Behaviour and use of protection in heifers and suckler cows kept outside in the winter time in Sweden

Beteende och användning av skydd hos kvigor och dikor som hålls utomhus under vintern i Sverige

Katharina Graunke

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Katharina Graunke

Diplomarbeit i biologi, Technische Universität München
Handledare: **Dr. Lena Lidfors, SLU Skara**
Prof. Dr. Roland Gerstmeier, TU München

CONTENTS

Glossary

English	German	Swedish
biting lice	Haarlinge/Federlinge	päls ätare
breed	Rasse	ras
to butt	mit dem Kopf stoßen	stänga till
climatic chamber	Klimakammer	klimat kammare
coat length	Felllänge	pälslängd
coniferous forest	Nadelwald	barrskog
conspecific	Artgenosse	artfränd
crepuscular	dämmerungsaktiv	skymningsaktiv
to crouch	kauern	kura
cubicle	Liegebox	liggbås
dairy cow	Milchkuh	mjölkko
deciduous forest	Laubwald	lövskog
diurnal pattern	Tagesrhythmus	dagsrytm
fat layer	Fettschicht	fettlager
fur	Fell	päls
grazing pattern	Weideverhalten	betesmönster
heifer	Färse	kviga
lactating	laktierend, milchproduzierend	lakterande, mjölk producerande
muzzle	Schnauze	mule
pasture	Weide	bete
precipitation	Niederschlag	nederbörd
predator	Raubtier	rovdjur
to ruminate	wiederkäuen	idissla
shelter	Schutz; Unterstand	skydd; ligghall
to shiver	zittern	huttra
suckler cow	Mutterkuh	diko
swamp	Sumpf	kärr

Summary

In today's agricultural environment it is possible for free-ranging cattle to behave almost as natural as they would in the wild. Usually free-ranging cattle live in mixed age groups and the cows and heifers mate naturally with breeding bulls which temporarily stay with the herd. Besides feeding of mineral supplements feeding only happens during winter time and concentrates are seldom fed. The animals are able to cope with different environmental challenges like low temperature, high wind speed or precipitation up to a certain degree by adapting physically and changing their behaviour. This means that cattle are capable of living outdoors even during winter without physical suffering, if certain conditions like access to food, possibilities of protection or good body condition and health are fulfilled. Little is known about the correlation between weather and the use of natural or artificial protection by cattle in Northern Europe and the results of the few carried out studies and observations of the animal owners are very diverse. Age and experience with winter weather and pregnancy play a role as well as outdoor raising of young cattle which makes early physical adaptation possible and which lets them learn protection behaviour as young animals. There is little knowledge about the influence of weather on the cattle's behaviour in semi-natural environments.

The aim of this study was to investigate the behaviour of cattle (*Bos taurus*) kept in semi-natural environment during winter time and to study the effect of weather, available protection and experience on the behaviour.

The study was carried out in the southwest of Sweden on the farm Trestena on a pasture of 12 ha which had not been used for agriculture for at least eight years. Protection was available by coniferous forest which was situated both on and around the pasture dividing it into four protection categories: In forest; Near protection, wind abandoned side; Near protection, wind facing side; No protection. From December 4th 2006 till March 22nd 2007 ten cows and ten heifers of Black Angus and Black Angus-Charolais-crossbreeds were observed as focal animals during a total of 240 hours. Each animal was followed one hour at a time and recordings were made with instantaneous sampling at 4-minute intervals for body position and general behaviour and continuously for social behaviour. Four hours of observations were carried out each day and these observation times were adjusted to the position of the sun. Temperature, wind speed and solar radiation were measured both in the animals' surrounding every four minutes and at the most exposed spot of the pasture per hour and later per 15 minutes. The different variables were combined to a single measure called Wind Chill Temperature (WCT). All collected data was analysed with a Poisson-regression model-link, logistic regression model-link functions, the Friedman two-way analysis of variance by ranks, the Wilcoxon signed ranks test and the Sign test.

To get an overview of the behaviour of the cows and heifers the percentages of the different body positions and the general and social behaviours were shown separately for morning and afternoon. The animals were lying more in the mornings than in the afternoons. The cows and heifers were feeding more in the afternoons, probably because feeding took place at noon from the end of January on. However, in December the cows and heifers spent more time feeding in the afternoon as well, even though feeding took place in the late afternoon. Social behaviours were of aggressive nature for about ¾ of the social recordings. Aggressive social behaviours were shown 21.9 percentage points more often while feeding from the feedracks and silage bales on the ground than while not feeding.

During the four months of observations the cows and heifers were in the forest in 12.4 %, near protection in 10.4 % and without protection in 77.2 % of the recordings. In total, there were no significant differences in the number of recordings when the cows and heifers were lying without protection compared to lying in the forest. If the proportionate percentages of lying per protection category were compared, the cows and heifers were lying significantly more in the forest compared with lying without any protection ($p < 0.001$). Resting (lying, ruminating, showing no activity) was quite similar, still the frequency of resting in the forest was significantly smaller if compared with resting without any protection ($p < 0.001$). The comparison of the proportionate percentages of resting in the forest compared with no protection showed significant differences ($p < 0.01$).

During precipitation, i.e. rain, snow and hail, the cows and heifers frequented the forest 2.71 times more often than when there was no precipitation ($p < 0.05$). No significant influence on the use of protection was established for the WCT alone. However, in 75 % of the observation hours the WCT in the animals' surrounding was at least 2 °C higher than at the most exposed spot of the pasture. The mean temperature differed with 1.8 °C ($p < 0.001$) and the mean wind speed differed with 1.7 m/sec ($p < 0.001$) between those areas.

The general behaviours lying, feeding and ruminating were all influenced by WCT, precipitation and precipitation at different WCT. Without precipitation the cows and heifers were lying less ($p < 0.001$), feeding more ($p < 0.001$) and ruminating less ($p < 0.001$) at low WCT. During precipitation they behaved the other way around and were lying more ($p < 0.001$), feeding less ($p < 0.001$) and ruminating more ($p < 0.001$) at low WCT.

Social behaviours were influenced by WCT, precipitation and precipitation at different WCT as well. When there was no precipitation, social behaviours in total ($p < 0.001$) and aggressive behaviours ($p < 0.001$) were less likely to be shown when the WCT was high, whereas during precipitation the probability to show social behaviours in total ($p < 0.001$) and aggressive behaviours ($p < 0,001$) was bigger when the WCT was low.

The number of other cattle within a two-cow-lengths-ambit around the focal animal was influenced by WCT and wind speed but not significantly by precipitation. At lower WCT ($p < 0.001$) and higher wind speeds ($p < 0.01$) there were more animals around the focal animal than at higher WCT and lower wind speeds. Furthermore, in the forest the cows and heifers had less other animals close to them than without any protection ($p < 0.01$).

The heifers and cows had found similar microclimates, but to do so the heifers tended to frequent the forest more than twice as often as the cows ($p = 0.053$). In total the heifers were also lying more than twice as often as the cows ($p < 0.05$).

The rare observations of direct behavioural changes due to weather show the difficulties to measure those changes. Still, they point out the importance that experienced cattle can have for the protection behaviour of a herd. Keeping animals in mixed age groups and giving some individuals the chance to evolve life experience and the capability to influence the behaviour of a whole herd is essential if the animals are kept outdoors at least for some time of the year.

The results indicate that the animals adapted to the circumstances and behaved differently according to the weather and degree of protection. The cows and heifers were able to find warmer microclimates even without always having to frequent protecting objects. The circumstances around feeding seem to hold a considerable stress potential especially at lower temperatures. However, to have conspecifics for protection during cold temperatures and high wind speeds seems to be important for cattle both when no other protection is available and when there is other protection. Experience seems to play a central role for cattle in the way of protecting themselves from weather and the ability to find suitable microclimates. The results indicate that the heifers did not have the same skills to find similar microclimates outside the forest as the cows. Further research on this topic has to be done in order to learn more about the relations between different factors of beef production with free-ranging cattle.

1. INTRODUCTION

In today's agricultural environment it is possible for free-ranging cattle to behave almost as natural as they would in the wild. The cows and heifers are mostly kept in mixed age groups and are usually naturally mated by breeding bulls which temporarily stay with the herd. During winter time the animals are merely fed silage, straw and/or hay and only get mineral supplements but no concentrate. Therefore behavioural studies under these conditions are very important in order to gain knowledge about cattle's natural and normal behaviour in general just as their behaviour in a natural environment uninfluenced by humans.

Adaptation to temperature

One of the most central factors for animals in coping with the environment is temperature. Especially in the winter time the temperature is a very important factor regarding production as well as animal welfare in free-ranging cattle. If the temperature falls below the so called Lower Critical Temperature (LCT) the animals must increase their metabolic heat production by shivering or other thermogenic processes in order to keep up their body temperature (CHRISTOPHERSON 1985). The higher demand for energy may influence production and even result in weight loss (CHRISTOPHERSON 1985). The LCT varies greatly depending on the stage of reproduction (Table 1) but also on physical conditions such as coat length or fat layer which not only differ between species but also between breeds (CHRISTOPHERSON 1985). Investigations of the LCT, however, usually have been determined on single-kept animals in restricted environments such as stalls and climatic chambers (CHRISTOPHERSON 1985). Therefore neither the effects of a group nor of wind, precipitation or radiation have been regarded in the LCT (CHRISTOPHERSON 1985).

Table 1: *Estimations of the LCT for beef cows of 500 kg weight (CHRISTOPHERSON 1985)*

Reproduction stage	LCT in °C
Early pregnancy	-13
Late pregnancy	-26
Lactating	-47

The Effective Environmental Temperature is the temperature the animals experience and is influenced by other factors in the environment (BAKER 2004). For example at a temperature of -20 °C with sunshine but no wind, a cow in early pregnancy might feel comfortable whereas she might already be in cold stress at -2 °C with strong wind and heavy snow-rain on wet ground. The factors that can influence the Effective Environmental Temperature all include heat loss by conduction, radiation and convection (BAKER 2004). Figure 1 illustrates the relations between Effective Temperature, food intake, maintenance energy requirements and energy gain.

Animals have different abilities to adapt to cold stress. Reactions to short, sudden cold are shivering, erection of fur, concentrating the blood circulation into the body, which results in a drop of temperature of skin and extremities, as well as behavioural changes such as crouching, crowding together, seeking shelter or lying down to keep the limbs warm and to loose less energy by reducing surface-volume-ratio (JOHNSSON et al. 2004). For the first two to three weeks, longer lasting cold results in raising the metabolism rate by production of the hormones adrenalin, noradrenalin and thyroxin and some corticosteroids (JOHNSSON et al. 2004). Later on the metabolism rate decreases and other bodily adaptations like thermal-change-systems for extremities, good isolation by fat and thick fur are made (JOHNSSON et al. 2004). Furthermore brown fat or brown adipose tissue (BAT) can play a minor role in withstanding cold in adult animals (JOHNSSON et al. 2004). In juveniles BAT

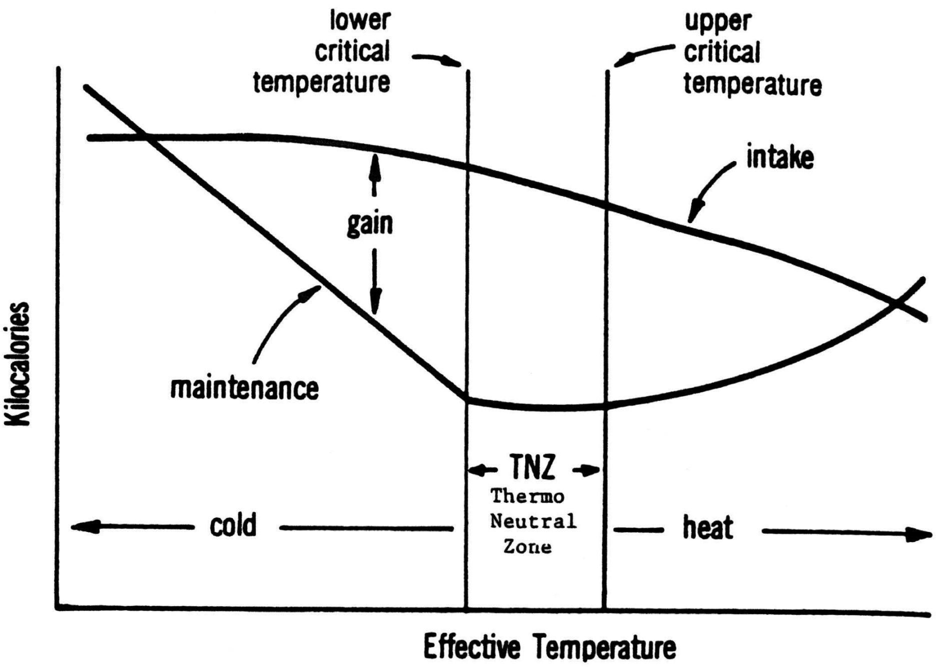

Figure 1: *Influence of the Effective Temperature on food intake, maintenance energy requirements and energy gain (from WAGNER 1988).*

is mainly placed around the neck, the shoulders, along the spinal cord and in the chest (ECKERT et al. 2000). In BAT oxidation reactions happen inside the cells which are rich in enzyme systems of the fat metabolism and therefore it quickly produces a lot of heat (ECKERT et al. 2000). Adult animals have decreased brown fat layers but with repeated exposure to cold it can rise again (JOHNSSON et al. 2004).

Diurnal pattern

Cattle have a very strict diurnal behaviour pattern. A study of the free-ranging Chillingham wild cattle in northern England by HALL (1989) revealed that daylight grazing during winter time took up 75 % of cattle activities. Being crepuscular animals grazing peaks occur around sunrise and sunset whereas there is low activity at midday (HAFEZ & BOUISSOU 1975, FRASER 1983). Therefore grazing in cattle is adjusted to sunlight (HUGHES & REID 1951 in HAFEZ & BOUISSOU 1975) which plays a very important role for the daily routine especially in the northern countries where solar radiation is temporarily very weak and day length differs a lot between summer and winter. Other behaviours are also influenced by the quite stereotyped grazing pattern (HAFEZ & BOUISSOU 1975) so that possibly the time with a low activity level during midday might decrease in length or even disappear on very short winter days.

Light intensity influences cattle behaviour as well. Calves of German Friesian, Simmental and their crossbreeds kept at four different levels of lighting (2, 20, 100 and 130 lux) showed wide differences in varying behaviours (DANNENMANN et. al. 1984/1985). At the lowest level of lighting resting behaviour lasted longest and was most frequent whereas feeding increased with higher light intensity (DANNENMANN et. al. 1984/1985). The duration and frequency of social behaviours increased significantly with higher light intensity and the duration of locomotion, exploration and licking of objects was also significantly higher with increasing light intensity (DANNENMANN et. al. 1984/1985). Generally these calves showed a much higher activity level at the highest light intensity in comparison to the lowest light intensity.

Use of protection

During winter time cattle are affected by low temperature, wind, rain and snow. In a pilot study OLARSBO (2005) found that there were great differences in the use of protection both due to weather but also due to habituation of the animals to use shelters, distance between both food and shelter and water and shelter. Accurate weather measurements, though, could not be made in this MSc report.
Earlier studies showed that cattle seem to prefer certain areas to perform various behaviours. In a student project on beef cattle kept on a ranch in the south of Sweden BENGTSSON et al. (1982) pointed out that these areas all had common characteristics which were an overall view of the area, either flat surrounding with poor forest stand or hilly more dense grown landscape and nearby protection against wind and rain. However, they did not make any specification about what behaviours were performed in these favourite areas. In a study by REDBO (2000) dairy heifers, which had been raised indoors but left outdoors in the summer and the following winter in the area of Uppsala, Sweden, lay down only in shelters during the winter time. They first lay down on the open ground in April (REDBO 2000). By contrast, the beef breeding bulls kept at Dagnäs, 20 km south of Skara in the southwest of Sweden, which stay outdoors all year round, never seem to use their shelter, even if there is heavy rain- or snowfall (Ida Lindström & Tomas Torsein, personal communication). These bulls often lie down such a long time, that when it snows they get "snow blankets" on their backs. Despite that they never seem to use protection they do not show any negative effects on their health because of this behaviour.
BEAVER & OLSON (1997) found that experienced Angus X Hereford cows grazed more frequently in an area protected from weather than inexperienced Angus X Hereford cows. Due to these results WAßMUTH (2003) points out the importance of early adaptation of animals to winter weather and proposes two rules: Heifers should be raised outdoors and cows have to be brought to their winter pasture early enough to be able to adapt to the circumstances. This knowledge indicates that there is a learning process taking place in which cattle learn how to properly protect themselves from weather. Naturally, older cattle which have experienced winter weather many times before are more skilled in protecting themselves than younger, less experienced cattle. However, still very little is known about this just as the preferences of where cattle perform different behaviours and if that is dependent on weather.

2. AIM

The aim of this study was to investigate how beef cattle (*Bos taurus*) behave when kept in a semi-natural environment during winter and how their behaviour is affected by weather, experience and pasture section with the so given protection.

The following questions have been formulated:

1. Do cattle show resting behaviours in all different protection categories of their pasture?
2. Do cattle use different protected sections of their pasture depending on the weather?
3. Do cattle spend different amounts of feeding, ruminating and lying respectively depending on the weather?
4. Do cattle perform social behaviour in equal frequency independent of the weather?
5. Does the distance between cattle differ according to the weather or degree of protection?
6. Do cattle seek better protection from weather with increasing degree of experience?

It was predicted that cattle would not rest in all different protection categories of their pasture and prefer to rest in sections which are well protected from wind and precipitation and at the same time also protected from predators.
They would use different protected sections during different types of weather.
Cattle would feed and ruminate the same amount of recordings independent of weather whereas they would lie more in warm sunny and very cold snowy weather.
Social behaviour would be performed with a higher frequency in warm weather whereas in cold weather the frequency would decrease.
The distance between cattle would be bigger in warm than in cold weather. Cattle would spread out more in the forest than close to it, but not as much as in the open field.
They would seek better protection from cold, windy and snowy weather with increasing degree of experience and react to weather changes faster than less experienced cattle.

3. MATERIAL AND METHODS

3.1. Material

The study was carried out on the farm Trestena (58°19' N, 13°29' E) 15 km south of Skara in the southwest of Sweden (Figure 2) on a pasture of about 12 ha with an elevation of in average 130 m above sea level. The pasture was slightly hilly with one steeper slope with in total approximately 10 m between the lowest and the highest point. About ⅓ of the pasture was covered with coniferous forest and birch forest. Deciduous forest and coniferous forest surrounded the fenced pasture at three sides. The pasture was marked off by a non-tarred road in the south which was lined by coniferous forest and a small open field which again was surrounded by coniferous forest. Since this area had not been used for agriculture for at least eight years, the ground was covered with a thick grass layer partly overgrowing stones and small rocks before the cattle were brought there. One swamp with bushes and low trees was close to the gravel road and the ground in parts of one of the coniferous forests was also quite wet. An aerial line with three electric cables running from west to east parted the forests. A man-made water source was available. For more detailed information see Figure 3.

