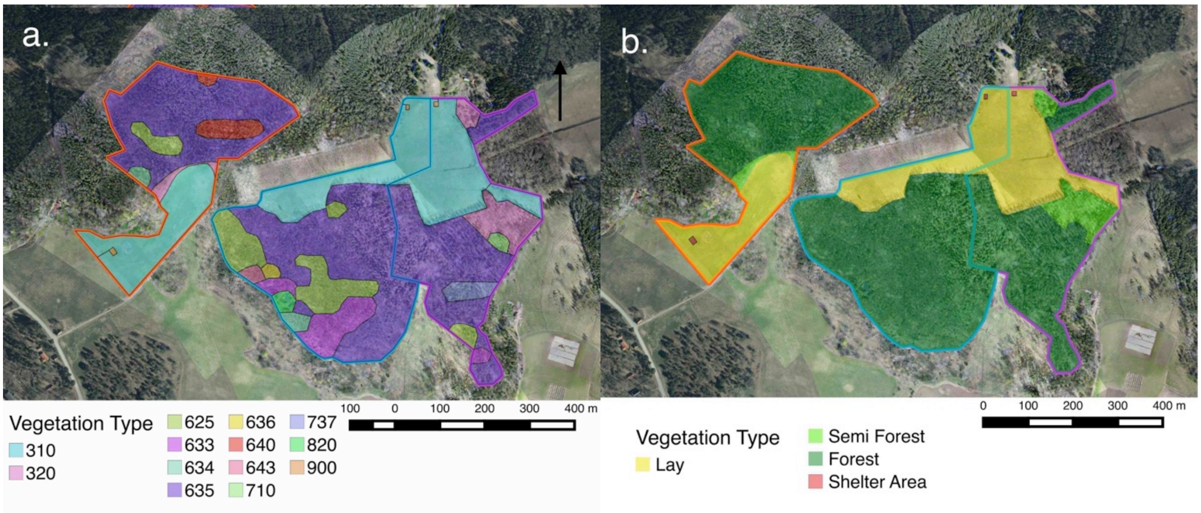

Figure 2 a. Complete Vegetation map including all inventoried vegetation types, 310 lay, 320 semi-forest, 625 coniferous forest on lichen-dominated areas, 633 coniferous forest on dry areas, 634 dry-fresh coniferous forest, 635 fresh coniferous forest, 636 fresh coniferous forest on wet areas, 640, coniferous forest on wet areas, 643 mixed forest on mires, 710 broad-leaved forest, 737 broad-leaved forest in wet areas, 820 mire, 900, shelter area.
Figure 2 b. Reclassified vegetation map whit four different classes, lay, semi-forest (forest with more grass), forest and shelter area. Lantmäteriet.se 2009, JTI 2014.

Weather data

Weather data with one observation per hour, consisting of continuous temperature, wind speed, precipitation and snow depth were obtained from a weather station at Uppsala University, about 14 km north of the study site (http://celsius.met.uu.se/). Temperature and wind speed data were linearly interpolated for every minute, while precipitation data were summarised for one, two or four hours because of the cumulative chilling effect of rain. This data were then subdivided into a vegetative and a non-vegetative season, according to the Swedish animal safety legislations that are based on the seasonality of grass (DFS 2007:6). The vegetative season of grass starts at 5° C (Peacock, 1975; Frame & Laidlaw, 2011) and the vegetative season is defined to start as the mean temperature have been above 5° C for five days (Frame & Laidlaw, 2011). In this study the mean temperature was calculated and the vegetative seasons were initiated by the first five days > 5° C and ended by the first five days with a mean temperature < 5° C. In addition, temperature data was divided into three temperature classes: cold < -5° C, intermediate > -5° C to < 15° C, and warm > 15° C. The cold class was arbitrary chosen to separate occasions when precipitation would wet the ponies' fur, from the occasions when it would fall as snow, which would not melt on their backs. The warm temperatures were set to > 15° C when precipitation would not make the ponies cold. Minimum temperatures below -5° C were recorded for 23 days and mean temperatures below -5° C were recorded for six days. Thus, the cold class only contained five observations and was therefore merged with the intermediate class. Maximum temperatures above 15° C were recorded during 173 days and mean temperatures above 15° C were recorded for 76 days.

