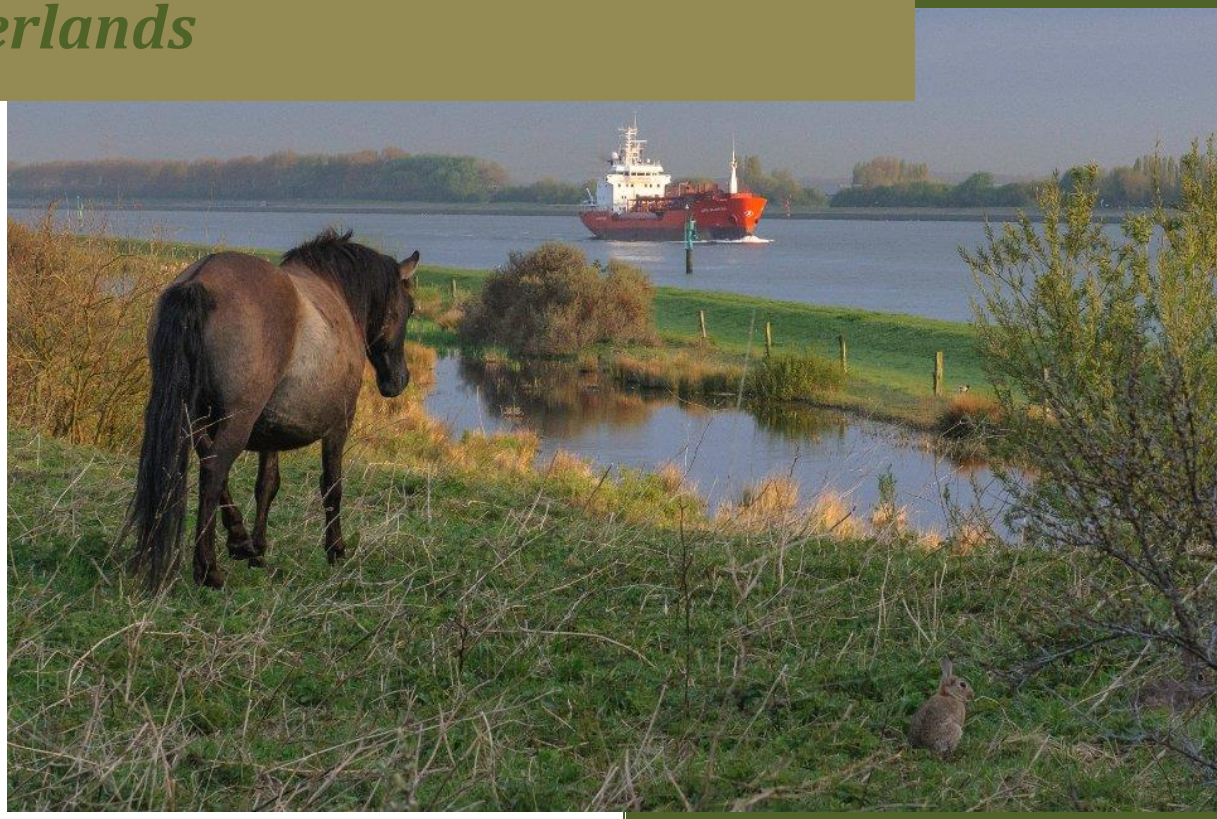
Masterthesis

Habitat use of feral Highland cattle and Konik horses on Landtong Rozenburg, the Netherlands



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February 2015

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ABSTRACT

On Landtong Rozenburg (ca 60 ha), a coastal dune area in the Netherlands, a herd of Highland cattle and two herds of feral Konik horses are used as a nature management tool. The use of large herbivores in nature management is common-use in maintaining or restoring the biodiversity of heathlands, grasslands, wetlands and coastal dunes. However the ecological process of grazing is a complex one and the outcome changes for each area. Since 2009 studies are performed on the behavior and habitat use of the cattle and koniks on Landtong Rozenburg. This study is an expansion of the previous studies. The time budget as well as different aspects of the foraging behavior of the cattle and koniks is analyzed. Behavioral data of the different herds were collected through instantaneous sampling in the field during to seven-week observation periods; July-August and November-December.