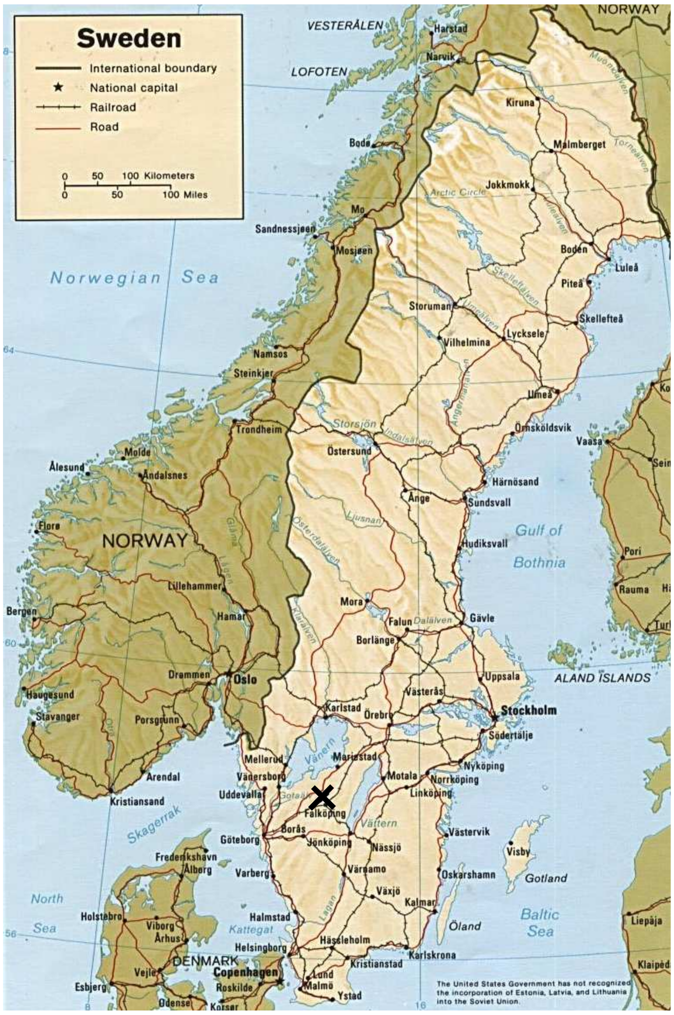

Figure 2: Map of Sweden. X marks the farm Trestena (from www.lib.utexas.edu/maps/europe/sweden.jpg).

In the beginning of the study the herd consisted of 82 cows and heifers of different breeds, most of them crossbreeds of beef breeds. Eleven heifer calves born between February 13th and April 1st 2006 and 14 calves born in July and August 2006 accompanied the herd as well as three breeding bulls. The bulls were brought to the small open field south of the road which marks off the study pasture on December 14th 2006. Two orphan twin calves of dairy breed born in July 2006 were brought to a stable the same day. The older heifer calves were separated from the herd on January 7th 2007 and the younger calves were separated on January 24th. One heifer had to be shot on February 2nd after being badly injured in a storm and due to not being pregnant three animals were slaughtered on February 5th. In January all animals had to be treated against pediculosis (a disease caused by biting lice), but besides that all cattle were healthy throughout the winter.

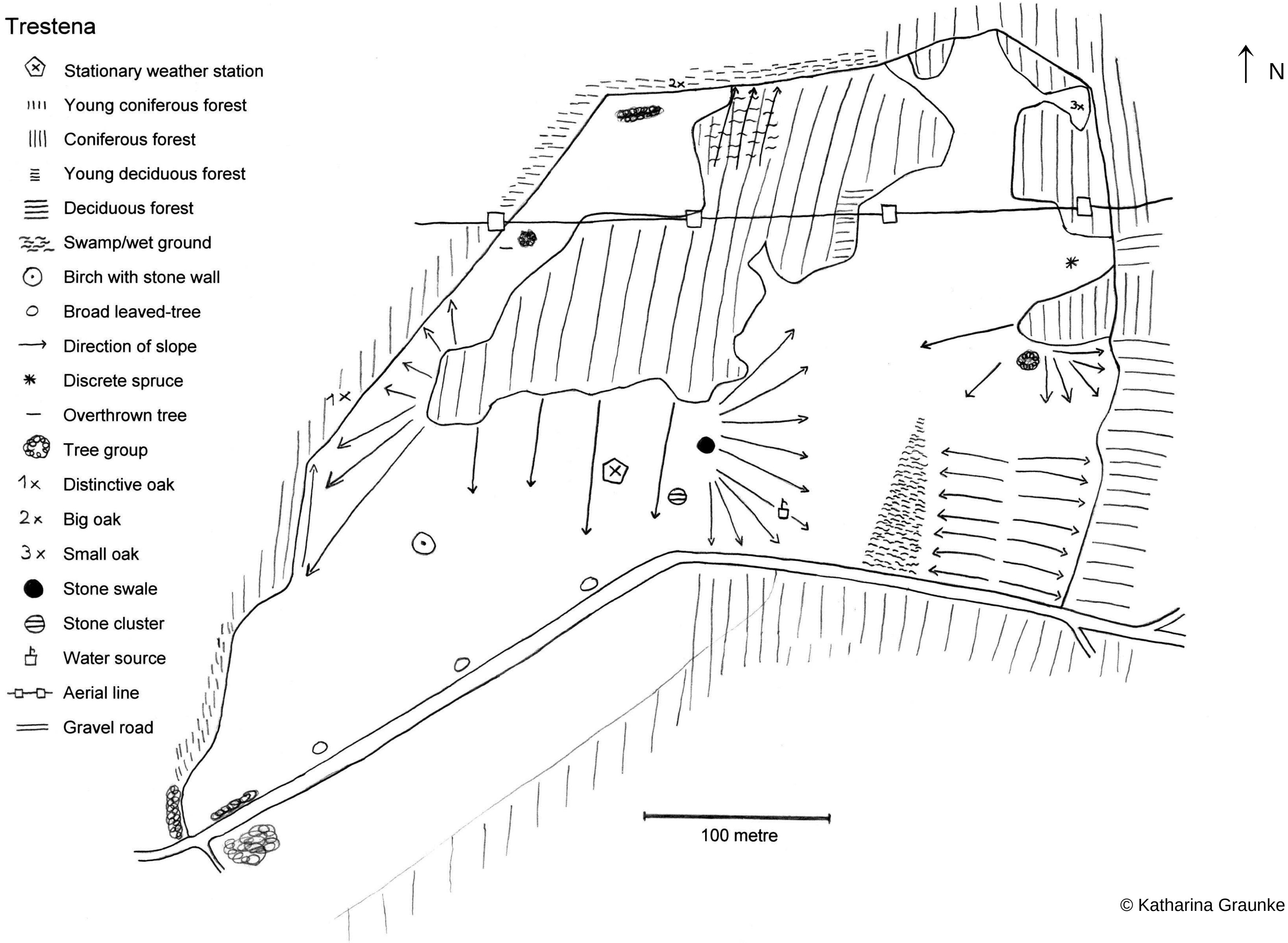

Figure 3: *Map of study field in Trestena.*

All cows and heifers were weighed and checked for body condition three times (December 14th 2006, January 19th 2007 and April 25th 2007). The body condition of the cows and heifers ranged between 1.5 and 5.0 with a mean of 3.7 for all animals and weighings (1.0:= ”severe underconditioning”, 5.0:= “severe overconditioning”; for further information see appendix, p. 61). The weighings and checks for body condition were part of a study carried out by Charlotte Hallén Sandgren from the Swedish Animal Health Service (Svenska Djurhälsovården).
The cattle were fed grass silage with low energy and protein concentration from three feedracks which were moved to different spots to avoid destroying the ground. The feedracks were filled up every second or third day, whenever necessary.

The owners of the cattle had applied for and received permission to keep the cattle outdoors without shelter during winter 2006-2007. According to regulations of the Swedish Animal Welfare Agency cattle must have access to dry, clean and protected areas. Therefore one or two bales of silage were placed on different spots of the pasture with every feeding, though never inside the forest to avoid damaging the dry, clean and protected areas there. If the sheltered areas in the cattle's winter pasture, meaning the coniferous forests, would have become too wet and would not have offered adequate protection anymore, straw beds would have been built up in the forests (Tomas Torsein, personal communication). However, this was not necessary throughout this winter.

3.2. Methods

Since the area was too big and woody no other method for behavioural studies like this was possible than focal sampling. Twenty focal animals were picked according to their age and therefore experience with winter weather and pregnancy and their breed. Ten cows born between 1997 and 2002 and ten heifers born in 2004 were selected randomly. In December six and from January on seven heifers were Black Angus-Charolais-crossbreeds and all other focal animals, both cows and heifers, were of pure Black Angus. Reserve animals were selected with the same criteria as the focal animals. Reserve cows were of Black Angus breed and reserve heifers were Black Angus-Charolais-crossbreeds. All focal and reserve animals were born and raised on two nearby farms and were kept outside all year round for at least several years, but “probably all their life” (Tomas Torsein, personal communication). Thus all of them had experienced at least two winters around Skara and were used to the weather conditions at these latitudes as was the rest of the herd. The focal animals had body conditions between 2.0 and 4.5 with a mean of 4.0 at all three measurements. The focal cows had a slightly higher body condition score (4.2) than the focal heifers (3.9). All animals were supposed to be pregnant. Later it was found that three of the focal heifers were not pregnant. After being badly injured in a storm on January 13th and 14th one of those three non-pregnant Black Angus-heifers had to be replaced with a pregnant Black Angus-Charolais-crossbreed from January on.

Observations were made four hours per day on 15 days per month from December 4th 2006 to March 22nd 2007. Each day there was one period of two hours in the morning and a second period of two hours in the afternoon. Observation times were adjusted to the position of the sun. The data about the position of the sun were taken from www.stjarnhimlen.se for Jönköping which is the town closest to Skara for which data about the position of the sun was available and which suits best to the longitude of Skara. The first and second hour of observation (further on called “observation hour 1” and “observation hour 2”) were supposed to start 15 minutes and 90 minutes respectively after sunrise, the third and fourth hour of observation (further on called “observation hour 3” and “observation hour 4”) started 75 minutes and 150 minutes respectively after the highest position of the sun. Each observation hour lasted for 60 minutes. A time buffer of 15 minutes before and after the exact beginning was allowed in order to be able to find the focal animal. If the focal animal could not be found within these 30 minutes, it was allowed to pick one of the reserve animals (a cow for a cow and a heifer for a heifer) which ever one could find first. See Table 2 for the real starting times of the observation hours.

Table 2: *Mean minutes, standard error of mean, median, minimum and maximum of observation hours 1 and 2 after sunrise and of observation hours 3 and 4 after the highest position of the sun*

Observation hour	**1**	**2**	**3**	**4**
Mean	15.54	79.98	70.28	135.87
Standard error of mean	1.269	1.340	0.873	1.205
Median	14	79	70	134.5
Minimum	-1	63	51	115
Maximum	54	114	94	155

For each week the median of sunrise and highest position of the sun was taken and rounded to the closest number that could be divided by five. The starting times were calculated with these median times. In order to get data under the most random conditions every focal animal was observed three hours per month, each time during a different observation hour, but at most one hour per day. Every month a different observation hour was left out within each individual. At the end of the observation series each focal animal had been observed three times in each observation hour and 12 hours altogether. After five days with observations (further on called “observation days”) every focal animal had been observed one hour. In the mornings always one cow and one heifer was observed and the same was done in the afternoon. The order of this was selected randomly for five successive observation days. For the next five observation days the order was reversed and after that the same cow-heifer-order as during the first five observation days started again (for exact order see appendix, p. 62). However, the focal animal for each hour was picked randomly. Between each observation of the same focal animal were at least two observation days, still there were always at least three days between each observation hour. An example of the exact timetable with dates, observation hours, cattle numbers and starting times is given in the appendix, p. 63.

General behaviour was recorded with instantaneous recording with an interval of four minutes (⇒ 15 intervals / observation hour). Within each interval social behaviours important for this study were recorded continuously. All social behaviours except for “Intermediate pressing” and “Scrabbling” were also recorded if the focal animal received the behaviour. The recorded behaviours are listed in Table 3 and Table 4. Due to recording methods the general behaviours had a possible range from 0-15 times per hour whereas the social behaviours had a minimum of 0 and an undefined maximum per observation hour.

Table 3: *Ethogram of the recorded body positions and general behaviours*

Behaviour group	Behaviour	Definition
Body position		
No further grouping	Standing	Max. 1 leg does not touch ground, no forward movement
	Walking	Max. 3 legs touch ground, forward movement
	Running	Max. 2 legs touch ground, fast forward movement
	Lying	Body touches ground, no weight on legs
General		
Feeding	Eating silage	Picking, chewing or swallowing silage
	Eating vegetation	Picking, chewing or swallowing vegetation
	Drinking	Sucking and swallowing water
Ruminating	Ruminating	Regurgitating or chewing on partly digested food
No activity	No activity	No visible activity
	Only while lying	
	Head up	Head held up, no visible activity
	Head on the ground	Head touches ground, no visible activity
	On the side	Lying lateral, legs more or less stretched out
Exploring	Licking on something	Passing tongue over ground or object
	Sniffing	Sucking in air holding head in the air or close to ground or object
	Looking	Focussing or observing something and following it with eyes and/or head
Grooming	Licking themselves	Passing tongue over own body part
	Scratching on something	Rubbing body on object
	Scratching themselves	Rubbing body with claw
Other	Other	Other behaviour

Table 4: *Ethogram of the recorded social behaviours*

Behaviour group	Behaviour	Definition
Positive	Sniffing on others	Sucking in air holding head very close to other cattle
	Licking others	Passing tongue over body of other cattle
	Touching head with head/muzzle	Touching head of other cattle with own head/muzzle
	Touching other body part with head/muzzle	Touching body part except for head of other cattle with own head/muzzle
Aggressive	Threatening cattle	Showing aggressive dominant behaviour towards other cattle without touching
	Driving off cattle	Trying to make other cattle move by showing aggressive dominant behaviour and moving towards it without touching
	Pushing	Pressing other cattle away often with head
	Butting	Swinging head with force against body of other cattle
	Fighting	Pushing head-to-head trying to overpower each other or to gain access to flanks often with short chase
	Mounting others	Climbing on other cattle from the back with front legs placed around flanks
	Kicking	Kicking with hind leg in direction of other cattle
	Scrabbling	Pawing with front claw on ground so earth is dispersed, often front claw slams in own abdomen producing a dull sound
Other	Intermediate pressing	By pressing own body between two other cattle forcing one or both of them to move
	Leaning with body on other cattle	Putting weight of own body on other cattle
	Scratching on other cattle (rubbing)	Rubbing part of own body on other cattle (mostly rubbing forehead on horn or heel)

The pasture was divided into the four different protection categories “In forest”, “Near protection, wind abandoned side”, “Near protection, wind facing side” and “No protection”. The two “Near protection…”-categories were the areas which were close to everything which could protect the cows and heifers from wind and weather such as tree groups, stone walls, bushes, solitary trees and also the forest. 5-10 m distance to the protecting object was allowed to be still in the “Near protection…”-category depending on size and height of the protection. According to the wind direction these areas were then classified as “wind abandoned side” or “wind facing side” during the observation. See Figure 4 for a map of the study field with available protection.

Other animals in a two-cow-lengths-ambit (ca. 5 m) around the focal animal’s head were counted to estimate the distance between the cows. The estimation was as follows: “The more individuals in the two-cow-lengths-ambit the closer they are to each other.” No difference was made between cow, heifer, bull or calf, only if the own calf was within this ambit it was noted additionally even though it was also counted together with the other individuals.

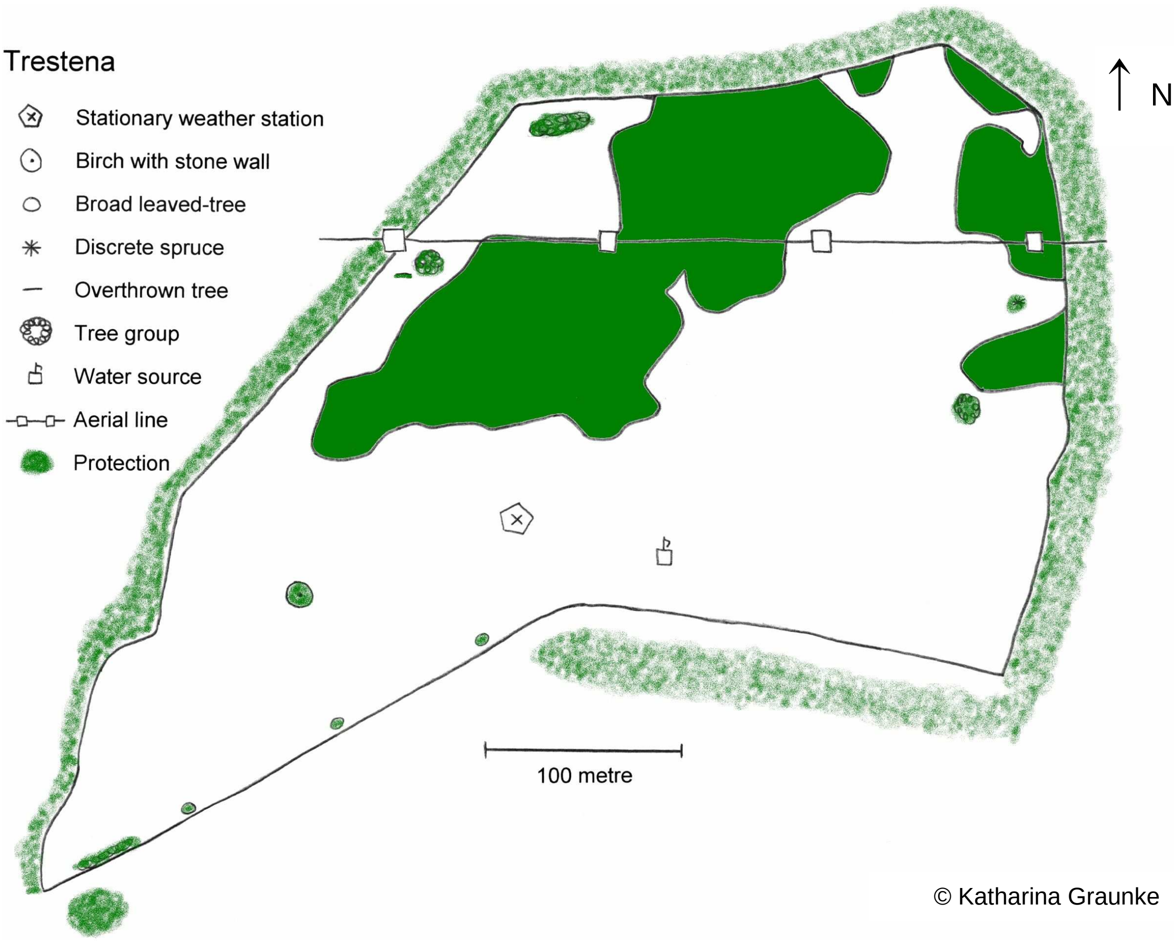

Figure 4: *Map of study field in Trestena which shows the protection available for the animals. The permanent green marks the forest the animals could go into.*