Statistical Analysis

Habitat Selection

Resource selection functions (RSFs) provide a tool to estimate animal preference for, or avoidance of, certain habitats (Manly et al. 2002). RSF-models were developed with a use-availability design to evaluate the ponies' preference for different vegetation types within the vegetative and non-vegetative season respectively, including day and night as fixed effects. The statistical analyses were preformed in R (R Core Team, 2013) using the regression fitted with the glm function in R (using the binomial distribution family). Habitat variables at horse GPS locations were compared to random available locations within each enclosure. Available points were generated in a 1:1 ratio of used and available locations. Habitat selection was evaluated using generalized linear regression for binomial data and AIC-values were used to identify the most parsimonious model in the selection of prediction parameters.

Shelter Usage

For evaluation of the ponies SSB, general linear models of time duration in shelter were fitted with environmental parameters. All shelter bouts shorter than 6 minutes were deleted to eliminate nonsense visits in the shelter, such as wallowing in the gravel for scratching purposes. Shelter camera data were based on the whole group altogether, and do not represent SSB per pony. To assess whether the weather had any significant effect on the ponies' shelter usage the time spent in the shelter was fitted in a multiple linear regression with temperature, precipitation, and wind speed as predictor variables. A comparative table using data from both GPS collars and camera traps were set up for time periods that had data available from both sources.

Results

The vegetative season had already started when the experiment was initiated, and lasted until the 22 of October. The non-vegetative season lasted from the 23 of October until the 10th of April, which is slightly shorter than the mean number of days over the last ten years (2004-2014). The grounds were never observed to be muddy or trampled at any time during the experiment.

Shelter Usage

The camera traps showed that during the non-vegetative season the ponies' visited the shelters almost twice as much long (64 min) as during the vegetative season (36 min) (Table 3). The most extended visit in the shelter (338 min) occurred in February at -2° C.

Table 3. Shelter visits in minutes per day and number of observed visits, divided by temperature class and season

Temp class	Mean	(range)	Number of observations
Cold (< -5° C)	155	(111 – 220)	**5**
Intermediate (> -5°, < 15° C)	49	(6 – 338)	287
Warm (> 15° C)	36	(6 – 108)	67
Vegetative season	36	(6 -140)	209
Non-vegetative season	64	(6- 338)	150
Whole year	48	(6 - 338)	359

The SSB preference was slightly higher during temperatures < 15° C. The regression estimates showed that precipitation made the ponies more motivated to use the shelters, while wind speed had no impact on their SSB (Table 4). The ponies also used the shelters more during the non-vegetative season than during the vegetative season.

Table 4. Regression estimates of shelter visits length on temperature intervals, precipitation, wind speed and season for Gotland ponies

Coefficients:	Estimate	Std. Error	Pr(>|t|)	
General temp class (<15° C)	3.78776	0.12248	< 2e-16	***
Warm temp class (> 15° C)	3.93058	0.17825	< 2e-16	***
Precipitation (mm/h)	0.09958	0.02728	0.000302	***
Wind speed (m/s)	0.0101	0.03869	0.794122	
Vegetative season	-0.65306	0.10472	1.28E-09	***

Habitat Selection

When separating GPS registrations by vegetation type (Table 5) it became clear that the use of both the lay, forest and shelter area followed the same pattern in all three enclosures. Lay was used more during the vegetative season than during the non-vegetative season, opposite to forest and shelter area, which was used more than the lay during the non-vegetative season than during the vegetative season. The usage of semi forest in enclosure 2 and 3 did not seem to differ between the seasons.

Table 5. GPS registrations in percentage, divided by vegetation type, season and enclosure

Enclosure	Season	Lay	Semi Forest	Forest	Shelter Area
1	Vegetative	45	-	53	1,7
	Non-Vegetative	34	-	65	0,8
2	Vegetative	49	9	38	4,8
	Non-Vegetative	44	11	44	0,4
3	Vegetative	51	2	44	3,8
	Non-Vegetative	41	2	55	1,6
All	Vegetative	48	-	44	3,8
	Non-Vegetative	40	-	55	1,0
	Both	45	-	48	2,6

The regression estimates (Table 6) shows that lay was the most favoured vegetation type during the vegetative season, and it was used more than both types of forest. However, forest use did increase during nighttime, compared to daytime. Precipitation increased the ponies' time spent on lay and decreases time spent in forest. Wind speed and temperature had no significant effect on the ponies' behaviour.