During daylight (between 9:00 and 16:00h) both cattle and koniks spent most of their time foraging (33% and 50% respectively). In the summer period foraging time was significantly lower than in winter. Grassland was overall the preferred habitat type for foraging, though there is a difference of food intake between the cattle and konik. Cattle on average spent 71% of their time foraging on grasses, while koniks spent 96% of their time foraging on grasses. To investigate the habitat use of the cattle and konik herds differs between seasons the date from this study (the only one including the summer period) was aggregated with data from the previous studies. There is a clear difference between seasons on the habitat use of the cattle and konik. Foraging time significantly is significantly lower in summer for all herds. Also there is a shift in preferred foraging habitat during autumn when the cattle spent less time foraging in grasslands and more in scrubs and forest.

The resulting information from the analysis of the habitat use and foraging in different seasons can be used to say something about the influence of the Highland cattle and Konik horses on Landtong Rozenburg on the vegetation structure. As the Highland cattle focus their foraging in the grasslands they help to maintain grassland. The cattle forage throughout the entire area on grass, but more importantly also on scrubs which will result in an open vegetation structure. Together the koniks and cattle help maintain an open, diverse vegetation structure on Landtong Rozenburg

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1. INTRODUCTION

Research on the phenomenon of recent anthropogenic climate change, or global warming, is performed in different fields with different focuses. Focus on identifying the impacts of climate change on biodiversity and predicting the effects in the future, is one of them. It is known that biodiversity in vegetation is defined by a number of climatic variables. Since the first plants have evolved on the earth climate has been constantly changing and these long-term changes are known to have had serious impacts on the vegetation diversity and distribution in the past (Shaney et al., 2010). For example during interglacial periods most areas were dominated by forest type vegetation while glacial periods saw a dominance of herbaceous vegetation types (Huntley, 2005). These changing climatic variables relevant to the distribution and function of vegetation species include changes in CO_2-concentrations, global temperature, precipitation patterns and the occurrence of extreme weather events such as fires or storms (Dunlop & Brown, 2008).
Because specific vegetation species can only function physiologically under a narrow range of specific environmental conditions, climate change will remain to have a significant impact on vegetation, from the individual level to the level of ecosystems or biomes, thus possibly resulting in more vegetation shifts in the future (Sala et al., 2000; MEA, 2005; Pressey et al., 2007).
However, changing climatic variables are not the only factors influencing vegetation distribution. Other factors also put pressure on the environment such as habitat degradation and loss or the introduction of exotic species by humans. The combination of all these factors will determine the development of vegetation patterns (Mackey, 2007).

A study performed by Beschta et al. (2013) suggests that in order for native vegetation to cope with the effects of climate change, grazing as a management tool should be greatly reduced or eliminated as grazing puts too much stress on vegetation. However, Svejcar et al. (2014) dispute this statement, saying that eliminating the use of grazing will not provide the solution for problems created by climate change. There still might be a connection between the problems caused by climate change and grazing when it comes to vegetation distribution, but what this connection is will be difficult to say. Not only are there still knowledge gaps in the science of climate change, also grazing itself is a hugely complex ecological process which impacts differ greatly for different vegetation types and climatic variables, as well as in timing, intensity, frequency and on the type of animal (Heitschmidt & Stuth, 1991; Boyd & Sevjcar, 2009).

In Western Europe grazing as tool for nature management is increasingly being used to maintain or restore the biodiversity of heathlands, grasslands, wetlands and coastal dunes (WallisDeVries et al., 1998; Vulink, 2001). In general grazing is performed with large herbivores, such as sheep, horses and cattle, which directly influence the vegetation distribution, structure and productivity through selective grazing, but also through trampling and eliminative behavior (Valentine, 1990; Heitschmidt & Stuth, 1991; WallisDeVries et al., 1998). It is believed that direct consumption of dominant species by herbivores enhances vegetation diversity as it creates better conditions for less competitive species. However, as stated before the ecological process of grazing is a

complex one and thus both positive and negative effects on vegetation diversity and distribution have been reported. These different outcomes can be linked to different grazing management regimes, each with different habitat use by the herbivores (WallisDeVries, 1995). Nature management wants to know and try to understand the impact of grazing by the herbivores in a particular area in order to appropriately adjust the management before any negative impacts on the vegetation would become visible. Thus, there is not one approach with can be applied to all areas in Western Europe, not even for example all coastal dune areas (Lamoot, 2004).