Temperature, wind speed, relative humidity and solar radiation were measured with a portable weather station (Lutron, LM-8000) about 1.1 m above the ground (approximate height of the head of the focal animals) within the surrounding of the focal animal every four minutes and any kind of precipitation was written down per interval. A stationary weather station (Vaisala, WXT 510) was put up at one spot of the pasture where there was no protection from weather e.g. by forest (Figure 4). This station additionally measured precipitation. All measures of the stationary weather station were means per hour and from February 19th 2007 on means per 15 minutes respectively[1]. The measures from the stationary weather station were synchronized to the real time of the recordings of behaviour and weather with the portable weather station so that each interval got allocated recordings of the stationary weather station from the corresponding hour and 15 minutes respectively. For the statistical analyses the weather data, except for relative humidity, was combined to a single measure called Wind Chill Temperature (WCT) given in °C for each weather station. The following equation developed from Environment Canada's Wind Chill Program (2003) and modified by TUCKER et al. (2007) was used:

[1] Because of apprehension of lacking memory capacity the measures were first saved as means per hour. Later this was found baseless and the means were saved per 15 minutes.

$$W = 13.12 + 0.6215 \times T_{air} - 13.17 \times V^{0.16} + 0.3965 \times T_{air} \times V^{0.16}$$

W: = wind chill index based on °C
T_{air}: = air temperature in °C
V: = wind speed in km/h

If the wind speed was 0.2 m/sec or below, this equation would add some units to the temperature and hence in this case the original temperature was used. According to Environment Canada's Wind Chill Program bright sunshine might reduce the effect of wind chill by 6-10 units. The observer noted that a bright cloudless winter day in Trestena's latitude never had a light intensity below 20 000 lux and a sunny day with some clouds never had a light intensity below 15 000 lux. Light intensity of the stationary weather station was measured in kW/m² which is not convertible into lux. Thus values in lux taken from the portable weather station in the surrounding of the stationary weather station were compared with measures from the stationary weather station in kW/m² taken at the same time. 15 000 lux correspond roughly with 0.1 kW/m² and 20 000 lux with 0.2 kW/m². Therefore sunlight was included as follows: If light intensity was above 15 000 lux (portable weather station) and 0.1 kW/m² (stationary weather station) respectively 6 units were added to W and if light intensity was above 20 000 lux (portable weather station) and 0.2 kW/m² (stationary weather station) respectively 10 units were added. The result was called the Wind Chill Temperature, given in °C.

3.2.1. Statistics

For statistical analyses all measures were combined per observation hour although in different ways. From temperature, wind speed and Wind Chill Temperature a mean per hour was calculated as well as for the number of animals in the ambit of the focal animal.
Relative humidity was very different between the two weather stations even when test measurements of the two stations were made right next to each other. Probably the relative humidity measurements of the portable weather station were very much influenced by wind speed since sudden drops of the humidity were noted a couple of times when the wind speed increased. Thus, relative humidity was not included in statistics.
The protection categories had codes which became higher the less protection the category offered (1:= "In forest", 2:= "Near protection, wind abandoned side", 3:= "Near protection, wind facing side", 4:= "No protection"). The median from the noted protection categories per interval was determined for each observation hour.
The investigated behaviours lying, feeding, ruminating and social behaviours were counted per hour. Due to the summary of the social behaviours to frequencies per hour, the whole observation hour had to be treated as missing if the focal animal was out of sight of the observer during some time in one interval, since this interval was then treated as missing. For the percentage of recordings of body positions, general and social behaviours every single recording of every focal animal and every hour was used so that n = 21 and all 3600 intervals except for the missing data went into calculations.
Since after rain, snow or hail the ground stays wet or covered with snow or hail for some time and since that might influence the animals' behaviour the whole hour was declared as with precipitation, even if it was only during one interval. The stationary weather station could not measure snow properly. Hence, if precipitation was noted by the observer but not from the stationary weather station the noted precipitation was adopted into the precipitation measurements of the stationary weather station.

Statistical analyses were done with SPSS 13.0 (SPSS Inc., USA) and R version 2.5.1 (The R Foundation for Statistical Computing). The collected data, except for the weather data, showed no normal distribution as it is usual for behavioural data and which played a role in choosing the statistical tests and models. For the different questions hypotheses were formulated and different tests and models were used as appropriate.
To evaluate differences of quantitative data of two or more related variables the Friedman two-way analysis of variance by ranks and the Wilcoxon signed ranks test were conducted (question 1). With the Sign test measured data from two related samples was tested for differences (Wind Chill Temperature, temperature and wind speed of portable and stationary weather station, question 2).
To estimate the influence of different factors on the response variables Generalized Linear Mixed Models were used which enable to regard time-dependent intra-individual correlations of the particular units of observation (= each observed cow and heifer). For count data a Poisson-regression model-link was used (questions 3 to 5) and logistic regression model-link functions for multinomial data (question 2). To answer question 6 both models were computed.
According to the longitudinal character of the data an autoregressive correlation process with order one (AR-1) was used as correlation structure in fitting generalized linear mixed regression models. The shapes of the Poisson- and logit link-functions (binary logistic regression) are shown below:

Poisson regression: $$\text{count} = \exp(\beta_0 + \beta_1 X_1 + \ldots + \beta_p X_p)$$

Logistic regression: $$P(Y_i = 1 | X_i = x_i) = \frac{\exp(\beta_0 + \beta_1 X_1 + \ldots + \beta_p X_p)}{1 + \exp(\beta_0 + \beta_1 X_1 + \ldots + \beta_p X_p)}$$

In the Poisson model the response was a count variable and $\beta_1,\ldots,\beta_p$ were the estimates of the log-linear effects of the different factors $X_1,\ldots,X_p$ on the response. Tested factors were Wind Chill Temperature and wind speed of portable and stationary weather station, precipitation, age group, month, observation day and observation hour depending on the question. Y_i was the binary aim variable which indicated the presence of an observable event in comparison to a reference category. In the multinomial context considering the four possible response categories three logistic models with “No protection” as reference category were computed: “In forest” vs. “No protection”, “Near protection, wind abandoned side” vs. “No protection” and “Near protection, wind facing side” vs. “No protection”.
The results are presented as “factor” per unit or category. Factor “1.00” would mean that there is no effect on the response by the appropriate variable. A factor smaller than 1.00 means that the response becomes smaller by the factor per unit or category, a factor bigger than 1.00 makes the response bigger by the factor per unit or category.
To describe the influence of variables on different behaviours or other variables graphs were made as follows: The estimated number of a variable or of a behaviour (y-axis) was calculated with the belonging factor so that the median or mean number of recordings of this variable was reached at the mean value of the variable on the x-axis. The axes cover the range of minimum and maximum of the belonging variables.

3.2.2. Hypotheses

The following questions were asked and the hypotheses tested:

1. Do cattle show resting behaviours in all different protection categories of their pasture?

   H_0:= "Cattle show resting behaviours in equal shares in all different protection categories of their pasture and do not show a preference for well protected sections."

   H_1:= "Cattle prefer to rest in well protected categories of their pasture."

   The shares of resting behaviours per focal animal in each of the four different protection categories regarding the total amount of recordings in the different categories were compared with each other as well as the total amount of the resting behaviours in the categories. First resting was defined as lying (= "lying"), then the focal animals was resting when it was lying, ruminating or showing no activity (= "resting"). Since the two "Near protection…"-categories were relatively small in comparison with "In forest" and "No protection" those two most extreme categories were then tested against each other. N = 19, because the shot heifer and her replacement heifer were taken out of the statistics since they both were not observed over the whole period while the others were.

2. Do cattle use different protected sections of their pasture depending on the weather?

   H_0:= "The use of different protected pasture sections is independent of the weather."

   H_1:= "The use of different protected pasture sections is dependent on the weather."

   Model "In forest" vs. "No protection": n = 189
   Model "Near protection, wind abandoned side" vs. "No protection": n = 168
   Model "Near protection, wind facing side" vs. "No protection": n = 171

   The WCT and precipitation of the stationary weather station were used for the analysis since this would have been the assumed worst weather possible for the focal animal.

3. Do cattle spend different amounts of feeding, ruminating and lying respectively depending on the weather?

   H_0:= "Cattle spend equal amounts of feeding, ruminating and lying respectively independent of the weather."

   H_1:= "The amounts of feeding, ruminating and lying behaviour respectively differ according to the weather."

   Since the WCT of the portable weather station was the real temperature for the focal animals and since the animals react to what they experience this WCT was used. For ruminating and lying precipitation noted by the observer was used in the models. Feeding could only be performed unprotected and therefore the precipitation measurements of the stationary weather station were used which was working only from observation day 9 and which once had a battery break down. Therefore n = 205 for feeding and n = 238 for lying and ruminating.

4. Do cattle perform social behaviour in equal frequency independent of the weather?

   H_0:= "Cattle perform social behaviour in equal frequency independent of the weather."

   H_1:= "The frequency in which cattle perform social behaviour is dependent on the weather."

   The Wind Chill Temperature of the portable weather station and the precipitation noted by the observer were used for analysis because this was the experienced situation for the cows and heifers (n = 230).

5. Does the distance between cattle differ according to the weather or the degree of protection?

   H_{01}:= "The distance between cattle is independent of the weather."

   H_{11}:= "The distance between cattle is dependent on the weather."

   H_{02}:= "The distance between cattle is independent of the degree of protection (feedracks excluded)."

   H_{12}:= "The distance between cattle is dependent of the degree of protection (feedracks excluded)."

   To test the influence of the degree of protection the measurements when the focal animals were eating silage were excluded as this could only be performed unprotected. During two hours the focal animal was only eating silage so for that reason n = 236 whereas n = 238 while testing the influence of the weather (WCT). In cold weather the cows and heifers could have chosen to crowd closer together even while feeding and therefore eating silage was not excluded for this analysis. Furthermore the WCT of the portable weather station and the observer-noted precipitation were used.

6. Do cattle seek better protection from weather with increasing degree of experience?

   H_0:= "Cattle seek equivalent protection from weather independent of their degree of experience."

   H_1:= "Cattle seek better protection from weather with increasing degree of experience."

   The influence of the age (possible age categories were cow and heifer) on different variables was tested together with the different models used to answer the other questions. As a result the number of n differs between 168 and 238.

4. RESULTS

4.1. Body positions and behaviours in general

The focal animals were standing for more than ¾ of the observations (Figure 5). They were lying more in the two morning hours than in the two afternoon hours whereas walking did not seem to be influenced by day time (Figure 5). Running was only recorded a few times in the animals (Figure 5).

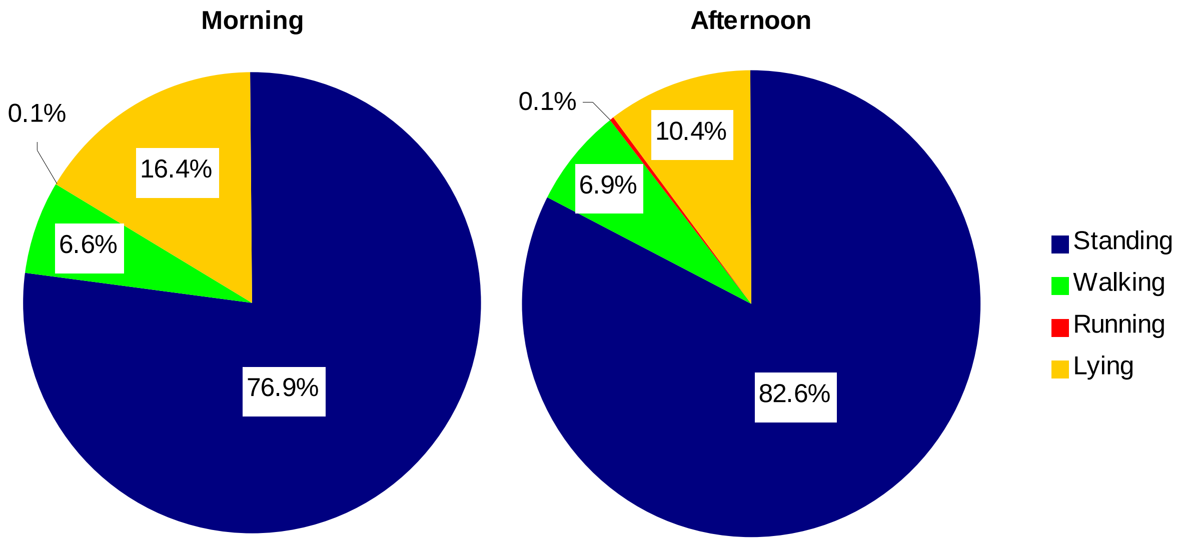

Figure 5: *Percentage of recordings of different body positions performed by beef cows and heifers in the morning and afternoon from December to March (n = 21).*

The biggest difference in behaviour between morning and afternoon was during the coldest month February with a mean temperature of -3.2 °C and a mean WCT of -7.4 °C. The cattle were then lying almost ⅓ of the recordings in the morning whereas they were only lying 3.6 % in the afternoon (Figure 6). They also walked more than twice as much during the afternoons compared to the mornings in February (Figure 6).

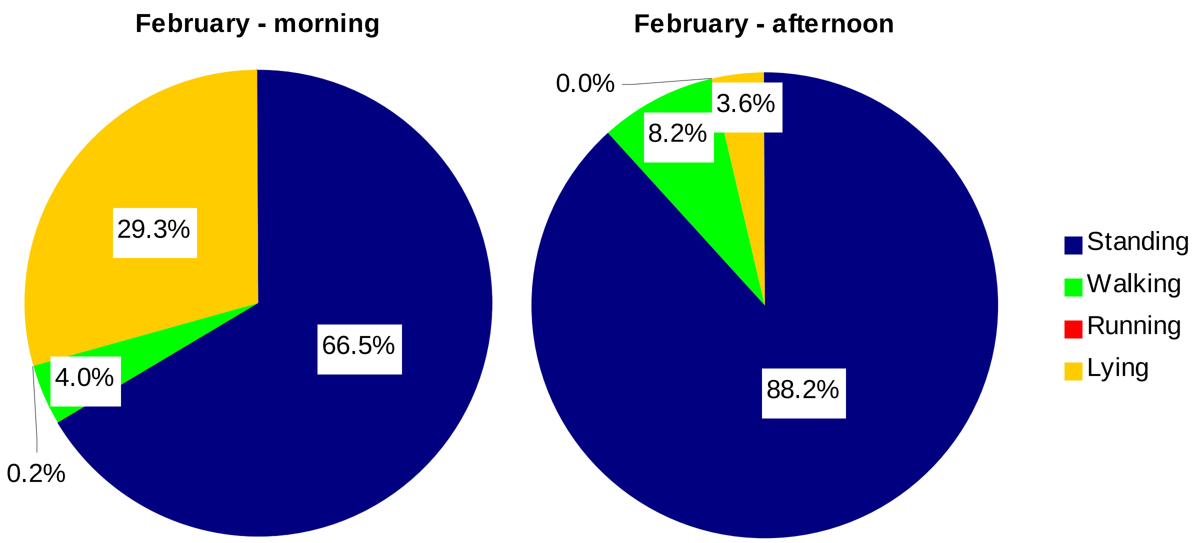

Figure 6: *Percentage of recordings of different body positions performed by beef cows and heifers in the morning and afternoon during February (n = 20).*

Over the whole observation period the biggest difference in general behaviours between morning and afternoon was feeding which was 13.7 percentage points lower in the morning than in the afternoon (Figure 7). The percentage of recordings of ruminating, no activity and exploring were between 4.0 and 6.0 percentage points lower in the afternoon than in the mornings (Figure 7). Only the behaviour groups grooming and other had about the same percentages in the mornings and in the afternoons (Figure 7).

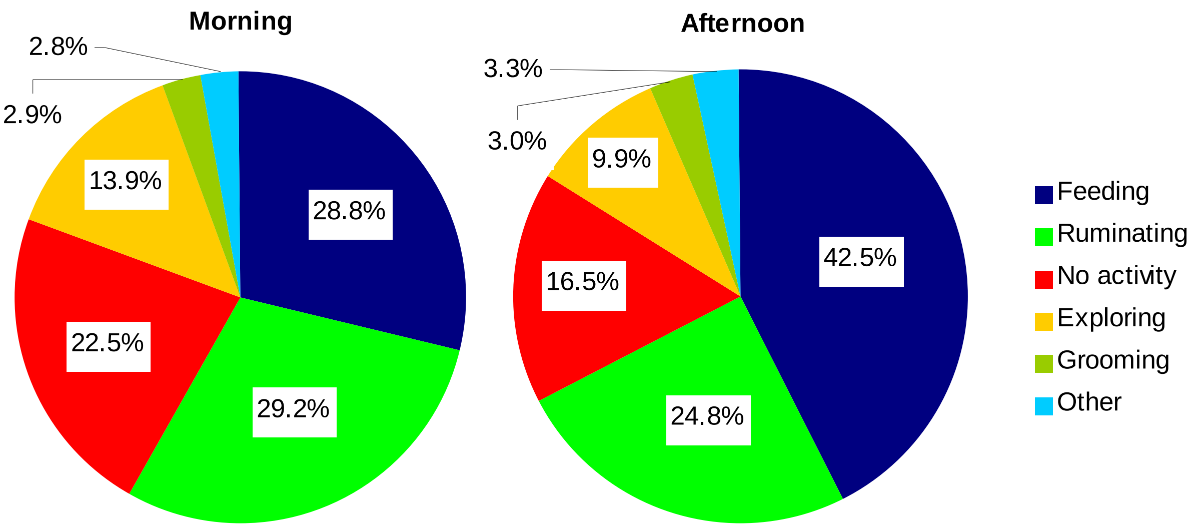

Figure 7: *Percentage of recordings of different behaviours performed by beef cows and heifers in the morning and afternoon from December to March (n = 21).*

About ¾ of all social behaviours were of aggressive nature and not even 20 % had a positive intention (Figure 8). Other social behaviours which could not be grouped into being either positive or aggressive were shown in 6.2 % of the recordings (Figure 8). 51.1 % of all social behaviours took place while feeding and 86.6 % of those behaviours were of aggressive nature. The percentage of aggressive behaviour while not feeding was considerable less (64.7 %) whereas the percentage of positive behaviour made up almost ⅓ while not feeding (6.8 % while feeding).
The cows showed and received less social behaviours than the heifers (Table 5). Only the aggressive behaviours “Threatening cattle” and “Driving off cattle” were performed much more often by cows than by heifers (Table 5). Most common aggressive behaviour both while feeding and not feeding was “Pushing” with almost ⅓ of the recordings of aggressive behaviours followed by “Driving off” (28.3 %). With 48.6 % of the positive behaviours “Sniffing on others” was by far most common, followed by “Licking others” (20.6 %) (Table 5).