Table 6. Regression estimates from the RSF-model for the ponies' vegetation type preference in relation to weather patterns during the vegetative season. Regression estimates for the continuous variables (without interaction effect) are related to the usage of the vegetation type lay

Vegetative Season	**Estimate**	**Std. Error**	**Pr(>|z|)**	
Lay	1.110306	0.041496	< 2e-16	***
Semi Forest	-1.033944	0.156080	3.48e-11	***
Forest	-1.351532	0.048082	< 2e-16	***
Shelter	3.467997	0.664843	1.83e-07	***
Precipitation	0.053876	0.020562	0.00879	**
Wind speed	-0.007114	0.010887	0.51346	
Temp	-0.001407	0.002184	0.51965	
Night	-0.279697	0.026901	< 2e-16	***
Semi Forest: Precipitation	0.050566	0.061111	0.40798	
Forest: Precipitation	-0.505072	0.052560	< 2e-16	***
Shelter: Precipitation	0.984183	0.789997	0.21284	
Semi Forest: Wind speed	-0.076684	0.041585	0.06518	.
Forest: Wind speed	0.031180	0.016397	0.05723	.
Shelter: Wind speed	-0.158670	0.146429	0.27855	
Semi Forest: Temp	0.015600	0.008272	0.05929	.
Forest: Temp	-0.028900	0.003342	< 2e-16	***
Shelter: Temp	0.057764	0.029687	0.05168	.
Semi Forest: Night	1.363213	0.097674	< 2e-16	***
Forest: Night	1.195187	0.040403	< 2e-16	***
Shelter: Night	0.054062	0.479930	0.91031	

Lay was the most favoured vegetation type also during the non-vegetative season (Table 7). As well as in the vegetative season, precipitation reduced forest usage. High temperatures also reduced forest use. Snow depth on the other hand increased the use of both forest types and the shelter areas. Forest use was increased during the night, while the usage of shelter areas was increased during the day.

Table 7. Regression estimates from the RSF-model for the ponies' vegetation type preference in relation to the weather patterns during non-vegetative season. Regression estimates for the continuous variables (without interaction effect) are related to the usage of the vegetation type lay

Non-vegetative Season	Estimate	Std. Error	Pr(>|z|)	
Lay	1.226134	0.044522	< 2e-16	***
Semi Forest	-0.284772	0.138883	0.040321	*
Forest	-1.269251	0.039785	< 2e-16	***
Shelter	3.002266	0.623984	1.50e-06	***
Precipitation	0.194004	0.082361	0.018496	*
Wind speed	-0.023958	0.013172	0.068932	.
Temp	0.015867	0.004724	0.000782	***
Night	-0.609208	0.034340	< 2e-16	***
Snow	-0.058511	0.002212	< 2e-16	***
Semi Forest: Precipitation	-0.124238	0.254481	0.625408	
Forest: Precipitation	-0.297481	0.107015	0.005439	**
Shelter: Precipitation	-0.268794	0.882025	0.760560	
Semi Forest: Wind speed	-0.035389	0.042412	0.404044	
Forest: Wind speed	0.011271	0.017274	0.514080	
Shelter: Wind speed	0.243401	0.196621	0.215746	
Semi Forest: Temp	-0.037338	0.015874	0.018664	*
Forest: Temp	-0.044439	0.006175	6.16e-13	***
Shelter: Temp	-0.016162	0.065372	0.804731	
Semi Forest: Night	1.202157	0.111662	< 2e-16	***
Forest: Night	1.450173	0.046342	< 2e-16	***
Shelter: Night	-1.040102	0.515578	0.043659	*
Semi Forest: Snow	0.073095	0.005970	< 2e-16	***
Forest: Snow	0.089751	0.002603	< 2e-16	***
Shelter: Snow	0.167053	0.038099	1.16e-05	***