In the Netherlands one of several coastal dune areas is Landtong Rozenburg. In this area, as in many, grazing by large herbivores is used as a tool in nature management since 1999. As stated the outcome of grazing management differs for each area due to different climate factors and natural processes. Since 2009 several studies have been carried out in the area to try to give more insight in the situation of Landtong Rozenburg, but while the habitat use of the herbivores is investigated, the next step, which is to make link to the influence of the herbivores on the vegetation structure, is still missing. Another aspect that is missing from previous studies is the difference of habitat use between seasons. From the previous studies data is available on all seasons, except summer. This current study tries to make the link between habitat use and influence on vegetation structure, and seasonal differences through continuation of the work done by previous studies and additional research in the field and through literature.
The main research question which will be answered is;

- *What is the habitat use of feral Highland cattle (*Bos Taurus spp.*) and Konik horses (*Equus ferus caballus*) on Landtong Rozenburg, the Netherlands and how can this influence the vegetation structure?*

The main focus lies on the habitat use of Highland cattle and Konik horse, therefore several additional questions are asked;

- *What is the time budget of Highland cattle and Konik horses?*
- *Is there a difference in foraging behavior between Highland cattle and Konik horses?*
- *Does the habitat use of Highland cattle and Konik horses differ between seasons?*

These answers to these questions will be used to answer the following question;

- *How does the habitat use of Highland cattle and Konik horses influence vegetation structure?*

Why and how these aspects are investigated is explained in the following chapters (Background and Research Methods).

2. BACKGROUND

2.1 Research area

Research was performed on Landtong Rozenburg which is one of several coastal nature areas in the Netherlands. This point of land is located near the Port of Rotterdam, situated between the waterways of Nieuwe Waterweg and Calandkanaal (**Error! Reference source not found.**).

This 60 hectares large area got his current shape as a result of the realization of the Calandkanaal and adjacent ports. Oil- and gas pipes running below the area prohibit building. Because of this and until recently limited nature management, natural processes as desalination, succession, precipitation and evaporation have led to great diversity of plant- and animal species (Linnartz, 2011). In the nineties an agreement was reached as to the development of 750 hectares of natural- and recreational areas as compensation for the construction of the port Maasvlakte-2. Landtong Rozenburg is part of this development and also one of the model areas of a WWF-project called Nieuw Rotterdams Peil aimed at improving nature qualities and sustainable development of the ports and city (WWF, 1997). Since 1999 nature management in the area is cooperation between the two foundations of Ark Natuurontwikkeling and FREE Nature. Nature management in the area consists of a minimum of human interference in order for natural processes to take place. The only management tool used is natural grazing by feral Highland cattle (*Bos taurus spp.*) and Konik horses (*Equus ferus caballus)* which has led to great variation in the area with, among others, wetlands, grasslands, scrublands and small forest areas (Linnartz, 2011). Since 1999 a herd of Highland cattle is grazing on Landtong Rozenburg which was accompanied by a herd of Konik horses in 2008 and another herd in 2012.
During this study a herd of 10 Highland cattle and two herds of Konik horses (13 and 6 individuals respectively) were present in the area.

Figure 2.1
The area of Landtong Rozenburg, located west of the city of Rotterdam.

2.2 Habitat use of large herbivores

The habitat use of large free-ranging herbivores is mainly determined by the foraging decisions they have to make throughout the day. These decisions are made at different scales as presented by Senft et al. (1987); regional, landscape, plant community and patch scale. In this research all scales, except the regional scale, are included, because the area is relatively small. At a regional scale foraging decisions are aimed at selecting feeding areas with suitable vegetation communities, these decisions determine the terrain use. Decisions on the plant community scale determine the feeding patch and at the patch scale decisions are based upon nutritive quality and availability (Senft et al., 1987; Bailey et al., 1996; WallisDeVries, 1994). All this means that in an area where the preferred vegetation type is only sparsely available, herbivores will search for more feeding sites, but also will they forage more in other, less preferred vegetation types. This results in a broader terrain use (Bailey et al., 1996). Not only the total area covered by the preferred vegetation type, but also the spatial distribution is important. Small patches cannot feed a whole herd, which means the herd will travel more to forage in other areas, while they will be less explorative if the vegetation is available in concentrated in large patches (Bailey et al., 1996).