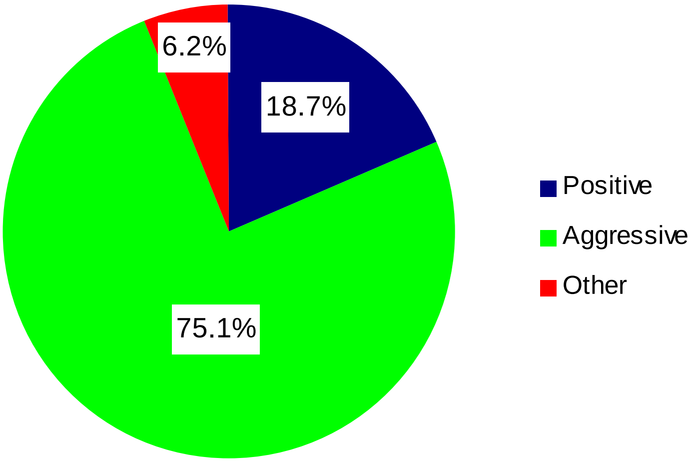

Figure 8: *Percentage of recordings of social behaviours divided into positive, aggressive and other from December to March (n = 21).*

Table 5: *Frequency of social behaviours shown for cows and heifers each performed and received*

Behaviour group	**Social behaviour**	**Cow**		**Heifer**		**Total**
		Performed	**Received**	**Performed**	**Received**	
Positive	Sniffing on others	62	48	111	52	273
	Licking others	11	32	39	35	117
	Touching head with head/muzzle	20	14	39	25	98
	Touching other body part with head/muzzle	14	20	23	20	77
Aggressive	Threatening cattle	167	72	141	118	498
	Driving off cattle	209	120	166	152	647
	Pushing	187	127	213	185	712
	Butting	85	47	137	86	355
	Fighting	2	0	26	1	29
	Mounting others	0	0	2	0	2
	Kicking	3	0	2	0	5
	Scrabbling	3	-	13	-	16
Other	Intermediate pressing	58	-	69	-	127
	Leaning with body on other cattle	0	0	1	0	1
	Scratching on other cattle (rubbing)	9	5	10	6	30
	In total	830	485	979	680	2974

4.2. Where did the animals lie and rest?

Lying was significantly different ($p < 0.001$; $n = 19$; Figure 9) in the four different protection categories. The cows and heifers were lying unprotected in more recordings than in the forest (Figure 9), although this difference was not significant ($p = 0.435$; $n = 19$; Figure 9). There were only few recordings of cows lying near protection (Figure 9).

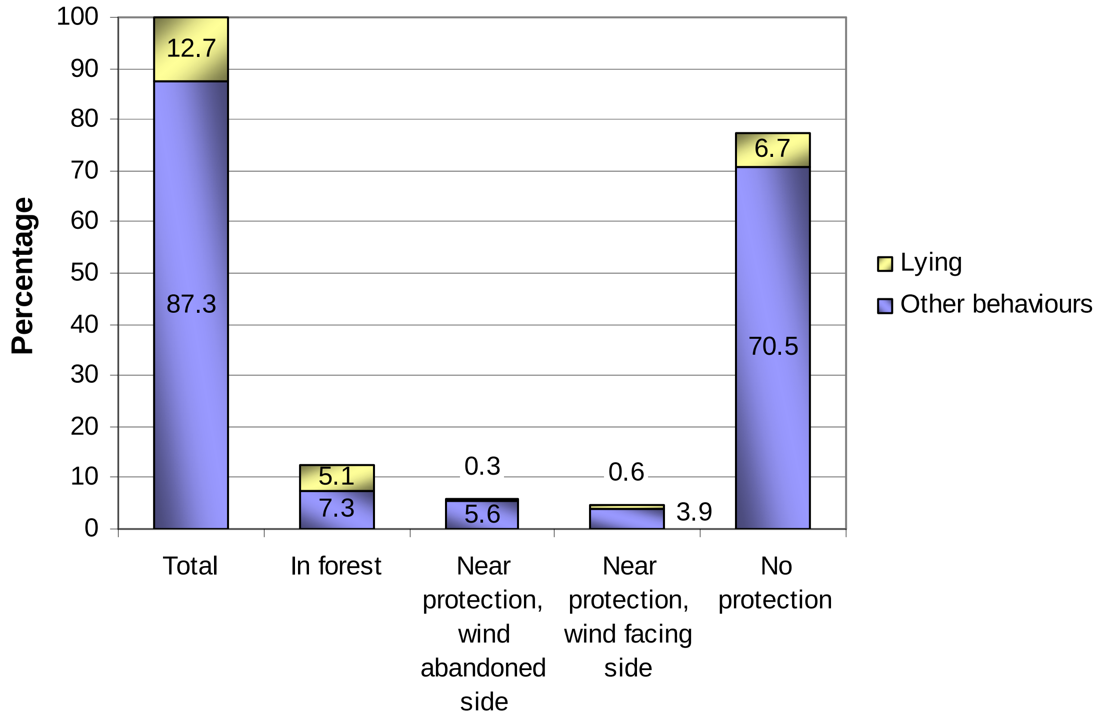

Figure 9: *Percentage of lying in total and in the different protection categories (n = 19).*

However, regarding the proportion of lying in the different protection categories the animals used the four different protection categories significantly different ($p < 0.001$; $n = 19$; Figure 10). If the category ”No protection” was compared with “In forest” the beef cows and heifers preferred to lie in the forest ($p = 0.002$; $n = 19$; Figure 10). Fourteen animals were lying proportionately more in the forest (regarding the total number of recordings in the two categories), four proportionately more unprotected and one cow did not lie at all while being observed.

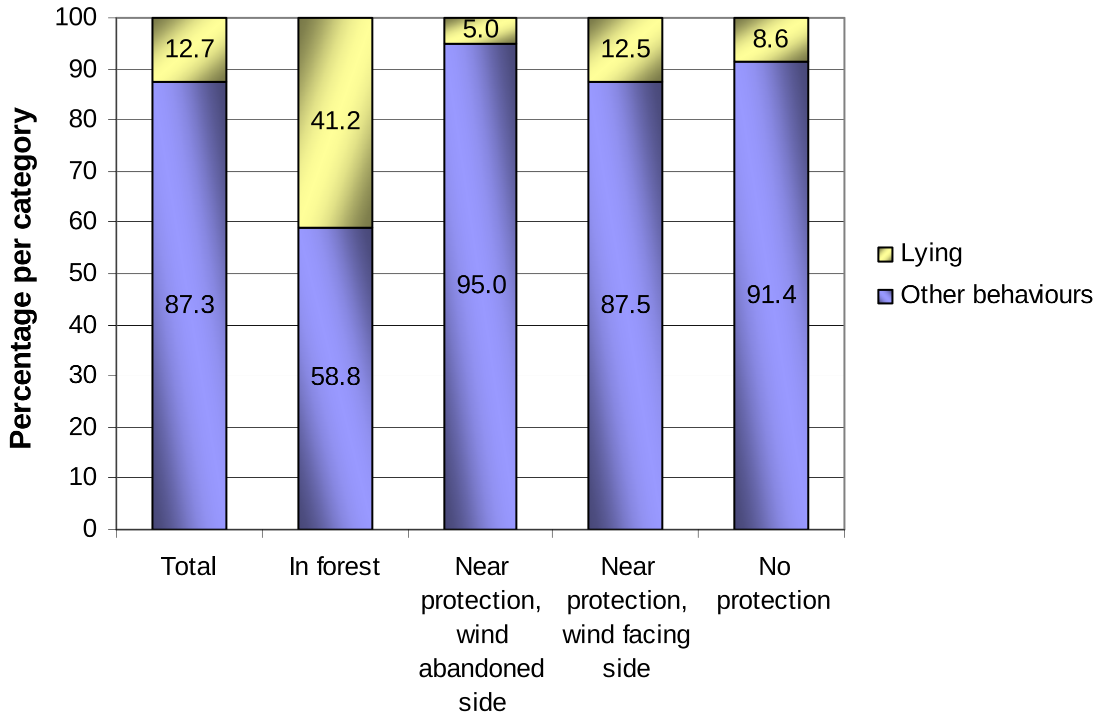

Figure 10: *Percentage of lying in total and per protection category (n = 19).*

The four different protection categories were used for resting significantly different ($p < 0.001$; $n = 19$; Figure 11). The cows and heifers rested unprotected in significantly more recordings than they did in the forest ($p < 0.001$; $n = 19$; Figure 11). In total, 18 animals have been recorded resting more often unprotected and one heifer was recorded the same number resting in forest and without protection.

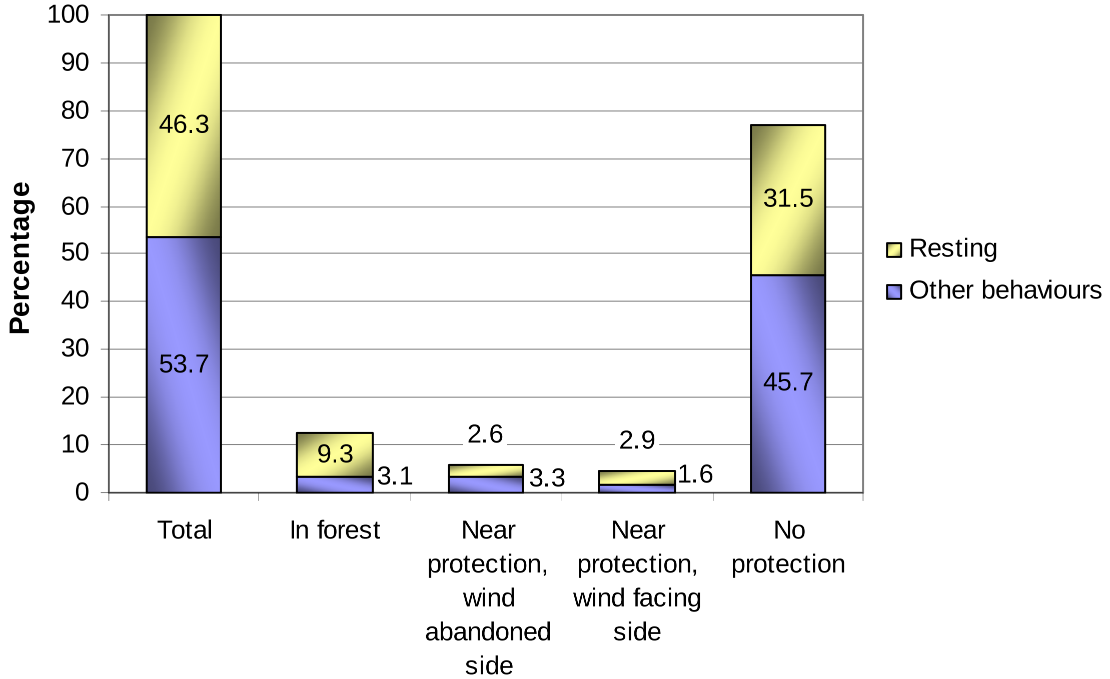

Figure 11: *Percentage of resting in total and in the different protection categories (n = 19).*

When the proportion of recordings in the different protection categories was regarded, the focal animals used the four protection categories for resting (lying, ruminating, showing no activity) significantly different ($p = 0.001$; $n = 19$; Figure 12). They clearly preferred to rest in the forest ($p < 0.001$; $n = 19$) when compared with the category "No protection". 18 of 19 focal animals then rested proportionately more in the forest; only one heifer rested proportionately more unprotected (Figure 12).

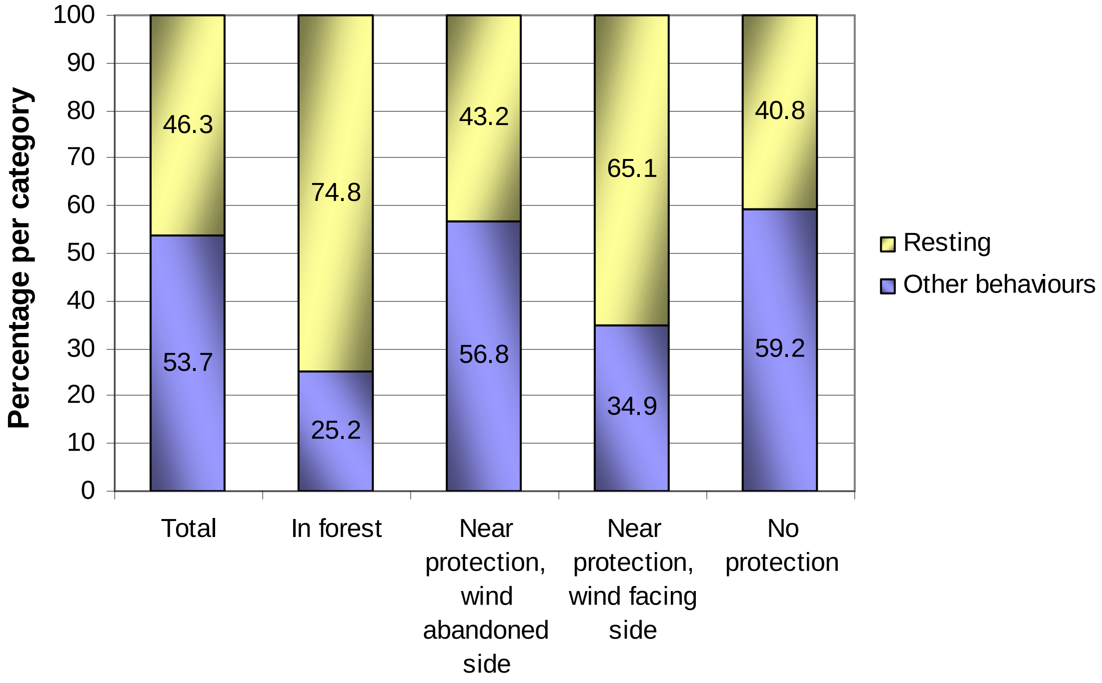

Figure 12: *Percentage of resting in total and per protection category (n = 19).*

4.3. How did the cattle protect themselves?

The use of the four different protection categories depended on precipitation except for the category "Near protection, wind abandoned side" which did not seem to be influenced by precipitation. However, the categories "Near protection, wind abandoned side" and "Near protection, wind facing side" were used quite seldom, thus statistical significances are difficult to prove.

The forest was used with a more than 2.7 bigger probability if there was precipitation ($p = 0.018$; factor: 2.71). The cows and heifers had a tendency to frequent the category "Near protection, wind facing side" more than 3.5 times as often if there was precipitation ($p = 0.060$; factor: 3.52) while the category "Near protection, wind abandoned side" did not seem to be influenced by precipitation. The WCT did not have any significant impact on the use of the protection categories.

Since this was not anticipated the WCT from the portable weather station was tested for differences to the stationary weather station. To exclude possible falsifications by the equation used to calculate the WCT, the temperature and the wind speed alone were also tested. All three test variables were significantly different between the two weather stations ($p < 0.001$) with WCT and temperature at the stationary weather station being lower than in the focal animals' surrounding in 185 and 196 hours respectively and with wind speed at the stationary weather station being higher than in the surrounding of the focal animals in all 206 hours. In 91.7 % of the observation hours the mean WCT was higher in the surrounding of the focal animal than at the stationary weather station. The means of the weather variables of the two weather stations showed a difference of 1.8 °C (temperature), 3.7 °C (WCT) and 1.7 m/sec (= 6.1 km/h; wind speed). See Table 6 for the minimum, maximum, mean and standard error of mean of temperature, wind speed and Wind Chill Temperature of the two weather stations during the observation hours. Figure 13 shows the differences between portable and stationary weather station. In 75.0 % of the observation hours the animals had found microclimates where the WCT was 2 °C or more warmer than at the exposed spot of the stationary weather station regardless of the protection categories. In 2.9 % of the hours the temperature was lower where the focal animal was than where the stationary weather station was but the wind speed was never higher.

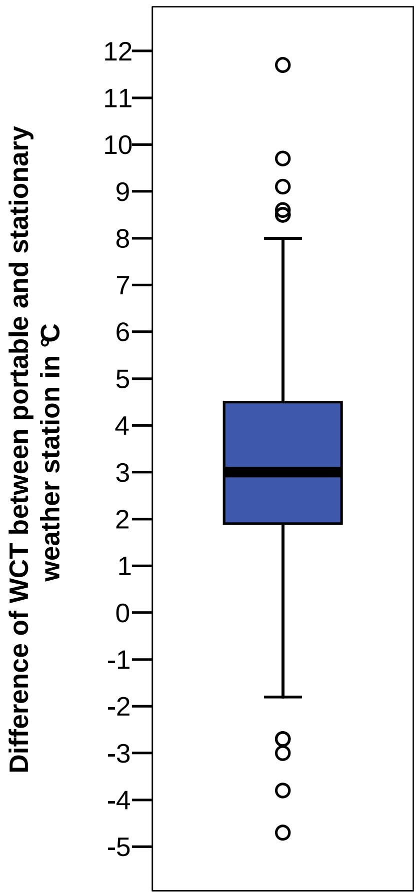

Figure 13: *Differences of WCT of portable and stationary weather stations in °C (n = 205).*

Table 6: *Minimum, maximum, mean and standard (std.) error of mean of temperature (n = 206) and WCT (n = 205) in °C and of wind speed (n = 206) in m/sec for portable weather station (PWS) and stationary weather station (SWS) calculated from the means per observation hour*

	Minimum		Maximum		Mean		Std. error of mean	
	PWS	SWS	PWS	SWS	PWS	SWS	PWS	SWS
Temperature	-11.6	-12.5	13.8	11.3	2.3	0.5	0.32	0.33
WCT	-16.9	-22.7	21.0	16.6	0.4	-3.3	0.38	0.46
Wind speed	0.0	0.4	6.6	9.4	1.2	2.9	0.07	0.12

4.4. Impacts on common behaviour

The common behaviours lying, feeding and ruminating were all influenced by Wind Chill Temperature and precipitation although partially different.