In general, the vegetation types were used in a similar way in the three enclosures, but the ponies' preference for different vegetation types differed some between the enclosures (Table 8). The ponies in enclosure 1 had a higher preference for lay during the vegetative season than the ponies in the two other enclosures. During the non-vegetative season the preference for lay in enclosure 1 was almost twice as high, compared to the ponies in enclosure 2 and 3. Forest use was similar in the enclosures during the non-vegetative season, but during the vegetative season the ponies of enclosure 1 used the forest more than in enclosure 2 and 3. The use of shelter areas was unequal among the enclosures during both seasons and the ponies in enclosure 2 had the highest shelter-area preference during the vegetative season, and the lowest preference during the non-vegetative season.

Table 8. Regression estimates from the fitted RSF-models of vegetation preference within each enclosure for vegetative and non-vegetative season

Vegetative Season	**Estimate**	**Std. Error**	**Pr (>|z|)**	
Lay: Enclosure 1	1.26214	0.02300	< 2e-16	***
Lay: Enclosure 2	0.75763	0.01895	< 2e-16	***
Lay: Enclosure 3	0.98053	0.01927	< 2e-16	***
Semi Forest: Enclosure 1	NA	NA	NA	
Semi Forest: Enclosure 2	-0.56620	0.04312	< 2e-16	***
Semi Forest: Enclosure 3	0.34888	0.09099	0.000126	***
Forest: Enclosure 1	-1.09543	0.02025	< 2e-16	***
Forest: Enclosure 2	-1.14449	0.02369	< 2e-16	***
Forest: Enclosure 3	-1.33955	0.02251	< 2e-16	***
Shelter area: Enclosure 1	3.56671	0.32066	< 2e-16	***
Shelter area: Enclosure 2	4.76312	0.33474	< 2e-16	***
Shelter area: Enclosure 3	3.83374	0.24514	< 2e-16	***

Non-vegetative Season	**Estimate**	**Std. Error**	**Pr (>|z|)**	
Lay: Enclosure 1	0.95773	0.03199	< 2e-16	***
Lay: Enclosure 2	0.54583	0.02772	< 2e-16	***
Lay: Enclosure 3	0.58195	0.02405	< 2e-16	***
Semi Forest: Enclosure 1	NA	NA	NA	
Semi Forest: Enclosure 2	-0.08800	0.05331	0.098820	.
Semi Forest: Enclosure 3	0.37711	0.10429	0.000299	***
Forest: Enclosure 1	-0.49943	0.02118	< 2e-16	***
Forest: Enclosure 2	-0.51758	0.02704	< 2e-16	***
Forest: Enclosure 3	-0.50556	0.02003	< 2e-16	***
Shelter area: Enclosure 1	2.59650	0.29924	< 2e-16	***
Shelter area: Enclosure 2	2.30259	0.39641	6.3e-09	***
Shelter area: Enclosure 3	3.97500	0.35682	< 2e-16	***

Shelter data and GPS data from time periods that had bot data types were put together and for comparison. In enclosure 3 the GPS data has got a lower value than the camera data in two out of three time periods and the data sets corresponded well. In enclosure 2 and 3 the GPS data got lower values in five out of six occasions, and the data sets did not correspond as well as for enclosure 3.

Table 9. Shelter use in minutes from GPS and camera data (and GPS data in proportion to camera data). Only time periods that had both GPS and camera data are presented. GPS data was obtained from two or three horses per enclosure and is presented as a mean value of the number of ponies marked with a GPS in the enclosure, whilst camera data is presented as a combined value per enclosure.

Enclosure	Collection Method	29/8-5/9	14/9-23/10	8/12-20/12	23/10-27/1	27/1-13/4	Mean
1	GPS	23	13	16	-	18	18
	Camera	50	33	13	-	45	35
	(%)	(47)	(39)	(129)	-	(39)	(64)
2	GPS	75	-	-	13	-	44
	Camera	115	-	-	43	-	79
	(%)	(65)	-	-	(31)	-	(48)
3	GPS	41	18	-	-	48	35
	Camera	39	16	-	-	61	39
	(%)	(103)	(113)	-	-	(78)	(98)
Mean	GPS	46	15	16	13	33	25
	Camera	68	24	13	43	53	40
	(%)	(68)	(63)	(129)	(31)	(62)	(70)

The photographs taken every second week throughout the year in all enclosures showed the change in the ground coverage (Figure 3). These photos also show that the ground coverage was intact during the study with no sign of trampling or mud on the lay in any of the enclosures.