So in general, the spatial distribution determines the impact of grazing and trampling on the vegetation. Vegetation communities that are exposed to limited foraging will not be severely impacted, while the highest impact can be expected in areas with intensive grazing. Also, some vegetation species will be more vulnerable than others to the same amount of grazing and trampling (Lamoot, 2004). However, there are some fundamental differences between herbivores on feeding strategies, with the main difference between grazers and browsers (Gordan & Prins, 2008). The model derived by Hoffmann and Stewart (1972) divides large herbivores into different feeding types based on the morphology of the digestive system and feeding strategy (Figure 2.2). According to this the Konik horses and Highland cattle are both considered grazers, which means they are relatively less selective at the patch scale. While they both are considered as grazers, there is a slight difference in diet composition as cattle will eat more woody and herb species (WallisDeVries, 1994).

As both Koniks and cattle have the same feeding strategy, their difference in impact on the vegetation lies in their foraging strategies. Research performed by Lamoot (2004) and Vulink (2001) both show that Highland cattle foraged more throughout the entire area available, while Koniks tend to stay more in the same places. With this information it can be hypothesized how the vegetation structure with regard to the forested areas will be influenced. In places where the grazing pressure of the Koniks is high opportunities are created for other vegetation to spread out, of these places are near forested areas this is these are the most likely species to do this. On the other hand the cattle will restrain the spreading of forest species by foraging and trampling. So dependent on where the herbivores are located the area, the impact on the vegetation will differ.