If there was no precipitation, the cows and heifers were lying with almost 20 % higher probability at a higher WCT than a lower WCT ($p < 0.001$; factor: 1.19 / °C; Figure 14, turquoise line). During precipitation the probability for lying was nearly ¼ smaller than without precipitation ($p = 0.012$; factor: 0.76) and the higher the WCT the less probable it was that they were lying during precipitation ($p < 0.001$; factor: 0.90 / °C; Figure 14, brown line). During later observation days the probability for lying was significantly higher ($p = 0.008$; factor 1.02 / observation day).

Feeding was influenced by precipitation and WCT as well. Without precipitation the probability of feeding was smaller if the WCT was higher ($p < 0.001$; factor: 0.92 / °C; Figure 14, blue line) while during precipitation they fed with a significantly higher probability at a higher WCT ($p < 0.001$; factor: 1.05 / °C; Figure 14, red line). Altogether the probability of feeding was 25 % lower if there was precipitation ($p < 0.001$; factor: 0.75)

If the WCT was high the probability for ruminating without precipitation was significantly higher than at low WCT ($p < 0.001$; factor: 1.07 / °C; Figure 14, green line) but during precipitation the probability to ruminate was smaller at higher WCT ($p < 0.001$; factor: 0.96 / °C; Figure 14, yellow line). However, during precipitation the probability for rumination had a tendency to be higher ($p = 0.095$; factor: 1.12).

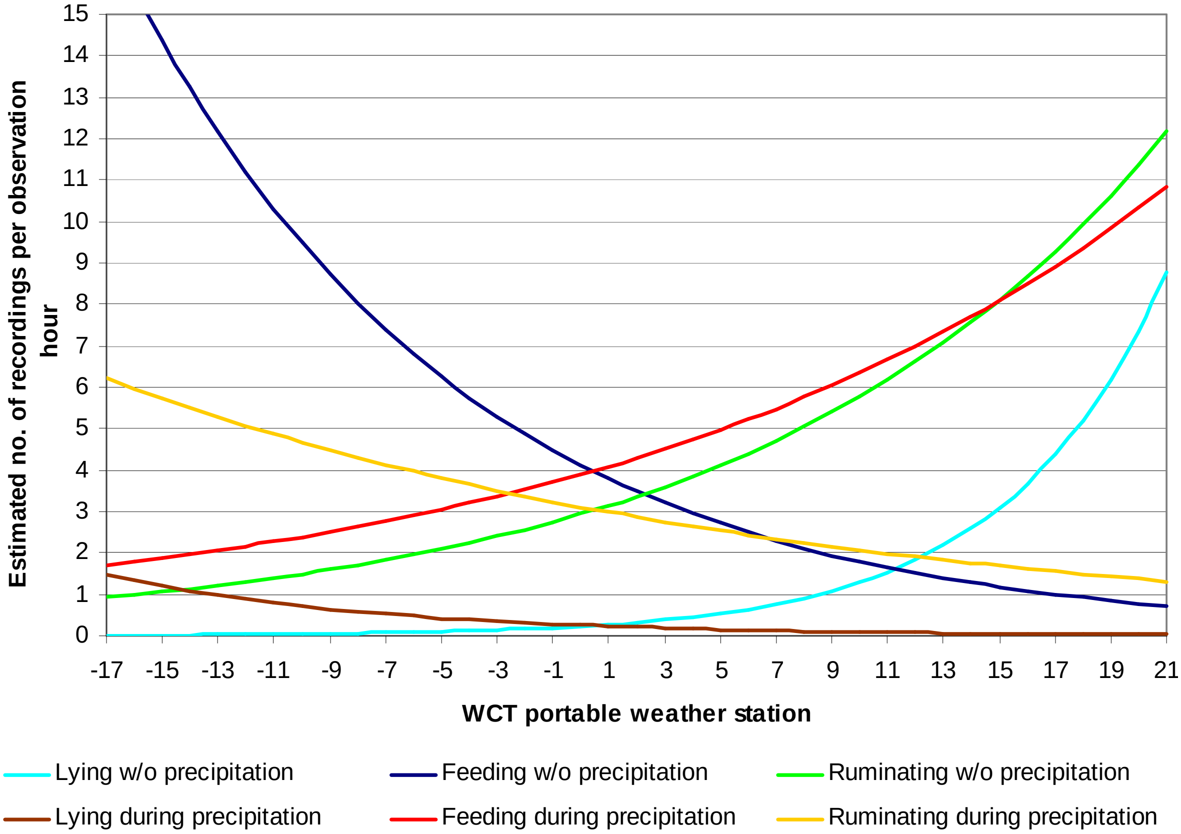

Figure 14: *Estimated number of recordings per observation hour of lying, feeding and ruminating at different WCT of the portable weather station. Median number of recordings per observation hour: lying = 0; ⇒ 0.25 taken as median; feeding = 4; ruminating = 3. Mean of WCT = 0.4 °C. Feeding exceeds the possible maximum number of recordings per observation hour at -15.5 °C (n = 238 for lying and ruminating; n = 205 for feeding).*

4.5. Impacts on social behaviour

The focal animals were more likely to show social activity when the WCT was low ($p < 0.001$; factor: 0.93 / °C; Figure 15, blue line) and over 20 % less likely to perform social behaviours when there was precipitation ($p < 0.001$; factor: 0.77). During precipitation, though, they had a greater probability to show social activity if the WCT was higher ($p < 0.001$; factor: 1.03 / °C; Figure 15, red line).

Aggressive behaviour was influenced by WCT, precipitation, observation day and observation hour. The probability to show aggressive behaviours was significantly higher when the WCT was low ($p < 0.001$; factor: 0.92 / °C; Figure 15, yellow line), when there was no precipitation ($p < 0.001$; factor: 0.80), during earlier observation days ($p < 0.001$; factor: 0.97 / observation day; Figure 16) and in the earlier observation hours ($p = 0.003$; factor: 0.88 / observation hour). On certain days the animals had a slightly greater probability to perform aggressive behaviours in later observation hours ($p < 0.001$; factor: 1.01 / observation hour). During precipitation the probability to show aggressive social behaviours was higher if the WCT was higher ($p < 0.001$; factor: 1.03 / °C; Figure 15, green line).

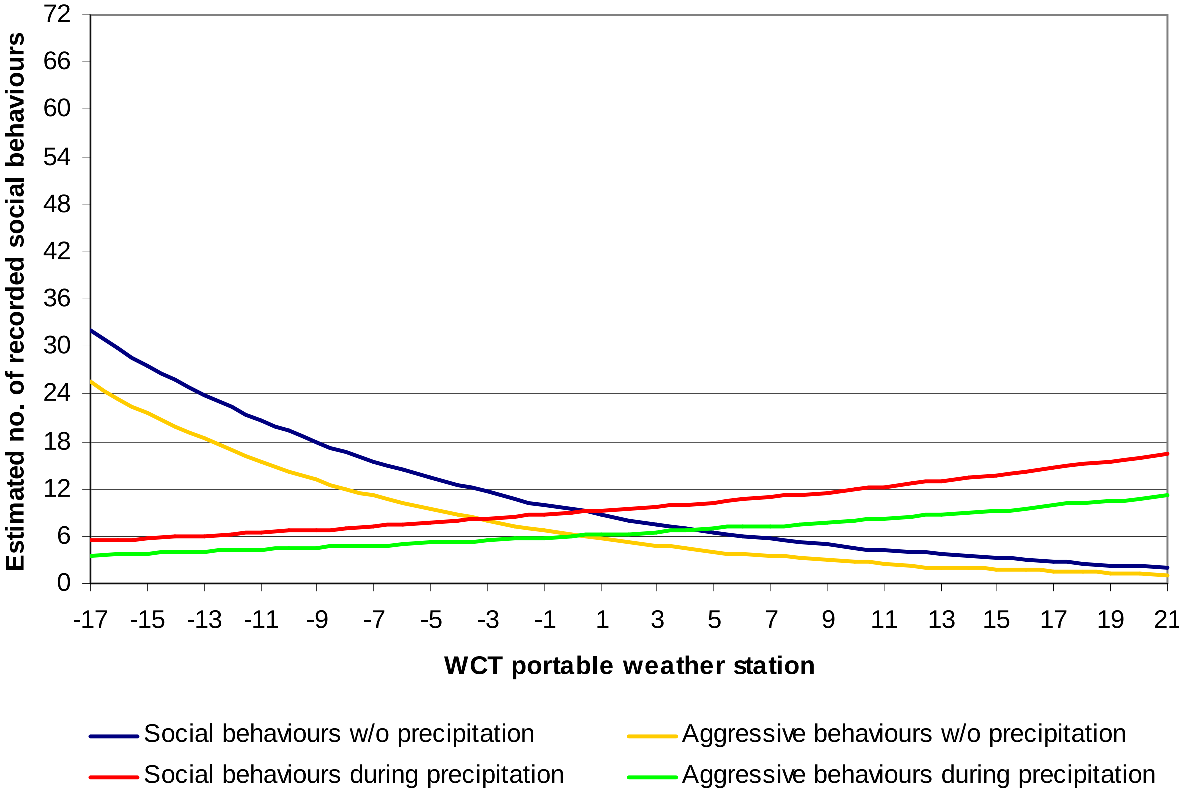

Figure 15: *Estimated number of recorded social behaviours in total and aggressive behaviours at different WCT of the portable weather station. Median number of recordings per observation hour: social behaviour in total = 9; aggressive behaviour = 6; Mean WCT = 0.4 °C (n = 230).*

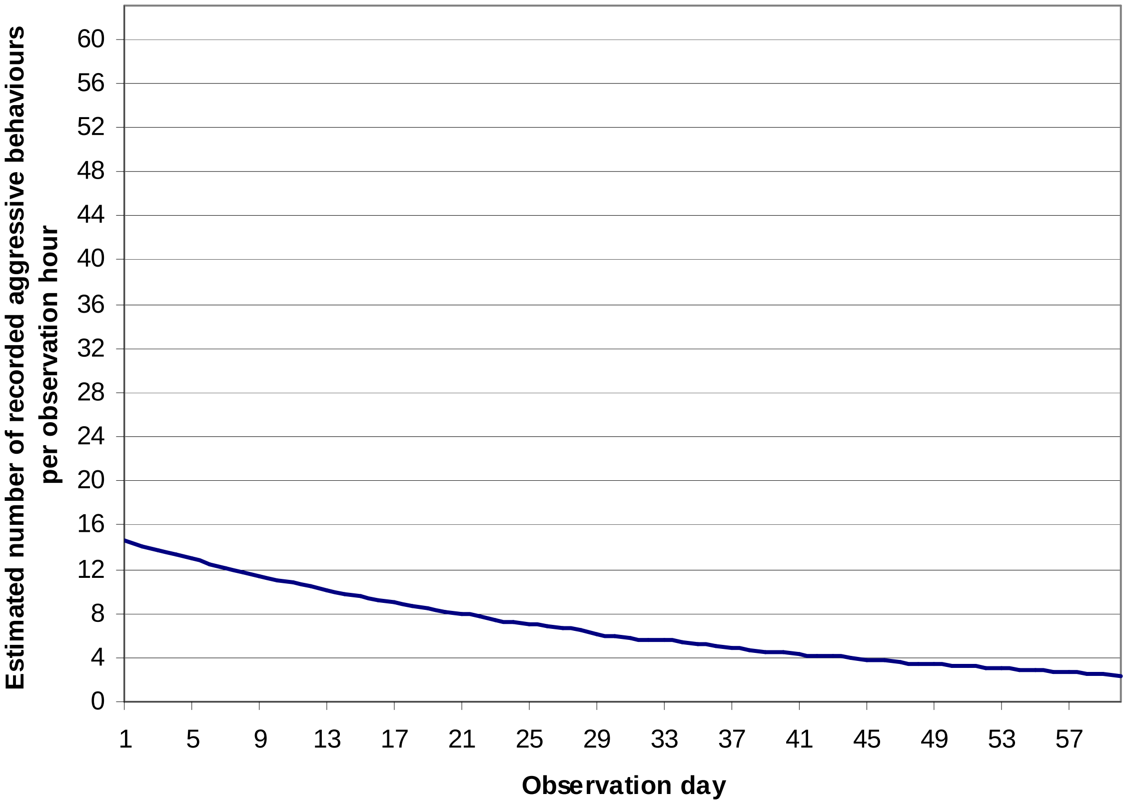

Figure 16: *Estimated number of recordings of aggressive behaviours per observation hour for continuing observation days. Median number of recordings per observation hour: aggressive behaviours = 6, reached between observation day 30 and 31 (n = 230).*

Positive behaviours were not affected by WCT and observation hours but the probability of performing positive behaviours during precipitation tended to be lower (p = 0.055; factor: 0.83).

The other social behaviours which could not be grouped into positive or aggressive were not affected by any variable.

4.6. The distance between cattle

A high number of animals in the ambit of the focal animal was significantly more probable if the WCT was lower ($p < 0.001$; factor: 0.98 / °C; Figure 17) and more than 25 % less likely in successive observation months ($p < 0.001$; factor: 0.73 / month; Figure 18). Increasing wind speed in the animals' surrounding made them more likely to come closer together ($p = 0.002$; factor: 1.08 / m/sec). In the forest the cows and heifers were almost 45 % more likely to be spread out than without protection ($p = 0.002$; factor: 1.13 / protection category). Precipitation did not have any significant impact on the distance between the cattle.

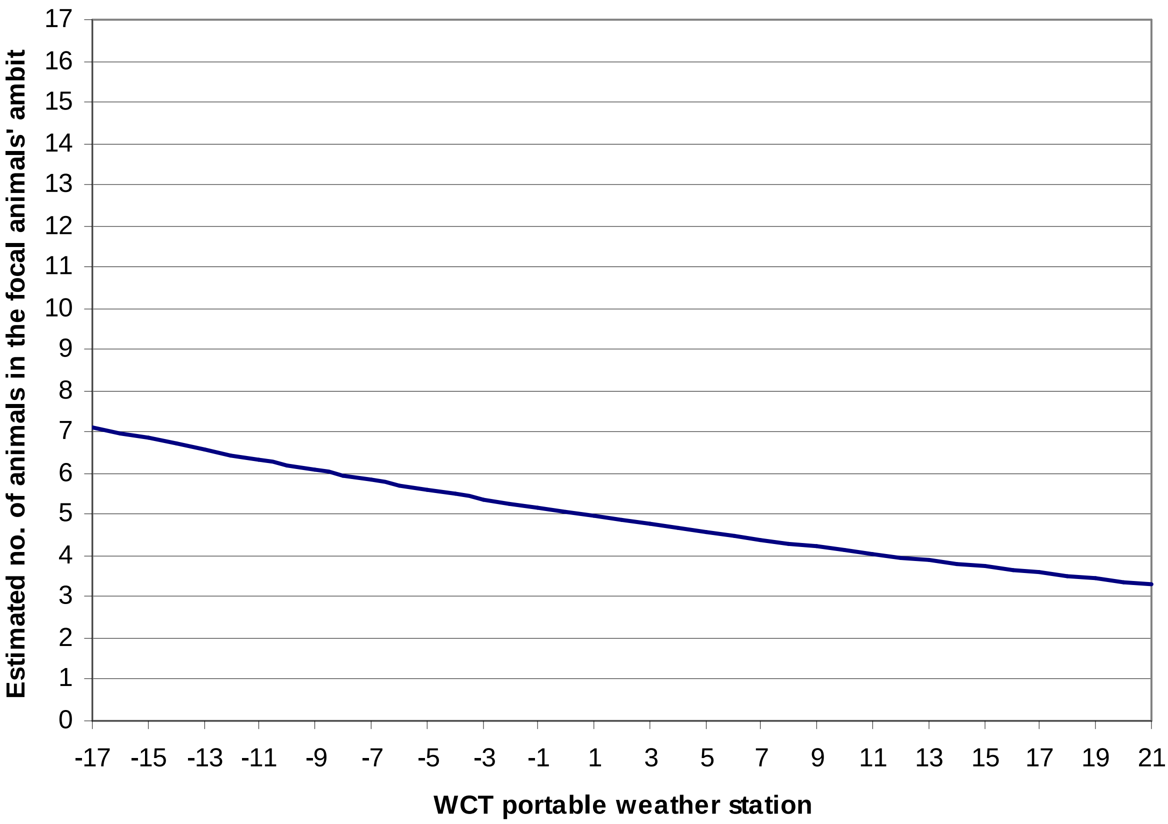

Figure 17: *Estimated number of animals in the focal animals' ambit at different WCT of the portable weather station. Mean number of animals in the two-cow-length-ambit of the focal animal = 5. Mean WCT = 0.4 °C (n = 238).*

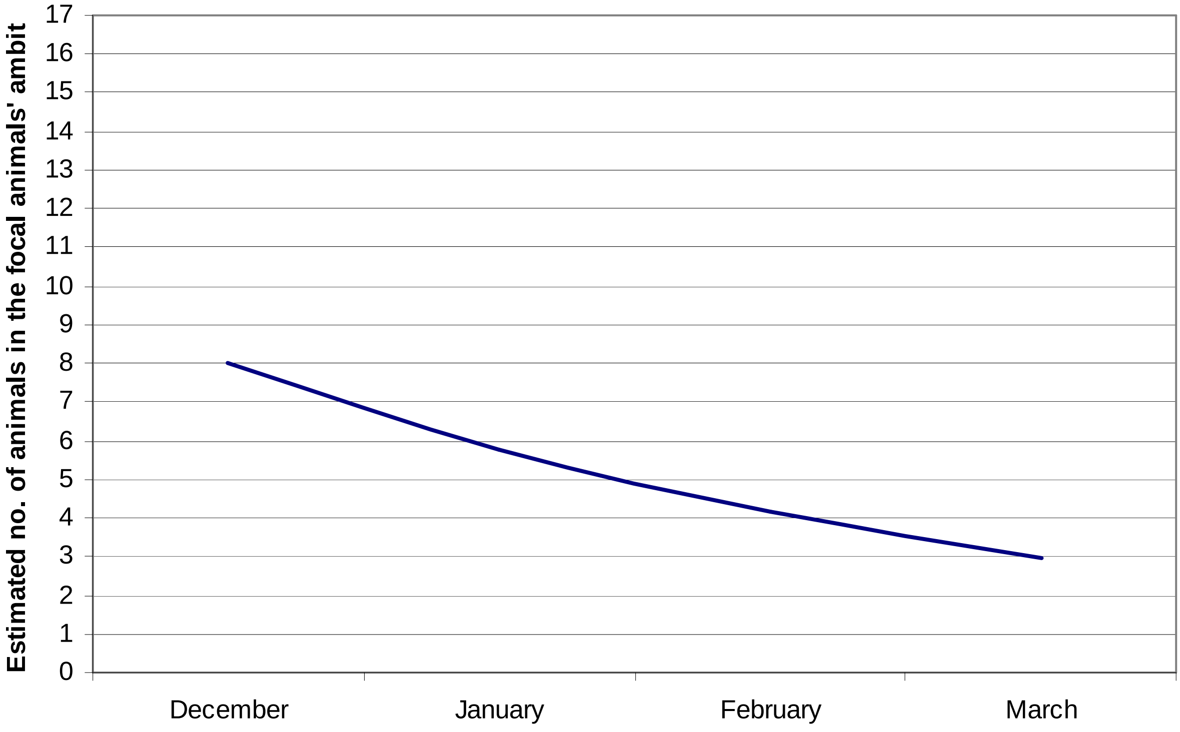

Figure 18: *Estimated number of animals in the focal animals' ambit for the four observation months. Mean number of animals in the focal animals' surrounding per observation hour = 5, reached between January and February (n = 238).*

4.7. The role of experience

Cows had a tendency to frequent the forest with a probability less than half as high as heifers (p = 0.053; factor: 0.43) and to use the category "Near protection, wind abandoned side" with a probability more than ⅔ smaller than heifers (p = 0.085; factor: 0.29). Nevertheless, the differences between the WCT of the portable and the stationary weather station showed no differences between the age groups in median and quartiles (Figure 19), merely the upper whisker and the distribution of the outliers were different. The cows had four lower outliers whereas the heifers had one; on the other hand the heifers had three upper outliers and the cows one which lay within the range of the upper whisker of the heifers.