Figure 3. Photographs of the ground coverage in enclosure 1. a) 1 December 2014, b) 13 January 2015, c) 24 February 2015 and d) 11 May 2015.

Discussion

In this study, lay was the most used vegetation type by the ponies throughout the year. The forest was used more during the non-vegetative season than the vegetative season and more during the night than during the day. It was somewhat hard to compare the SSB in this study to the literature. The enclosures in this study were not large enough for the ponies to make their own home ranges like feral horses that have no fences to restrain them, but much bigger than the small paddocks which have been used in most other SSB studies of horses.

Shelter Usage

Shelter seeking behaviour was assessed using GPS collars and movement sensitive cameras traps. GPS data for shelter areas was obtained at an individual level continuously throughout the year, but was based on an arbitrary sized area corresponding in size to the shelter. Although the GPS-locations were not accurate enough to guarantee that the pony carrying the GPS collar actually was inside the shelter at the time of the registration, it have been in proximity to the shelter, probably using the shelter for shade, windbreak or just to be close to the other ponies using the shelter. Camera trap data was on the other hand more precise, covering almost the whole inside area of the shelter, however it had time periods of missing data due to technical errors. When processing shelter-pictures from this study, it was sometimes hard to separate some ponies, especially from the black and white pictures taken during the dark hours. Therefore, theses pictures resulted in a joint value of how much the shelters were used by the whole group, not of how much a single pony used the shelter. Thus individual SSB values would most likely not have been as high as the measured combined value. This implies that both data types may have overestimated the individual shelter use. The methods used in this study differ from previous work on SSB, which has often been assessed using direct observations, (Autio, 2008; Duncan, 1985; Heleski & Murtazashvili, 2010; Mejdell & Bøe, 2005; Michanek & Ventorp, 1996). When watching horses directly it could be easier to differentiate between animals to get individual results of SSB, but compared to the passive methods used in this study, direct observations are very resource demanding. Comparing the GPS and the camera data sets (Table 9), all three results from enclosure 3 corresponded very well to each other, and the GPS data explained between 78-113 % of the camera registrations. The results from 8/12 - 20/12 in enclosure 1 also corresponded well, while the other results from enclosure 1, and all results from enclosure 2 did not. When camera data is higher than GPS data, it could be because the pony activating the camera was not wearing a GPS collar at the time. When the camera data on the other hand has a lower amount of observations than the GPS data for the same time interval, it could be caused by ponies being close, but not inside the shelter. For most time periods there seem to have been an underestimation of the shelter usage in the GPS data compared to the camera data. In enclosure 1 and 2 the shelters were also surrounded by forest, which could have interfered with the accuracy of the GPS. The GPS data only represents the two or three ponies that were wearing GPS collars at the time, and group composition and rank could have influenced the GPS value for shelter area. Having collars on all ponies' at the same time would probably diminish this effect, and if it were possible to fully identify ponies from shelter pictures, comparisons at an individual level could be possible. This would be useful when comparing different SSB studies that have used different assessment methods. Shelter use was lower (F-test p-value=0.05) between September 14th and January 27th than during the periods before and after. Hence, this finding does not reinforce the Swedish animal welfare regulations stipulating mandatory shelters for free-ranging horses only during the non-vegetative season. It rather implies that shelter use is affected by more parameters than vegetative/non-vegetative season, and that their importance seems to vary both between and within horse groups. Variation between enclosures may derive from differences in feed availability or natural circumstances in the enclosures, as well as from group composition of the ponies.