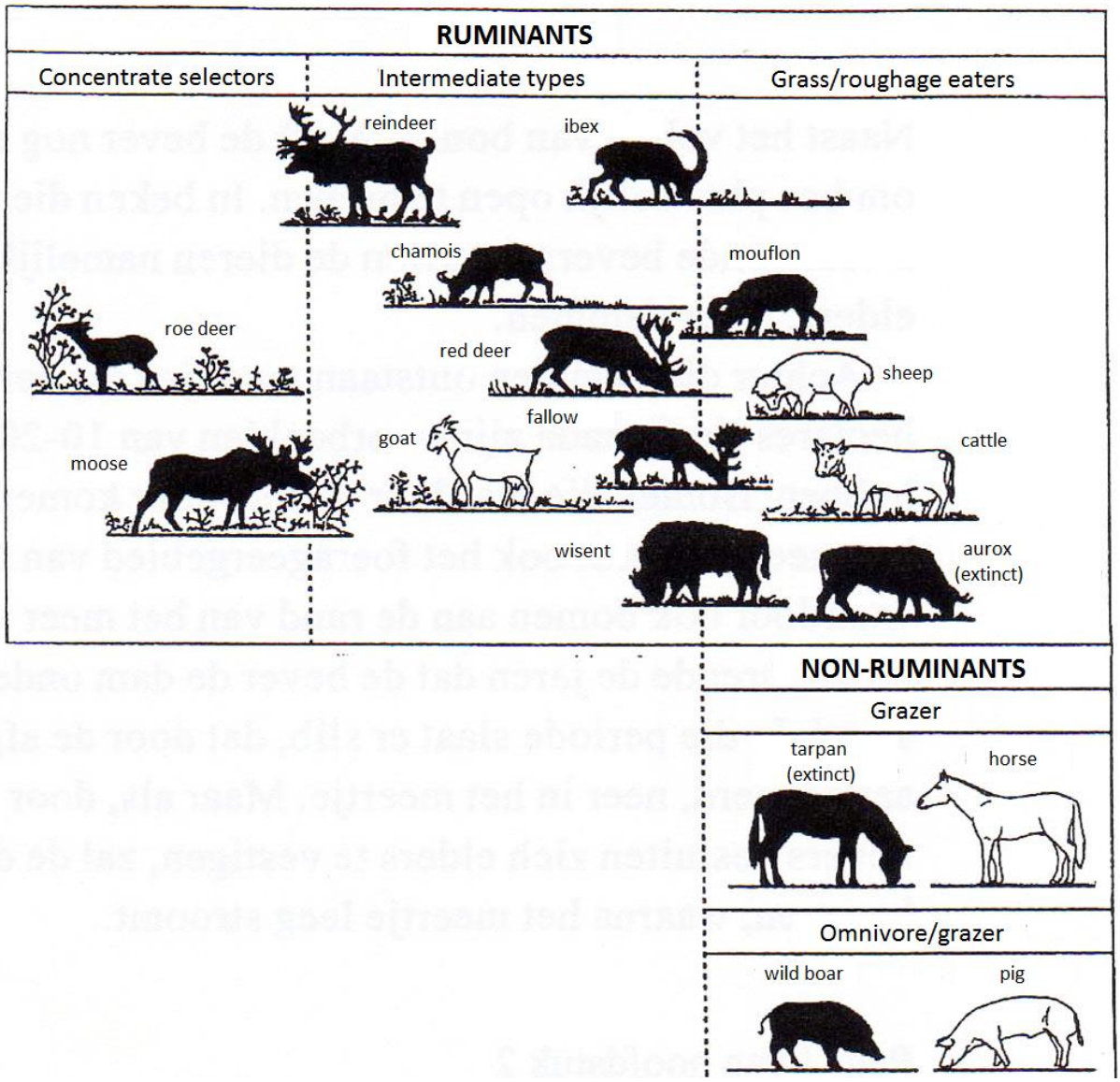

Figure 2.2
Different types of feeding among ruminants and non-ruminants according to Hofmann (1989).

3. RESEARCH METHODS

3.1 Behavioral observations

Data on the behavior of the Konik horses and Highland cattle were collected through observations in the field. All observations took place during daylight (between 9:00h and 16:00h) and were done by one observer. Data were collected through the use of instantaneous sampling at time intervals of five minutes, as done in previous studies. Also a time interval of five minutes best represents the continuous sampling method as concluded by Lamoot (2004). Observations took place during two seven-week periods; one period in summer (July-August) and one in winter (November-December). Five days a week during an seven hour period either one of the two herds of Koniks or the herd of cattle was observed; two days for the cattle, two days for the large herd of Koniks and one day for the small group of Koniks. These days were be rotated each week.
In line with previous studies in the area the entire herd was monitored and the behavior displayed by the majority of the herd was recorded. Using a protocol form (Appendix A) different behaviors, as well as the habitat types in which these behaviors were performed, and the vegetation type and height which was foraged on were recorded. Both foraging as well as non-foraging behavior (ruminating, drinking, resting, moving and mating) was taken into account.

The area was divided into nine habitat types: 'bare ground', 'grassland', 'herbs', 'scrubs', 'forest', 'water', 'grassland under trees', 'scrubs with herbs' and 'moss'. The different habitat types in the field were determined by the most prominent vegetation, for example, if the location of a herd consists primarily of grass if is considered grassland. If the herds performed foraging behavior the vegetation type was determined, which were grouped into four classes: 'grasses', 'herbs', 'shrubs' and 'trees'. These classes will be further specified in: 'wood small-reed', 'common reed', 'mix of wood small-reed and common reed', 'mix of wood small-reed and grass' and 'other'; 'creeping thistle', 'ragwort', 'nettle', 'hemp agrimony', 'great burdock' and 'other'; 'eglantine rose', 'blackberry/dewberry', 'creeping willow' and 'other'; and 'willow', 'poplar', 'white abele', 'elderberry', 'alder', 'silverberry', 'sea-buckthorn' and 'other' respectively. When foraging behavior was performed on grass the following data was collected: grass height and color. Vegetation height is determined by using a scale related to the physiognomy of the animal: 'shortly grazed', 'hoof', 'knee' and 'belly' which corresponds with '< 3 cm', '3-20 cm', '20-50 cm' and '> 50 cm' respectively (Lamoot, 2004). Grass color is determined as this is an indication of the nutritional value. Grass color is divided between yellow/brown, green and a mix of both.

Since, the behavior and habitat use of the Koniks and cattle is not only determined by the availability of different vegetation species, data is also collected on the weather conditions ('temperature', 'precipitation', 'cloud cover' and 'shadow cover'). For example, in the summer with high temperatures and no clouds it is likely that the Koniks and cattle will stay in the shadow or near water more than they would do otherwise, and this results in a different impact on the vegetation.
Additionally, and different from previous studies in the area, the location of the animals in the field will be recorded by using GPS (Global Positioning System) in order to

investigate the pressure of Koniks and cattle in different parts of the area. Since there are no animals equipped with GPS-collars, GPS-coordinates will also need to be recorded in the field every five minutes. The advantage of recording the GPS data in the field is the ability to link this data directly to the behavioral observations, which can be helpful in determining the overall impact on vegetation as each behavior induce a different impact.