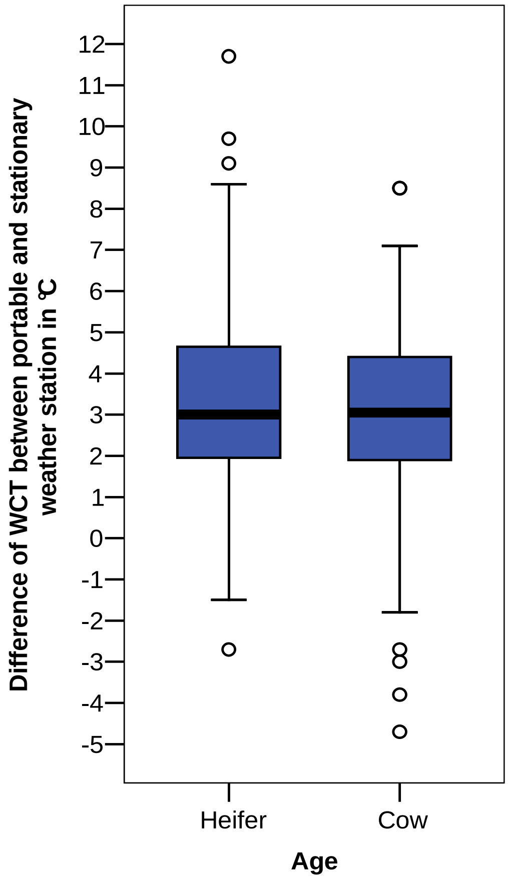

Figure 19: Differences of WCT of the two weather stations in °C shown for the two age groups heifer and cow (n = 205).

The probability for lying was more than two times higher in heifers than in cows (p = 0.037; factor: 0.45), but ruminating and feeding was not influenced by age group.

There was a tendency that cows were less likely to show and receive social behaviours than heifers (p = 0.055; factor: 0.78). The probability of cows to show and receive positive behaviours was over ⅓ smaller than of heifers (p = 0.038; factor: 0.62). However, age group did not affect aggressive and other social behaviours.

The number of animals in the ambit of the focal animals did not differ between the age groups as well.

4.8. Additional observations

Direct and immediate changes in the behaviour as a reaction to weather could be observed only five times. Two times the herd crowded together after a longer period of strong rain with wind speeds up to 9.3 m/sec. Still, not every animal was following the herd, once for example the focal animal was not accompanying the others. Both times the cattle were seeking protection at the same spot in the pasture which was on a field next to a coniferous forest. Two other times the cows and heifers were slowly, one after the other, going into the forest during a snow storm. It took at least 45 minutes until almost all animals had come into the forest. The most direct change in the behaviour was observed on March 18th 2007 in the afternoon. It was a sunny afternoon with some clouds and most cows and heifers were resting in the sun, many lying with closed eyes. Suddenly the oldest cow (10 years old) started to walk towards a coniferous forest and forced every cow and heifer lying in her way to stand up and follow her (no typical behaviour for her) when an extremely dark and thick cloud came. Within 15 minutes the light intensity dropped down from over 22 000 lux to 2 000 lux and most animals had followed the old cow into the forest just before a heavy hail storm began. Again though, not all animals had followed her and four cows and heifers were observed in the open field eating from a feedrack in the middle of the hail storm.

After about 20 observation days it was noticed that the cows and heifers mostly were lying in such a way that the front part of their body was lying somewhat higher than the back part (Figure 20 and Figure 21) even when the surrounding was flat (Figure 21). From then on it was observed that the cows and heifers in fact did always lie in the described way. Only in calves not older than two weeks and once in a heifer it was found that they were lying flat and some calves were even lying head downhill.

During calving from February till April 2007 the owners of the cattle checked the herd twice every night around 2400 h and 0400 h. It was observed that usually every animal was inside the forest and resting there except for some which were feeding outside at the feedracks. Observations (undertaken by Kristina Lindgren, JTI Uppsala) from 0600 h till 2200 h which were made on three days during December and February showed that after 1900 h and before 0600 h (one morning in December) and 0800 h (two mornings in February) respectively almost all animals were in the forest either standing or lying except for some which were feeding from the feedracks in the open area.

Figure 20: *All cows and heifers lie higher with front part of their body than with back part.*

Figure 21: *Even in a flat surrounding this cow chooses a spot where she can lie higher with the front part of the body.*

5. DISCUSSION

5.1. Body positions and behaviours in general

With an average of 79.8 % standing and 13.4 % lying throughout the four observation months December 2006 till March 2007 the cows and heifers showed a quite similar tendency in the apportionment of body positions as the nearly wild living Chillingham cattle in northern England which stood 71.4 % and were lying 14.9 % in summer and winter observations made over two years (HALL 1989). Walking, though, played a much bigger role in the Chillingham cows (13.1 % (HALL 1989) versus 6.8 % in this study), most probably because the study included summer when the cattle were not fed whereas the cows and heifers of this study were constantly fed throughout the observations and therefore in no need of walking longer distances searching for grazing grounds. The winter 2006-2007 was unusually wet in the southwest of Sweden which was also an unnatural situation for the animals. Still, in both studies the female animals were almost lying the same amount of recordings. Obviously, the animals found enough reasonably dry places to lie down and made use of them.
The big difference in the apportionment of body positions between morning and afternoon in February 2007 may result from the cold mornings (mean temperature -4.1 °C and mean WCT -9.8 °C) and could be interpreted as a first adaptation to the cold. The animals were lying almost ⅓ of the recordings in the mornings mostly ruminating or showing no activity and thereby most probably saving energy whereas in the afternoons they were feeding 52.3 % of the recordings, a behaviour that naturally can only be performed standing. With a mean temperature of -2.3 °C and a mean WCT of -5.2 °C the animals ruminated less and were more active in the warmer afternoons. Another aspect is the feeding time which was changed from late afternoon after the observations to noon in-between the two observation periods in the end of January. Therefore the feedracks were empty in the mornings and full in the afternoons at feeding days. Feeding days, though, were only seven of the 15 observation days in February. The more than twice as high percentage points of walking in February afternoon match the high percentage of feeding, since while feeding, the cows and heifers were more likely to move (between the different feedracks and between feedracks and the water source) than while ruminating or showing no activity.

The apportionment of the general behaviours with the differences between morning and afternoon can as well be explained by the cooler mornings with a mean temperature of -0.5 °C and a mean WCT of -5.2 °C (afternoons: mean temperature 1.5 °C, mean WCT -1.3 °C). The cows and heifers were resting over 50 % of the recordings in the mornings but were also showing more explorative behaviour. This can be explained by the feeding time in February and March (around noon) when the animals fed 20.0 and 28.6 percentage points respectively more in the afternoon which means that they had less time to explore. Vice versa in January the focal animals explored and also groomed more in the afternoon while the amount spent feeding was hardly different between the two daytimes. Having had pediculosis in January the animals were in need to find objects on which they could scratch themselves. The cows and heifers were probably not moving very much at night which becalmed the itching so that in the mornings they felt less itching than later in the day and therefore had less intention to explore and groom in the morning.

The evolutionary unnatural situation for cattle to feed close to competitors, many times with physical contact as it happens at feedracks, could be responsible for the higher percentage of aggressive behaviours while feeding than while not feeding. Still, showing ag-

gressive behaviour in almost ⅔ of the recordings while not feeding is quite much. However, REINHARDT et al. (1986) found a similar proportion of social behaviour in semi-wild living Scottish Highland cattle kept all year round on a 5 ha enclosure in the Rhein-Taunus Naturpark, Germany (77.4 % agonistic encounters, 22.6 % non-agonistic interactions). Information about the apportionment of different social behaviours in other studies was very scarce and it was striking that the literature about social behaviour in cattle hardly describes positive social behaviours or female-female interactions in free-ranging cattle as also BOUISSOU et al. (2001) points out. This might be a hint that cows and heifers do not communicate much positively. On the other hand the lack of description may be a result of the very complex and subtle way of communicating which is easily overlooked or possibly too difficult to detect as HALL (1989) points out. Duration of behaviours, though, was not measured in this study. Positive behaviours like licking or sniffing on others may take longer than aggressive behaviours such as pushing or butting. Therefore nothing about the actual time spent with either positive or aggressive behaviours can be said.
Pushing and driving off were behaviours which were mostly performed close to the feedracks in order to gain or keep access to food. Therefore it is coherent that those two behaviours were the most common aggressive behaviours, both while feeding and not feeding. The positive behaviours sniffing and licking are, according to HAFEZ & BOUISSOU (1975), the two most common positive interactions in domestic cattle and were also most common in this study.

5.2. Where did the animals lie and rest?

In 54.8 % of the recorded resting incidents in the forest, the cows and heifers were lying, whereas the percentage of lying when resting unprotected was only 21.3 %. This shows that the cattle did react to protection. They adapted to the circumstances and changed their resting behaviour by standing rather than lying when they were without protection. Although it could have been the other way around: They changed their environment by rather going into the forest if they had the intention to lie down, even though in total they did not lie more often in the forest than unprotected. One reason for rather standing than lying when unprotected is certainly the inability to flee immediately from other cows or danger when lying or to run and scare off predators at once since the process of standing up takes about 7 seconds (GUSTAFSON & LUND-MAGNUSSEN 1995). Without protection the animals are both more easily spotted and reached than in the forest. Furthermore resting includes sleep (only lying) and a half-asleep dozing state (both lying and standing) which cattle often reach while ruminating (PHILLIPS 2002). In these states they certainly perceive their environment subdued and possible danger might not be noticed right away. All the more important it is for cattle to be hidden or to have alert conspecifics, at least while lying. Another aspect is the fact that from inside the forest (surely 10 m and more from the edge) the outside surrounding is quite easily observed, whereas from the outside details in the darker inside of the forest can hardly be seen. This gives animals (lying) inside the forest additional time to react before they themselves are spotted. The resting behaviours rumination and no activity, both including the dozing state, can be performed standing and if doing so there obviously was no great need for the cows and heifers to move farther away from food into the forest. When one just regards resting behaviours while standing 73.8 % of them were performed in an unprotected area and only 12.2 % in the forest. In a study by SENFT et al. (1985) the cattle rested up to ¼ of the daytime within a 100-m radius of the water source during winter. Fence lines and fence corners were also favoured resting sites (SENFT et al. 1985). However, these yearling heifers hardly had shelter, since they lived on short-grass steppe in northeastern Colorado (SENFT et al. 1985).

5.3. How did the cattle protect themselves?

Even though the probability to frequent the forest instead of staying unprotected was more than 2.7 times higher if there was precipitation, the cows and heifers used the forest only during 12.4 % of the recordings. The category "Near protection, wind facing side" was frequented in only 4.5 % of the recordings, though being used with a 3.5 times higher probability during precipitation. In 88 of the 240 observation hours (= 36.7 %) there was at least one interval with precipitation and only in 17.0 % of those hours the focal animal was more than half of the measurements in the forest. In comparison with the hours completely without precipitation the animals were in 9.2 % of those observation hours more than half of the measurements in the forest. However, precipitation was slightly overstated since an hour was classified as with precipitation as soon as there once was precipitation no matter of duration and intensity and still the factor is high. If duration and especially intensity were regarded the results might be different, yet this was not possible in this study. VANDENHEEDE et al. (1995) reported a significant higher occupation rate of a human-built shelter without bedding from 0.4 l/m² rain per hour and from duration of at least 2 h rain. Moreover, they mentioned that rain with lower intensity or shorter duration could also be pleasant for cattle. However, their study was made during the summer months at a mean temperature of 14.1 °C. Shorter rain and rain of lower intensity at lower temperatures especially around 0 °C and a little more may have the same effect on the animals as longer rain and higher intensity at higher temperatures whereas snow might have a quite different influence. Snow is rather dry especially at colder temperatures and the animals might not be as affected as by rain. Furthermore, VANDENHEEDE et al.'s (1995) study did not regard wind speed which also is an important factor in thermal stress particularly in combination with rain.

The differences between the means of temperature of the two weather stations at first do not seem to be very big. Yet, 1.8 °C mean difference in temperature within 320 m (maximum distance between stationary weather station and pasture fence) is quite much and absolutely relevant. The same is true for wind speed and WCT. 6.1 km/h difference on average in wind speed makes a big difference for the animals as well as 3.7 °C mean difference in Wind Chill Temperature.
In 16 of the 17 hours when the Wind Chill Temperature at the stationary weather station was higher than in the focal animals surrounding (portable weather station) the cows and heifers were at spots of the pasture where the solar radiation was lower than at the exposed spot where the stationary weather station was situated. In some cases the focal animals were in the forest where naturally the solar radiation is much lower than outside especially at sunshine. Only in one hour the wind speed in the surrounding of the focal heifer (body condition score 4.0), was partially much higher than where the stationary weather station was placed (but not on average in the whole hour). The focal animal, though, remained in the same area not farther away than 75 m from the stationary weather station. The heifer was eating silage from different feedracks and from a silage bale on the ground throughout the whole hour so obviously in this case feeding was of greater importance than protecting herself from wind. Furthermore, in only two observation hours with a negative difference in WCT it was partly raining very lightly at average temperatures of 5.6 °C and 5.0 °C respectively. The mean temperatures during hours with higher WCT at the stationary

weather station never even came close to the Lower Critical Temperature of a beef cow in early pregnancy (-13 °C). The seven heifers and seven cows which had a lower WCT in their surrounding in one or two observation hours had a mean body condition score at all three weighings of 4.2 and were thereby slightly fatter than the focal animals in total (4.0). Body condition surely plays an important role in the need to find the most comfortable microclimate. TUCKER et al. (2007) found that thinner cows had significantly higher maximum and lower minimum mean body temperatures than high-conditioned cows and that the probability for them was higher to lie with the front legs bent and the hind legs touching the body which is a way to save energy by minimizing surface-volume-ratio. The higher maximum and lower minimum body temperatures (TUCKER et al. 2007) imply that thinner cows are in greater need to find protection in order to be able to keep their body temperature constant.

5.4. Impacts on common behaviour

At higher WCT precipitation is rain or snow rain which means wet, while at lower WCT precipitation is rather dry snow. Obviously, the cows and heifers tried not to lie as much when it was wet. Especially the higher probability to lie at lower WCT while precipitation than at higher WCT shows this. Not regarding WCT the animals showed a similar reaction if only precipitation was considered with an almost 25 % lower probability to lie down during precipitation if compared with no precipitation. The higher probability for lying in later observation days corresponds with the weather. From observation day 21 till 45 (January 18th till February 25th 2007) the temperature was mostly below 0 °C and it rained (not snowed!) only on 3 days. In March (observation day 46 till 60) it usually rained lightly and shortly and the temperature was mainly well above 0 °C (as was the WCT). In general the ground was very dry and dried fast after rain. For all these reasons the animals were lying down more often in later observation days than in the beginning of observations.

Cattle can either feed or ruminate and therefore the probabilities for feeding and ruminating at different WCT with or without precipitation were opposed. At lower temperatures the animals have a greater need for energy and for that reason need to eat more. Feeding was only possible at the feedracks and at one or two separate silage bales on the ground and only as long as food was available. Usually the feedracks were nearly empty a couple of hours before the next feeding took place and the last bites of silage were not easy to reach for the animals. As a result it was more important for the cows and heifers to feed much as long as food was available especially when it was colder. Another explanation for less feeding at higher WCT is day length. Higher WCT occurred mainly during observations in March when the median day length was 11 h 20 min (from December till February the median day length was 7 h 36 min). As cattle mostly feed during day light and twilight they had much more time to feed in March when WCT was quite high. They also had time for a midday rest then, as it has been described by HAFEZ & BOUISSOU (1975) and FRASER (1983), since in the late afternoon, when observation hours had ended, it was still bright. During December and January observations not only began with day break (like in February and March) but in addition ended with dusk and therefore covered most of the day light period except for 90-120 min around noon. During those two months feeding was probably mainly compressed into the short day and longer breaks could not be afforded. An estimated higher number of recordings of feeding was the result and since rumination could take place at any spot of the pasture and at any time it naturally had to be opposed. While precipitation the influence of WCT was exactly vice versa. During precipitation the protection categories “In forest” and “Near protection, wind facing side” were frequented with a higher probability if compared to “No protection”. Food was only provided in the category “No protection”. As a result the animals were more likely to ruminate than to feed during precipitation. Another aspect could be that rumination, as part of digestion, produces heat. I.e. that during cold temperatures with precipitation rumination could be a source for warmth and with its calmer character also save energy. Yet, during precipitation the influence of the Wind Chill Temperature on feeding and ruminating, though converse, was not as strong as without precipitation.

5.5. Impacts on social behaviour

The cows and heifers were more likely to be socially active when it was cold. At colder temperatures the metabolism rate increases in the animals in the first two to three weeks caused by the release of – among others – the (stress) hormones adrenalin and some corticosteroids (JOHNSSON et al. 2004) which also set the body in alert (“fight-or-flight-response”) (WEHNER & GEHRING 1995). Adrenalin and cortisol (a corticosteroid) are related to aggressiveness (BORNETT et al. 2000). The stress level for the cows and heifers increased additionally during colder times, since then they needed more food in order to compensate for the higher energy demand caused by the increasing metabolism rate. The higher requirement of food entails more competition at the feedracks. Furthermore, the colder it became, the greater the need for the cattle was to find and defend the best places to protect themselves from weather. Therefore the animals had both more physical and more social stress during colder temperatures. An increase in social activity is only consequential. This is supported by the fact that only aggressive but not positive social behaviours were influenced by the Wind Chill Temperature.