In this experiment the shelters were used less in comparison to almost all previous studies of shelter usage, except for Ingólfsdóttir & Sigurjónsdóttirs (2008) study were most of the horses did not use their shelters at all. Reviewing previous studies I correlated enclosure size with shelter usage (Figure 4) In common for all these studies with high (12-48%) shelter use were small paddocks with 0,02-0,9 ha per horse including shelter area, and ad libitum forage fed close to the shed (0,02 ha is smaller than the Swedish recommendations of at least 0,03 ha per horse (SJV, 2011)). Hence these horses had little need for, or possibility to, forage on their own already being served an abundance of easily accessible feed. Most likely much of their SSB could be explained by the feed being close to the shelter and the small size of the enclosures. To avoid confounding effects from feed placement and enclosure size, it could be interesting to use randomized points to compare with their observed shelter use, to see how much of their SSB that could be explained by the random likeliness to be staying in the shelter at any given time.

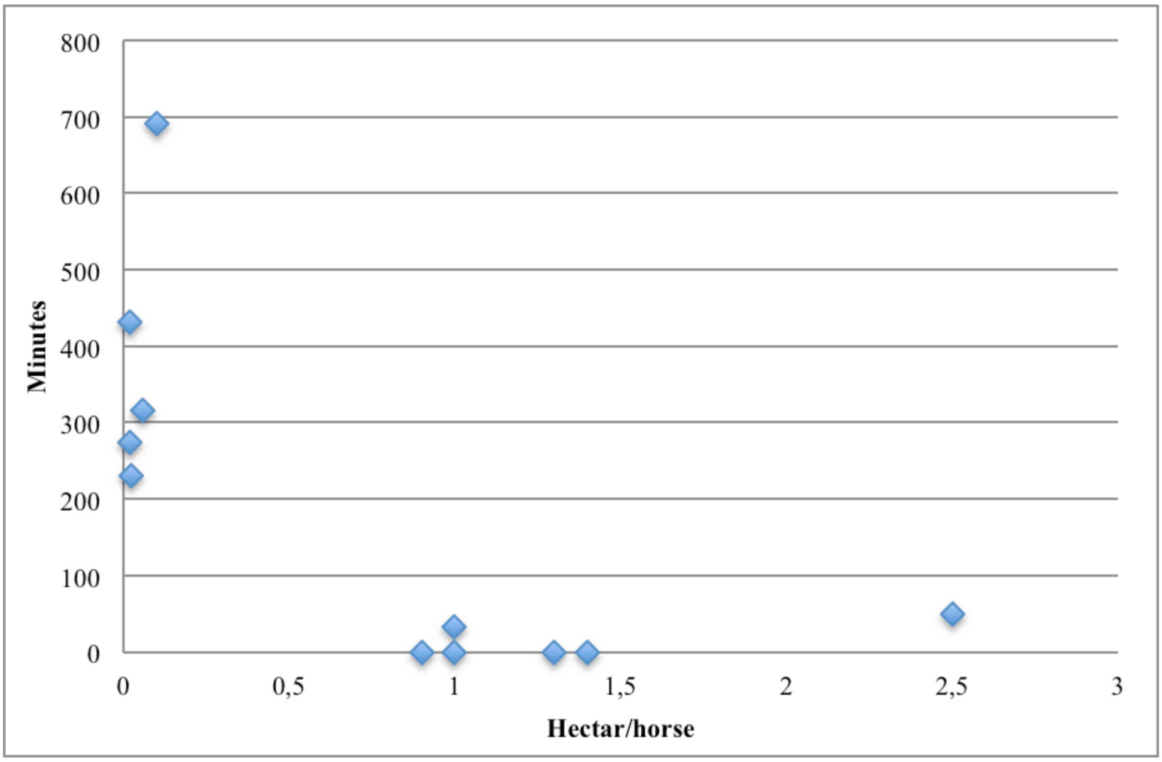

Figure 4. Shelter usage in minutes per day, in relation to paddock size in reviewed studies (Autio, 2008; Michanek & Ventorp, 1996; Ingólfsdóttir & Sigurjónsdóttir, 2008 (five markings); Brosäter & Peterhoff 2013; Mejdell & Bøe 2005; Hartman, 2015; Nilsson, 2006).

When studying the behaviour of feral Camargue horses, Duncan (1985) saw a negative correlation between foraging and standing resting. This would imply that when less time is spent foraging, more time would be used for immobile behaviours such as resting in the shelter. Since horses forage about 50-70 % of their time (Cosyns *et al.,* 2001; Duncan, 1985), it would be hard for a non-fed horse to spend the same amount of time in a shelter as the ad-lib fed horses. There are simply not enough hours per day, as the horses also have other essential behaviours to preform during the day. It is possible that the ad lib fed horses also needs the shelter more to keep warm, not doing as much walking as the non-feed horses do when foraging. The constant walking preformed by the non-fed horses should contribute to keeping their body temperature. According to Swedish legislations, horses that are kept outdoors for more than 16 hours a day, during the non-vegetative season, must be provided with a shelter in their paddocks. The ponies in this experiment made use for there shelters about 36 min during the vegetative season and 64 min per day during the non-vegetative season according to the camera trap data. Comparing the high SSB studies with the low SSB studies, they differ in both paddock size and feeding regimes. The low SSB horses had to work for the feed by fulfilling foraging behaviours, which the ad-lib fed horses with high SSB had no possibility to do in their small paddocks. The lack of possibility to preform real foraging behaviour may cause these horses to spend more time inside their shelters. Michanek & Ventorp (1996) mentions that the to Thoroughbred fillies in their study went out from their shelters in the middle of a rainfall to forage on the almost non-existing winter pasture. They further imply that this shows that when horses have the possibility to choose, foraging behaviour is prioritized over SSB. The results of shelter usage in this study further reinforces Michanek & Ventorp (1996) assumption that it is time to review the current standard of stabling horses in individual boxes and small paddocks, preventing them to preform their foraging behaviour. According the Swedish animal legislations there is no maximum time for horses to be stabled, as long as they get the possibility to move in all of their natural gates once a day. It seems that the Swedish legislations prioritizes SSB over both movement and foraging behaviours, even though horses are known to be prey animals from the plains, which have evolved to rely on their excellent reactivity and capability to escape fast from predators (McGreevy, 2004).

Habitat Selection

The lay seems to be the most important vegetation type for the ponies, not unexpectedly since it provides their main feed. The ponies did not even leave the lay during rain, probably prioritising foraging behaviour over SSB. Even so, use of the forest increased during the non-vegetative season, similar to the New Forest ponies (Putman et al., 1987). When snow covered the ground, the ponies in our study reduced their use of lay in favour of the forest. Most likely because the snow layer was shallower in the forest, making it easier for them to paw away the snow from the ground to obtain feed. Not only was the snow layer thicker on the lay compared to the snow layer in the forest, sometimes a hard snow crust was observed on the lay. Lower land with standing water was even covered by an ice crust, making it even harder to get through to the vegetation below. When the ponies were in the forest, they were observed to feed on both bryophytes and European blueberry shrubs (*Vaccinium myrtillus*). Their nutritional value is very poor, but they still contribute with fibres to their diet (Matsson, u.p.).

The ponies' habitat preferences changed not only due to differences in seasons and changes in temperature, there were also differences between the enclosures and between day and night behaviour. They spent more time in the forest during the night throughout the year, and in the non-vegetative season the shelters areas were used more during daytime. This SSB during daytime in the non-vegetative season could have been a way for the ponies' to harness the heat from the sun, as the shelter was open to the south.

The ponies showed differences in vegetation preferences among the enclosures. In enclosure 3 the ponies had an almost identical use of the shelter area during both seasons. This could possibly be explained by differences in the plant composition in the vegetation types between enclosure 3 and enclosure 1 and 2. The lay in enclosure 3 was most likely exposed to more wind, as it was not surrounded by forest in the same extent as the other two enclosures. Hence, there were probably less biting insects on the lay in enclosure 3, reducing the ponies need for refuge from biting insects during the vegetative season. In the non-vegetative season, the wind conditions in the lay in enclosure 3 may have increased the ponies motivation to use the shelters as windbreakers, which might explain why they had the highest preference for the shelter area during the non-vegetative season. The lay in enclosure 3 was also the smallest lay and it had the lowest biomass production during the year (Matsson, u.p.), which could further explain the high shelter-area preference of these ponies. The lay in enclosure 2 had the highest biomass production among the enclosures (Matsson, u.p.), while these ponies had the lowest lay preference during both seasons. They also kept had the highest body condition score; highest daily weight gain and they grew the most in withers height. Probably the ponies in enclosure 2 did not have to spend so much time feeding as the other ones did. The ponies in enclosure 2 also had the highest shelter preference during the vegetative season, supporting Duncan's (1985) theory about a negative correlation between foraging behaviours and SSB. The ponies in enclosure 1 had the highest lay preference during both seasons, and also had the lowest weight gain. Possibly they tried to maximize their nutritional intake by an increased foraging time due to their lay being of poor nutritional value. Even though the ponies almost doubled their SSB during the non-vegetative season, it was still low compared to the majority of other studies previously referred to in this thesis (Figure 1). The forest and the shelters were situated at opposite ends within the lays; maybe this distance decreased their motivation to use the shelters as weather protection? Or did the forest provide sufficient enough shelter for them?