The lower probability to show aggressive behaviours in the morning corresponds with the higher percentage of lying during the mornings (16.4 % vs. 10.4 % in the afternoons). While lying the animals usually show no other activity except for ruminating, neither social nor general. The increased probability to perform aggressive behaviours in the afternoons when regarding the day can be associated with the feeding which took place every second or third day at noon (from the end of January on) and after which competition for food increased. After the feeding usually all cows and heifers immediately wanted to eat. Each of the three feedracks could serve about 22 animals, depending on animal size. With 85 adult head plus 22 calves aged between 6 and 11 months in the beginning and 78 adult head plus up to 50 calves of at most 6 weeks of age in the end, the space at the feedracks and at the silage bales on the ground was limited and competition high. As the animals got used to the feeding rhythm and as days became longer it was observed that at feeding not all cows and heifers immediately stormed to the food. This was measured by a slightly lower probability to show aggressive behaviours during later observation days.

During precipitation the cows and heifers were less likely to be active which is shown with a 25 % smaller probability to feed and with a tendency to ruminate more. Ruminating can be regarded as rest for the animals. During that time they are not (socially) active. Besides, when they protected themselves from precipitation the focal animals had to go into the forest where they were wider spread which may have reduced any social stress. The forest also made it more difficult to come close to other animals fast since there were many overthrown trees and a lot of fallen off branches. If additionally taking rumination and the cows’ and heifers’ protection behaviour into account it is consequentially that the probabil-

ity to show social activity during precipitation was smaller. During precipitation social activity was more probable when the WCT was higher, which means that the animals were not only more likely to show social behaviours in general but also aggressive behaviours when it was raining rather than when it was snowing. This can be a sign that rain is more stressful and more unpleasant to the animals than snow.
The tendency to show positive social behaviours less often during precipitation fits to the lower probability to show activity in total. In general there was rather little positive behaviour. If even more data was collected the result might be more distinct.

5.6. The distance between cattle

In the forest the cows and heifers could not come close together as easily as outside and it might not have been as important. In the forest they were protected from wind and precipitation and they probably felt more secure from predators. Therefore they did not necessarily need conspecifics for protection from weather or predators. At lower temperatures the animals could protect and warm each other with body heat and exhaled breath. In order to perceive the difference the cows and heifers had to come closer together, since radiation of body heat does not reach too far and exhaled warm breath rises and mixes fast with the surrounding cooler air. Moreover, bodies can also be wind shield. As a result having more animals in their ambit gave the focal animals better protection from wind. Since precipitation comes from above – except if there is very strong wind – other animals cannot give protection from it. Furthermore, especially rain can be seen as a wall between the bodies and therefore body heat does not play a role in protection during precipitation. Thus, a change in behaviour regarding the distance between cattle during precipitation is not reasonable for protection.

The mean number of animals in the focal animals' ambit was five which resulted in 15.7 m² per head on average in the 78.5 m² big ambit where animals were counted. This is much space and sensible changes in WCT are difficult to produce. However, a smaller ambit where animals in the focal animal's ambit were counted might have given a more precise view, because then only cattle would have been counted which could have had more influence on the microclimate by body heat or wind protection.

5.7. The role of experience

The fact that cows had the tendency to frequent the forest and the category "Near protection, wind abandoned side" much less than heifers is quite surprising. Still, the cows were able to find suitable microclimates even outside the forest, so the median and the distribution of the values of differences of WCT between portable and stationary weather station were (almost) the same. This could be due to more experience not only with weather but also with different habitat types and how much protection they offer for the cows. The cows found appropriate microclimates without having to use the forest very much. This can be seen as an argument to keep cattle in mixed age groups. Especially when heifers experience their first pregnancy and birth and for the first time care for a calf, the presence of older, calmer and more prudent cows can calm the heifers down and give them the possibility to learn from the cows. The learning effect should not be underestimated, it might even influence productivity since the heifers and their calves certainly take advantage of the cows' experience.

However, the higher number of lower outliers of the cows could be explained with the slightly higher mean body condition score of 4.2 in comparison to 3.9 of the heifers. Additionally, the cows weighed 625 kg on average whereas the heifers weighed 561 kg, although the cows and heifers had about the same shoulder height. This means that the cows must have had a bigger body volume than the heifers. Since volume (place of production of body heat) increases cubically (with "x^3") whereas body surface (place of heat emission) increases quadratically (with "y^2"), the surface-volume-ratio becomes smaller with increasing body volume if height and body shape are the same. According to Bergmann's rule the cows must have had less body heat loss than the observed heifers which made it not as essential for the cows to always be in the warmest area.
The heifers had a more than twice as high probability to lie as the cows which may be explained by their need to temporarily reduce their surface-volume-ratio. By lying the animals can also actively reduce body surface which is exposed to wind. Fundamental behaviours like rumination and feeding always have to be performed to a certain extent. All focal cows and heifers were fully grown and except for three and later two heifers respectively they were all pregnant. As a consequence they had quite similar physical conditions and the recorded frequency of feeding and ruminating did not differ. Still, the heifers probably had a higher body heat loss than the cows. The amount of consumed food and food quality, though, was not measured and neither the absolute time of food intake per 24 h. Maybe there could have been found differences between the two age levels.

The herd of the observed cows and heifers was merged from mainly two groups of cattle. Older animals are usually more secure and have a more permanent place in the hierarchy of a group than younger animals. That might be the reason why the cows did not need to show and receive as much social behaviour as the heifers. Furthermore, facial expressions are rather poor in cattle (SCHLOETH 1961, BOUISSOU et al. 2001) and communication, especially in female cattle, is often very subtle so that recognition is very difficult, possibly not only for humans (HALL 1989) but also for younger cattle. If so, this could be a reason for why the younger heifers were more likely to express themselves by observable behaviours, though aggressive behaviours were not influenced by age. The cows apparently defended and asserted themselves with the same probability as the heifers. It was not possible to find differences in the other social behaviours probably because they were most likely not performed often enough.

The advantage of a smaller distance between the animals concerning protection from coldness obviously is something that is learned by cattle very early in their life. Otherwise there must have been a difference between the two age groups.

5.8. Additional observations

The rarely observed direct changes in behaviour as a result of weather correspond with experiences of the german teaching and experimental farms Köllitsch and Kalchreuth and several other private farms. According to GOLZE (2000) the cattle of different beef breeds (Fleckvieh, Limousin, German Angus and their crossbreeds) on these east german farms were using human-built shelters only after long lasting precipitation together with low temperatures and strong wind. ZUBE (1996) describes similar experiences from a third east german farm, Paulinenaue, where during three wet-cold days and nights in February 1996 the use of shelter was observed. The author points out that the use of shelter obviously depended less on weather conditions than on the presence or absence of soft and insulating lying places outside the shelter and the distance to food (ZUBE 1996).

The incident when the oldest cow of the herd forced others to stand up, follow her and in that way protected them from bad weather illustrates an interesting aspect in animal behaviour as well as in production. The biggest proportions of slaughtered head of beef breeds in Sweden are young bulls and heifers which are slaughtered at an average age of 18 months (bulls) and 23 months (heifers) (HESSLE 2007). These young animals are usually kept in homogenous groups of very little experience. The better grazing spots they find and the better they protect themselves from weather when grazing on pasture, the higher weight gain the animals will have. BEAVER & OLSON (1997) found that, grazing in unprotected areas during winter time, 7- to 8-year-old cattle used areas with higher standing crop significantly more than 3-year-old cattle. Younger cattle also used unprotected areas more frequently than older cattle and lost more weight ($p < 0.001$) and backfat ($p = 0.06$) (BEAVER & OLSON 1997). Depending on herd size, keeping one or several old animals with a herd of young cattle – possibly older breeding bulls and unfertile or non-pregnant older cows – might improve performance and thereby increase profitability despite the fact that those old animals need food and have to be handled. On the organic farm KC Ranch, Revingehed, in the south of Sweden one old cow or bull goes with ten growing young animals (Carl-Axel Dahlgren, personal communication). They have made very good experiences with this strategy both for the learning process of how the animals protect themselves in following winters and the growing ability in young cattle. Further research in this field could clarify the validity of this presumption.

The preference of the cows and heifers to lie higher with the front part of their body even if the surrounding was flat is presumably connected with rumination. An argument for this is that only calves younger than two weeks, with other words preruminant calves, have been observed to lie plane or even head downhill. Ruminant cattle need to eructate gases from the rumen (SAMBRAUS 1978, PHILLIPS 2002). Lying higher with the front part of the body probably eases that and thus this position is more comfortable for them. Describing the architecture of cubicles PHILLIPS (2002) writes: "[…] cows prefer them [the cubicles] to have a solid front, which may limit lunging space but gives greater comfort and a feeling of enclosed personal space". A reason for the described preference of solid fronts could be that, by moving in and out of the cubicles, bedding material is pushed from the middle against the solid front and builds a little heightening there. The shallow depression which emerges might come close to a lying place a cow would choose in natural environment (Figure 22). In the literature there could not be found descriptions of this type of lying preference and also some experienced researchers and farmers had neither noticed nor read about this before.

The observations made in the late evening, at night and in the early morning let assume that the animals mostly rested during darkness and in cold morning hours and that they preferred the forest to do so. In a study by SENFT et al. (1985) the cattle preferred to rest in low-laying areas and on lower slopes. Over half of the resting time during night they were on south-facing slopes (SENFT et al. 1985). However, these animals had hardly shelter and lived on shortgrass steppe in northeastern Colorado (SENFT et al. 1985). Occasional periods of food intake during nights have often been reported (e.g. by HANCOCK 1950, HAFEZ & BOUISSOU 1975, ARNOLD & DUDZINSKY 1978, SAMBRAUS 1978, SENFT et al. 1985, HALL 1989). ZUBE (1996) documented a sudden increase of animals using shelter with nightfall and a drop at daybreak and OLARSBO (2005) described the use of shelters as mostly during

Figure 22: *The absent snow marks off the place where a cow was lying; especially at the left end of the lying place a heightening is noticeable.*

early and late observations. Furthermore, they both point out that the distance between food and shelter and the presence of insulating lying places seemed to be of higher importance than weather. Nevertheless, in both studies the cows and heifers preferred to seek up shelter during darkness if the mentioned conditions were fulfilled. This indicates that cattle may feel safer and more secure being surrounded by protecting objects during darkness. Regarding the importance of the visual sense for cattle (ALBRIGHT & ARAVE 1997) the obvious difference between day and night makes perfect sense. For the observed cattle the forest replaced the human-built shelters and was therefore of greatest importance.

6. CONCLUSIONS

This study showed that the behaviour of beef cows and heifers living outdoors during winter time is highly influenced not only by parameters of their environment such as weather, type of protection and day length but also from other herd members, feeding situation and experience with winter weather and pregnancy. The feeding situation seemed to be most stressful for the animals. The evolutionary unnatural situation to feed close to conspecifics often with physical contact as it happens at feedracks resulted in an increasing number of social interactions, especially in an increase of aggressive behaviours. Before the animals got used to the feeding rhythm and before the days became longer, the limited space at the feedracks seemed to be an extra source of stress. A low WCT increased the stress at the feedracks (measured by a higher probability to show aggressive behaviours) but the animals did not show any change in their protection behaviour. However, the cows and heifers were very well able to find microclimates which were more suitable for them than the weather on the most exposed spot of the pasture where the stationary weather station was placed. Obviously, the animals were able to adapt to their environment and protected themselves by changes in behaviour, regarding general behaviour and social behaviour as well as the use of protection and grouping behaviour. By crowding together especially the wind speed can be decreased which is possibly the most important factor for the experienced weather situation of an animal. Precipitation, though, did not have any impact on the distance between the animals but influenced all other investigated behaviours (except for positive and other social behaviours) often also in combination with the WCT. The influence of experience was very distinct. By far the cows did not frequent the forest as often as the heifers (tendency) and the cows were lying less than half as often as the heifers. Yet, the cows were able to find similar microclimates as the heifers even without behaving the same way. The heifers were also socially more active than the cows even though the age level had no impact on aggressive behaviours. The very rare observed direct changes in behaviour caused by weather show that it is very difficult, maybe impossible, to statistically measure obvious and immediately perceivable changes in behaviour due to weather. Still, the incident when the oldest cow (10 years) forced other cows and heifers to stand up and follow her into the forest to protect them from a heavy hail storm points out a factor which should not be underestimated in the importance for production. Mixed age groups where experienced older cattle go with inexperienced young (possibly still growing) cattle could benefit the learning process and the physical adaptations which prepare the animals for fierce weather conditions and prevent them from losing body condition during those times.

7. ZUSAMMENFASSUNG

Die Bedingungen, unter denen Rinder in der heutigen Kulturlandschaft in der Freilandhaltung leben, ermöglichen es ihnen, sich fast so natürlich zu verhalten, wie sie es in der Wildnis tun würden. In der Freilandhaltung bestehen Herden meist aus gemischten Altersgruppen und die Kühe und Färsen werden von Zuchtbullen, die zeitweilig in der Herde leben, auf natürliche Weise gedeckt. Von Mineralfutter abgesehen erfolgen Fütterungen nur in den Wintermonaten, wobei Kraftfutter nur selten zugefüttert wird. Bis zu einem gewissen Grad sind die Tiere in der Lage mit verschiedenen umweltbedingten Herausforderungen wie niedrigen Temperaturen, starkem Wind oder Niederschlag fertig zu werden, da sie sich körperlich anpassen und ihr Verhalten entsprechend ändern. Daher können Rinder durchaus auch im nordeuropäischen Winter im Freien leben, ohne physisch Schaden zu nehmen, wenn bestimmte Voraussetzungen wie der Zugang zu Futter, Schutzmöglichkeiten und eine gute körperliche und gesundheitliche Verfassung gegeben sind. Über den Zusammenhang zwischen nordeuropäischem Wetter und der Nutzung von natürlichen oder künstlichen Schutzmöglichkeiten durch freilebende Rinder ist wenig bekannt. Außerdem variieren die Ergebnisse der wenigen Studien und Beobachtungen der Tierhalter stark. Alter und Erfahrung mit Winterwetter und Schwangerschaft spielen ebenso eine Rolle wie die Aufzucht von Jungrindern im Freien, die frühzeitige körperliche Anpassungen möglich macht und die die Jungtiere Schutzverhalten von klein auf lernen lässt. Über den Einfluss des Wetters auf das Verhalten von Rindern in Kulturlandschaften ist jedoch wenig bekannt.

Das Ziel dieser Studie war es daher, das Verhalten von Rindern (*Bos taurus*) zu erforschen, die im Winter in einer Naturlandschaft gehalten werden, und die Auswirkung von verschiedenen Wetterverhältnissen, vorhandenen Schutzmöglichkeiten und Erfahrungen der Tiere auf ihr Verhalten zu studieren.

Die Studie wurde im Südwesten Schwedens auf der Farm Trestena auf einer 12 ha großen Weide durchgeführt, die seit mindestens acht Jahren nicht mehr landwirtschaftlich genutzt wurde. Schutz bot Nadelwald sowohl innerhalb als auch angrenzend um die Weide herum, sodass die Weide in vier Schutzkategorien unterteilt werden konnte: im Wald, schutznah – windabgewandt, schutznah – windzugewandt, ohne Schutz. Von 4. Dezember 2006 bis 22. März 2007 wurden zehn Kühe und zehn Färsen der Fleischrassen Black Angus und Black Angus-Charolais-Kreuzungen als Fokustiere 240 Stunden beobachtet. Jedes Fokustier wurde 12-mal je eine Stunde beobachtet und die Datenerfassung erfolgte sowohl kontinuierlich (Sozialverhalten) als auch in 4-Minuten-Intervallen (Körperposition und allgemeines Verhalten) an vier Stunden pro Tag, wobei sich die Beobachtungszeiten nach dem Sonnenstand richteten. Temperatur, Windgeschwindigkeit und Sonneneinstrahlung wurden sowohl alle vier Minuten im Umkreis der Fokustiere gemessen als auch pro Stunde bzw. pro Viertelstunde an der ungeschütztesten Stelle der Weide. Die verschiedenen Variablen wurden zu einem einzigen Wert, der sogenannten Wind Chill Temperature (WCT), zusammengefasst. Alle erfassten Daten dieser Arbeit wurden mit einer Linkfunktion des Poisson-Regressionsmodells, Linkfunktionen des logistischen Regressionsmodells, der Friedmans-Zwei-Weg-Rangvarianzanalyse, dem Wilcoxon-Vorzeichenrang-Test und dem Vorzeichentest analysiert.

Um eine Übersicht über das Verhalten der Kühe und Färsen zu bekommen, wurde die Häufigkeit der verschiedenen Körperpositionen und des allgemeinen sowie des sozialen Verhaltens jeweils für Vormittag und Nachmittag in Prozent dargestellt. Vormittags lagen die

Tiere häufiger als nachmittags. Die Kühe und Färsen fraßen nachmittags öfter, vermutlich da die Fütterungen ab Ende Januar mittags stattfanden. Allerdings fraßen sie auch an den Dezembernachmittagen öfter, obwohl die Fütterung zu dieser Zeit am späten Nachmittag erfolgte. Soziale Verhaltensweisen waren zu etwa ¾ aggressiver Natur. Während des Fressens an Futtertischen und Silageballen am Boden wurde aggressives Verhalten um 21,9 Prozentpunkte häufiger gezeigt als während anderer Verhaltensweisen.

Während der vier Beobachtungsmonate waren die Kühe und Färsen 12,4 % der Aufzeichnungen im Wald, 10,4 % schutznah und 77,2 % der Aufzeichnungen ohne Schutz. Insgesamt gab es keinen signifikanten Unterschied zwischen der Häufigkeit, mit der die Kühe und Färsen ohne Schutz lagen und mit der sie im Wald lagen. Vergleicht man die anteiligen Prozentsätze der Verhaltensweise Liegen in den verschiedenen Schutzkategorien, so ist dieser Anteil im Wald signifikant höher verglichen mit Liegen ohne Schutz ($p < 0,001$). Sehr ähnlich zeigte sich die Verhaltensweise Ruhen (d.h. Liegen, Wiederkäuen, keine Aktivität), allerdings war die Häufigkeit von Ruhen im Wald signifikant kleiner als Ruhen ohne Schutz ($p < 0,001$). Bei Beachtung der Häufigkeit des Aufenthalts in der jeweiligen Schutzkategorie zeigten sich signifikante Unterschiede auch beim Vergleich von Ruhen im Wald und Ruhen ohne Schutz ($p < 0,01$).

Bei Niederschlag, d.h. Regen, Schnee und Hagel, suchten die Kühe und Färsen den Wald 2,71-mal häufiger auf als in Zeiten ohne Niederschlag ($p < 0,05$). Es wurde kein signifikanter Einfluss der WCT auf die Nutzung von Schutz gefunden. Jedoch war in 75 % der Beobachtungsstunden die WCT in der Umgebung der Fokustiere mindestens 2 °C höher als an der ungeschütztesten Stelle der Weide. Die mittlere Temperatur unterschied sich um 1,8 °C ($p < 0,001$) und die mittlere Windgeschwindigkeit unterschied sich um 1,7 m/sec ($p < 0,001$) zwischen den beiden Umgebungen.

Die allgemeinen Verhaltensweisen Liegen, Fressen und Wiederkäuen wurden von WCT, Niederschlag und Niederschlag zu unterschiedlichen WCT beeinflusst. Wenn die WCT niedrig war, lagen die Kühe und Färsen ohne Niederschlag seltener ($p < 0,001$), fraßen häufiger ($p < 0,001$) und wiederkäuten seltener ($p < 0,001$). Während Zeiten mit Niederschlag verhielten sich die Tiere genau umgekehrt. Sie lagen bei niedriger WCT häufiger ($p < 0,001$), fraßen seltener ($p < 0,001$) und wiederkäuten häufiger ($p < 0,001$).

Auch das soziale Verhalten wurde von WCT, Niederschlag und Niederschlag bei unterschiedlicher WCT beeinflusst. Ohne Niederschlag war die Wahrscheinlichkeit geringer, dass soziales Verhalten insgesamt ($p < 0,001$) und aggressives Verhalten im Speziellen ($p < 0,001$) beobachtet wurden, wenn die WCT hoch war, wohingegen die Wahrscheinlichkeit bei Niederschlag größer war, soziales Verhalten insgesamt ($p < 0,001$) und aggressives Verhalten im Speziellen ($p < 0,001$) zu zeigen, wenn die WCT hoch war.

Die Anzahl von Rindern in einem Zwei-Kuhlängen-Umkreis um das Fokustier wurde von WCT und Windgeschwindigkeit beeinflusst, jedoch nicht signifikant von Niederschlag. Bei kälteren WCT ($p < 0,001$) und höheren Windgeschwindigkeiten ($p < 0,01$) befanden sich mehr Tiere im Umkreis der Fokustiere als bei höheren WCT und niedrigeren Windgeschwindigkeiten. Desweiteren hatten die Kühe und Färsen im Wald weniger Artgenossen um sich als ohne Schutz ($p < 0,01$).

Die Kühe und Färsen fanden ähnliche Mikroklimata, aber die Färsen mussten dazu den Wald mehr als doppelt so häufig wie die Kühe aufsuchen ($p = 0,053$). Insgesamt lagen die Färsen auch mehr als doppelt so häufig wie die Kühe ($p < 0,05$).

Die seltenen Beobachtungen von direkten Verhaltensänderungen, die auf das Wetter zurückzuführen sind, zeigen die Schwierigkeit, solche Änderungen zu messen. Allerdings heben sie die Bedeutung hervor, die erfahrene Rinder für das Schutzverhalten einer Herde haben können. Tiere in gemischten Altersgruppen zu halten und einigen Individuen die Chance zu geben, Lebenserfahrung zu sammeln und die Fähigkeit zu entwickeln, das Verhalten einer ganzen Herde zu beeinflussen, ist grundlegend, wenn die Tiere zumindest zeitweise im Freien gehalten werden.

Abschließend bemerkt zeigen die Ergebnisse, dass sich die Tiere den Witterungsverhältnissen anpassten und sich dem Grad des Schutzes entsprechend verhielten. Die Kühe und Färsen waren in der Lage, wärmere WCT zu finden, ohne dabei notwendigerweise die drei schützenden Weidegebiete aufsuchen zu müssen. Die Umstände um die Fütterung beinhalten ein beachtliches Stresspotenzial für die Tiere, vor allem bei niedrigen Temperaturen. Eine ausreichend große Anzahl von Artgenossen zu haben, ist jedoch äußerst wichtig für das Schutzverhalten von Rindern bei niedrigen Temperaturen und hohen Windgeschwindigkeiten, sowohl wenn keine anderen Schutzmöglichkeiten bestehen als auch wenn weitere Schutzmöglichkeiten vorhanden sind. Erfahrung scheint eine zentrale Rolle zu spielen, sowohl für die Art wie sich Rinder vor Wetter schützen als auch für ihre Fähigkeit, passende Mikroklimata zu finden. Die Ergebnisse induzieren, dass die Färsen nicht die gleichen Fähigkeiten hatten, ähnliche Mikroklimata außerhalb des Waldes zu finden so wie es die Kühe konnten. Weitere Forschungen zu diesem Thema sind daher nötig, um mehr über den Zusammenhang verschiedener Faktoren zu lernen, die die Fleischproduktion mit Rindern in Freilandhaltung beeinflussen.

8. SAMMANFATTNING

Förutsättningar för att hålla nötkreatur utomhus vintertid i dagens jordbrukslandskap möjliggör att de kan bete sig nästan såsom de skulle göra i vilt tillstånd. För det mesta hålls utegångsdjur i blandade åldersgrupper och hondjuren betäcks av avelstjurar, som får vistas en kortare tid med flocken. Bortsett från mineralfoder sker utfodring bara under vintern och kraftfoder ges sällan. Till en viss grad kan djuren klara av olika miljömässiga utmaningar såsom låga temperaturer, höga vindhastigheter och nederbörd genom att anpassa sig fysiskt och ändra sitt beteende. Det betyder att nötkreatur kan leva utomhus även under vintern utan att lida fysiskt om vissa kriterier såsom god tillgång till foder, skyddsmöjligheter, gott hull och god hälsa är uppfyllda. Det finns inte så mycket kunskap kring sambanden mellan väder och användningen av konstgjorda eller naturliga väderskydd från nötkreatur i Nordeuropa och resultaten av de få studier som finns och av djurägares observationer skiljer sig mycket från varandra. Djurens ålder och deras erfarenheter av vinterväder och av dräktighet har betydelse, liksom uppfödning av ungnöt utomhus så att fysiska anpassningar kan ske tidigt i livet och så att de unga djuren lär sig hur de kan hitta skydd mot dåligt väder. Vädrets inverkan på nötkreaturs beteende när de hålls i omväxlande terräng är inte väl studerat.

Syftet med den här studien var att undersöka beteendet hos nötkreatur (*Bos taurus*), som hölls utomhus i omväxlande terräng vintertid samt att studera effekterna av väder, tillgång till skydd och erfarenhet på beteendet.

Studien utfördes på Trestena, beläget mellan Skara och Falköping, i sydvästra Sverige. Djuren vistades på ett 12 ha stort område som inte hade använts för jord- och skogsbruk på minst åtta år. Skydd fanns genom granskog på och omkring området så att området kunde indelas i fyra skyddskategorier: i skogen, nära skydd – läsida, nära skydd – icke läsida, utan skydd. Från 4 december 2006 till 22 mars 2007 observerades tio kor och tio kvigor av Black Angus och Black Angus-Charolais-korsningar som fokaldjur under totalt 240 timmar. Fokaldjuren observerades under en timme varje gång och registreringar gjordes kontinuerligt (socialt beteende) och i 4-minuters-intervall (kroppspositioner och generellt beteende). Observationer gjordes fyra timmar per dag och observationstiderna anpassades till solens position. Temperatur, vindhastighet och ljusintensitet mättes var 4:e minut i fokaldjurens om-givning och per timme respektive per kvart i den mest exponerade delen av hagen. De olika variablerna sammanfördes till ett enda värde kallat för Wind Chill Temperature (WCT). Data analyserades med en linkfunktion av Poisson-regression, linkfunktioner av logistisk re-gressionsmodel, Friedmans tvåvägs variansanalys, Wilcoxon signed rank test och Sign test.

För att få en överblick över djurens beteende sammanställdes andelarna av de olika kroppspositionerna samt de generella och sociala beteendena uppdelat på för- respektive eftermiddagar. På förmiddagarna låg djuren oftare än på eftermiddagarna. Djuren åt oftare på eftermiddagarna, troligen på grund av att utfodring skedde vid lunchtid från och med slutet av januari. Även under de eftermiddagar i december då utfodring skedde sent på eftermiddagen åt djuren oftare under eftermiddagarna än under förmiddagarna. Ungefär ¾ av registreringarna för sociala beteenden var av aggressiv natur. Andelen aggressiva beteenden var 21,9 procentenheter högre när djuren åt från foderborden och från ensilagebalar på marken, än när de inte åt.

Under de fyra observationsmånaderna befann sig djuren i skogen under 12,4 %, nära skydd under 10,4 % och utan skydd under 77,2 % av registreringarna. Totalt sett fanns det ingen signifikant skillnad i antalet registreringar av att ligga utan skydd eller i skogen. Jämför man andelarna av att ligga i de olika skyddskategorierna så föredrog korna och kvigorna att ligga i skogen jämfört med att ligga utan skydd ($p < 0{,}01$). För beteendet vila (ligga, idissla, ingen aktivitet) var antalet registreringar att vila i skogen signifikant mindre än vila utan skydd ($p < 0{,}001$). En jämförelse av andelar per skyddskategori av att vila i skogen med att vila utan skydd visade att djuren även föredrog att vila i skogen ($p < 0{,}001$).

Under nederbörd, dvs. regn, snö och hagel, uppsökte djuren skogen 2,71 gånger oftare än när det var uppehåll ($p < 0{,}05$). Ingen signifikanta inverkan av WCT på användningen av skydd kunde finnas. Ändå var WCT i fokaldjurens område i 75 % av observations-timmarna minst 2°C högre än i hagens mest exponerade del. Temperatur och vindhastighet skiljde sig också signifikant åt mellan områdena då medeltemperaturen var 1,8°C högre ($p < 0{,}001$) och medelvindhastighet var 1,7 m/sec lägre ($p < 0{,}001$) där djuren befann sig än i hagens mest exponerade del.

De generella beteendena ligga, äta och idissla påverkades av WCT, nederbörd och nederbörd vid olika WCT. Vid uppehållsväder låg djuren mindre ($p < 0{,}001$), åt oftare ($p < 0{,}001$) och idisslade mindre ($p < 0{,}001$) när WCT var låg. Vid uppehållsväder var förhållandena omvända och de låg oftare ($p < 0{,}001$), åt mindre ($p < 0{,}001$) och idisslade oftare ($p < 0{,}001$) när WCT var låg.

Socialt beteende påverkades också av WCT, nederbörd och nederbörd vid olika WCT. Vid uppehållsväder var det mindre sannolik att sociala beteenden sammanlagt ($p < 0{,}001$) och aggressiva beteenden visades när WCT var högt ($p < 0{,}001$). Däremot var det troligare att socialt beteende sammanlagt ($p < 0{,}001$) och aggressivt beteende ($p < 0{,}001$) visades under nederbörd.

Antalet nötkreatur i en två-kolängders omkrets omkring fokaldjuret påverkades av WCT och vindhastighet men inte signifikant av nederbörd. Vid lägre WCT ($p < 0{,}001$) och högre vindhastighet ($p < 0{,}01$) var det fler djur nära fokaldjuren än vid högre WCT och lägre vindhastighet. Därutöver hade fokaldjuren få andra djur nära sig när de var i skogen än när de var utan skydd ($p < 0{,}01$).

Vid jämförelsen mellan kor och kvigor kunde de båda grupperna hitta liknande mikroklimat, men för att hitta dem behövde kvigorna söka upp skogen mer än dubbelt så ofta som korna ($p = 0{,}053$). Totalt låg kvigorna mer än dubbelt så ofta som korna ($p < 0{,}05$).

De få observationerna av direkta förändringar i beteendet på grund av väder som sågs i denna studie visar på svårigheterna i att mäta sådana förändringar. Ändå lyfter de fram den betydelse erfarna nötkreatur kan ha för skyddsbeteendet i en flock. Att hålla nötkreatur i blandade åldersgrupper och ge vissa individer chansen att samla livserfarenhet och att utveckla förmågan att påverka beteendet hos en hel flock är grundläggande, när djuren hålls utomhus åtminstone under delar av året.

Avslutningsvis indikerar resultaten att djuren anpassade sig till förhållandena och betedde sig olika beroende på graden av skydd. Djuren kunde hitta varmare mikroklimat utan att nödvändigtvis uppsöka skydd. Förhållandena kring foderplatser och utfodringsrutinerna utgör en väsentlig stresspotential för djuren – särskilt vid låga temperaturer. Ändå är artfränder ytterst viktiga för skyddsbeteendet hos nötkreatur vid låga temperaturer och höga vindhastigheter, både när inget annat väderskydd är tillgängligt och när det finns andra skyddsmöjligheter. Erfarenhet verkar spela en central roll i hur nötkreatur skyddar sig från vädret och för deras förmågan att hitta lämpliga mikroklimat. Resultaten indikerar att kvigorna inte hade samma förmåga att hitta liknande mikroklimat utanför skogen som korna. Ytterligare forskning inom detta område är nödvändig för att lära sig mer om sambanden mellan olika faktorer vid köttproduktionen med utomhushållning.

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	SCORE	Spinous processes (SP) (anatomy varies)	Spinous to Transverse processes	Transverse processes	Overhanging shelf (care - rumen fill)	Tuber coxae (hooks) & Tuber ischii (pins)	Between pins and hooks	Between the hooks	Tailhead to pins (anatomy varies)
SEVERE UNDERCONDITIONING (emaciated)	1.00	individual processes distinct, giving a saw-tooth appearance	deep depression	very prominent, > 1/2 length visible	definite shelf, gaunt, tucked	extremely sharp, no tissue cover	severe depression, devoid of flesh	severely depressed	bones very prominent with deep "V" shaped cavity under tail
	1.25								
	1.50								
	1.75			1/2 length of process visible					
FRAME OBVIOUS	2.00	individual processes evident	obvious depression		prominent shelf	prominent	very sunken		bones prominent "U" shaped cavity formed under tail
	2.25			between 1/2 to 1/3 of processes visible					
	2.50	sharp, prominent ridge					thin flesh covering	definite depression	first evidence of fat
	2.75			1/3 - 1/4 visible	moderate shelf				
FRAME & COVERING WELL BALANCED	3.00		smooth concave curve	< 1/4 visible	slight shelf	smooth	depression	moderate depression	bones smooth, cavity under tail shallow & fatty tissue lined
	3.25			appears smooth, TP's just discernable					
	3.50	smooth ridge, the SP's not evident	smooth slope	distinct ridge, no invidual processes discernable		covered	slight depression	slight depression	
	3.75						sloping		
FRAME NOT AS VISIBLE AS COVERING	4.00	flat, no processes discernable	nearly flat	smooth, rounded edge	none	rounded with fat		flat	bones rounded with fat and slight fat-filled depression under tail
	4.25						flat		
	4.50			edge barely discernable		buried in fat			bones buried in fat, cavity filled with fat forming tissue folds
	4.75								
SEVERE OVERCONDITIONING	5.00	buried in fat	rounded (convex)	buried in fat	bulging		rounded	rounded	

Figure 23: *Body condition scoring chart from* EDMONSON *et al. (1989).*

Table 7: *Cow-heifer-order from December till March; C = cow, H = heifer*

December															
Observation day	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Observation hour 1	H	C	H	C	H	C	H	C	H	C	H	C	H	C	H
Observation hour 2	C	H	C	H	C	H	C	H	C	H	C	H	C	H	C
Observation hour 3	C	H	H	H	C	H	C	C	C	H	C	H	H	H	C
Observation hour 4	H	C	C	C	H	C	H	H	H	C	H	C	C	C	H

January															
Observation day	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Observation hour 1	C	H	C	H	C	H	C	H	C	H	C	H	C	H	C
Observation hour 2	H	C	H	C	H	C	H	C	H	C	H	C	H	C	H
Observation hour 3	H	C	C	C	H	C	H	H	H	C	H	C	C	C	H
Observation hour 4	C	H	H	H	C	H	C	C	C	H	C	H	H	H	C

February															
Observation day	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Observation hour 1	H	C	H	C	H	C	H	C	H	C	H	C	H	C	H
Observation hour 2	C	H	C	H	C	H	C	H	C	H	C	H	C	H	C
Observation hour 3	C	H	H	H	C	H	C	C	C	H	C	H	H	H	C
Observation hour 4	H	C	C	C	H	C	H	H	H	C	H	C	C	C	H

March															
Observation day	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Observation hour 1	C	H	C	H	C	H	C	H	C	H	C	H	C	H	C
Observation hour 2	H	C	H	C	H	C	H	C	H	C	H	C	H	C	H
Observation hour 3	H	C	C	C	H	C	H	H	H	C	H	C	C	C	H
Observation hour 4	C	H	H	H	C	H	C	C	C	H	C	H	H	H	C

Table 8: *February as example for the timetable of observations with date, cattle number and starting time*

February		Observation hour 1		Observation hour 2		Observation hour 3		Observation hour 4	
		Start	**Animal**	**Start**	**Animal**	**Start**	**Animal**	**Start**	**Animal**
Th	**1**								
Fr	**2**								
Sa	**3**								
Su	**4**								
Mo	**5**								
Tu	**6**								
We	**7**	**8:05**	1315	**9:20**	155	**13:35**	109	**14:50**	1267
Th	**8**								
Fr	**9**	**8:05**	2028	**9:20**	204	**13:35**	183	**14:50**	127
Sa	**10**	**8:05**	1415	**9:20**	146	**13:35**	1309	**14:50**	114
Su	**11**	**8:05**	116	**9:20**	1303	**13:35**	191	**14:50**	149
Mo	**12**	**7:50**	1260	**9:05**	121	**13:30**	152	**14:45**	186
Tu	**13**								
We	**14**	**7:50**	127	**9:05**	1315	**13:30**	1267	**14:45**	155
Th	**15**	**7:50**	1309	**9:05**	109	**13:30**	2028	**14:45**	183
Fr	**16**	**7:50**	146	**9:05**	1415	**13:30**	116	**14:45**	1303
Sa	**17**	**7:50**	191	**9:05**	149	**13:30**	114	**14:45**	204
Su	**18**	**7:50**	152	**9:05**	186	**13:30**	1260	**14:45**	121
Mo	**19**	**7:35**	183	**8:50**	127	**13:30**	155	**14:45**	1309
Tu	**20**								
We	**21**	**7:35**	149	**8:50**	1267	**13:30**	1315	**14:45**	109
Th	**22**	**7:35**	1303	**8:50**	114	**13:30**	204	**14:45**	2028
Fr	**23**								
Sa	**24**	**7:35**	121	**8:50**	191	**13:30**	1415	**14:45**	116
Su	**25**	**7:35**	186	**8:50**	152	**13:30**	146	**14:45**	1260
Mo	**26**								
Tu	**27**								
We	**28**								

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E-post: hmh@slu.se
Hemsida: www.hmh.slu.se

Swedish University of Agricultural Sciences
Faculty of Veterinary Medicine and Animal Science
Department of Animal Environment and Health
P.O.B. 234
SE-532 23 Skara, Sweden
Phone: +46 (0)511 67000
E-mail: hmh@slu.se
Homepage: www.hmh.slu.se