In future research, it would be interesting to redo this study, having two control groups of ponies. One with no forest available, only lay and a shelter, and another that would have both lay and forest, but without any man made shelter. This would make it possible to further investigate which factors that influence the SSB in free ranging horses during Nordic conditions.

Animal Density

The free ranging horses of Camargue had an initial animal density of approximately 20 kg/ha in 1973 when described in a study by Duncan (1985). These horses were breeding freely, and as the animal density increased over the years it reached about 120 kg/ha in 1980. At this density the author reported that the lactating mares were starting to lose body condition at the end of each winter, confirming a sub acute food shortage. Lamoot et al. (2004) conducted a study on free ranging Shetland ponies and Highland cattle in the coastal dune areas of Belgium. There they referred to a high animal density with 85–107 kg/ha. The animal density during this study was approximately 80 kg/ha, including the forest with an unknown feed contribution. In this perspective, the animal density in this project must be considered as relatively high. Even so, the ground was not trampled and muddy like most horse paddocks are, which most likely could be explained by the good distribution the ponies had using all of their available resources thanks to the non-feeding regime.

Furthermore, to have a single species of grazing animal in a relatively small fenced area could force the animals to graze close to their own latrines, enhancing the risk of being infected by intestinal parasites. If a high animal density were needed to reach a certain result for preservation purposes, mixed grazing with another species would be preferable, also giving a better utilization of the grassland (Frame and Laidlaw, 2011; Höök Patriksson, 1998; Pehrson, 1994).

Improvement Opportunities

During the study there were some technical errors in the camera traps, resulting in missing values in the data sets. This lead to fewer recordings of shelters observations when the temperature were < 5° C (which was pre-defined as cold). Therefore the temperature class Cold was removed, and was not used in the statistics. In further research this could hopefully be avoided by better routines when changing memory cards.

Difficulties in fitting the GPS collars resulted in some chafing around the throatlatch on some of the ponies, especially around time of shedding. Therefore the collars had to be moved between the ponies regularly, to maintain a good welfare of the ponies. It would be better for the horses if a smaller GPS-collar, better suited for horses, were to be developed.

When processing the GPS-data, there was a certain amount of uncertainty noted in the GPS-positions. When conducting the botanical inventory it was noted that the error margin increased in the forest compared to the lay. The different vegetation-types in the detailed map were rather small compared to the presumed error margin of the GPS-positions, therefore, the simplified map were set up. For further research, it would be good to pin down the real uncertainty of the GPS-collars. One way to do so would be to mount a collar on a pole near the enclosures for 24 h, and then analysing the GPS- positions in a GIS. This could be done both on the lay and in the forest, to assess whether there was any difference in accuracy in relation to the ground coverage.

Conclusion

The ponies in this study have shown that they use their legally required shelters both in the vegetative and the non-vegetative season, but not at all to the same extent as horses in smaller paddocks fed ad libitum amounts of roughage. There seem to be a correlation between paddock area available per horse and shelter usage, horses that are given the opportunity to forage seems to prioritize foraging behaviours over SSB. A larger available area for horses is often followed by better foraging opportunities, which could explain this correlation. The ponies in this study spent most of their time on the lay, but used the forest throughout the year, probably for feeding purposes during the non-vegetative season, since the snow layer was shallower in the forest than on the lay. The use of the forest also increased during the night, while the use of shelter areas increased during the day in the non-vegetative season. The animal density was rather high in this study, but if a high density were needed for nature conservatory reasons, like when there is brushwood that needs to be kept down, mixed grazing would be preferable.

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