3.2 Data analysis

The first step in the data analysis is the calculation of the time budget of both Koniks and cattle. This calculation will be based on the total time spent on each behavior per day. The differences in overall time budget between Koniks and cattle will be investigated by using an ANOVA-model.
The habit use is then investigated by considering the mean foraging time per day per habitat type. An ANOVA-model will be used with two fixed factors 'habitat type' and 'species' to determine if foraging is performed significantly more in specific habitats by cattle and Koniks. The use of the habitat types will further be investigated by taking into account the availability of the habitat types. This will be done by dividing the mean foraging time per day per vegetation type by the available surface (in hectares) of that specific vegetation type. This preference for certain habitat types will be quantified using Jacobs' (1974) index of selection:

$$D_i = \frac{p_i - A_i}{(p_i + A_i) - (2 \cdot p_i \cdot A_i)}$$

in which p_i is the mean proportion of the total foraging time spent in the *i*th vegetation type and A_i is the proportion of the area covered by the *i*th vegetation type. The value of D can range from -1 to +1, with negative values indicating avoidance and positive values indicating preference of the vegetation type.

The above mentioned analyses will also be performed for different seasons. As data is collected in two separate time-periods (July-August and November-December) it is possible to investigate this difference using a mixed-model ANOVA on the different behavioral aspects. In order to see if this difference only occurs between these two time periods or if the behavior of the cattle and Koniks changed throughout a year data from the previous studies in the area will be combined with the data collected in this study.

Only the different behaviors and foraging behavior in different habitat types will be analyzed for seasonal differences. The different seasons are determined by plant productivity periods in temperate regions (Lamoot, 2004); summer: June-August; autumn: September-November; winter: December-February; spring (March-May). The different habitat types will be aggregated in six habitat types: 'bare ground', 'grassland', 'herbs', 'scrubs', 'forest' and 'water'.

The GPS data collected is digitalized and processed with Google Earth Pro, which makes it possible to determine if there is a pattern to the movements and location of the Koniks and cattle as this will most likely influence the vegetation development in the area.
All statistical analyses are performed with SPSS 20.

4. RESULTS

4.1 Time budget of Highland cattle and Konik horses

Error! Reference source not found. gives an overview of the time budget of the cattle and konik herds. In general foraging took the main part of the time-budget; on average 33% of the observed time for the cattle and 51% and 49% respectively for the large and small konik herd (Figure 4.1). Resting, walking and ruminating – the latter only applicable to cattle – are other behaviors which form the majority of the time budget. On average, cattle spent 33% of their day-time ruminating, 24% resting and 7% walking, while the konik herds on average spent 35% and 32% resp. of their time resting and 10% and 14% resp. walking. Other behaviors including drinking and mating accounted for only 3% of the total daytime for cattle and 4% and 5% resp. for konik. Figure B.1 in the Appendix illustrates the overall time budget and the variation between both observed time periods for the cattle and konik herds.

The multi-way ANOVA shows that the proportion of time per day spent on foraging is significantly affected by the factors 'Species' ($p < 0.001$) and 'Time period' ($p < 0.001$). Post-hoc test show that the influence of the factor 'Species' is limited to a significant difference between the cattle and both konik herds. The konik herds do not differ significantly. In the second time period (Nov-Dec) all herds have significantly longer foraging times than in the first time period (July-Aug). The interaction between the factors 'Species' and 'Season' is not significant.

The proportion of time resting is also significantly influenced by the factors 'Species' ($p = 0.001$) and 'Time period' ($p < 0.001$). In this also, this difference is only between the cattle and both konik herds. No significant difference is found between both konik herds. Opposite as with the time foraging, the time spent on resting is significantly shorter in the second time period (Nov-Dec) compared to the first time period (July-Aug). The interaction between the factors 'Species' and 'Season' is not significant.

Finally, the proportion of time walking is only significantly influenced by the factor 'Species' ($p <0.001$) and not by the factor 'Time period' ($p = 0.105$). All herds differ significantly in the time spent walking, with the cattle herd spending the least amount of time on walking and the small konik herd most. In this case also the interaction between the factors 'Species' and 'Season' is not significant.

In Appendix B figures B.2-7 show the difference between the different time periods for foraging, walking and resting for the different herds.

Table 4.1
Percentage of time per day spent on each behavior by the cattle and konik herds: mean, minimum (min.), maximum (max.) and Standard Error (SE).
Effect of time period on mean percentage of time per day: ***: p <0.005; **: p<0.01: *: p<0.05; n.s.: not significant.

Animal Species	Behavior	Time				Effect
		Mean	Min.	Max.	SE	Period
Cattle						
	Foraging	33.3	19.0	52.8	2.07	*
	Ruminating	32.7	19.0	41.7	1.39	n.s.
	Drinking	0.7	0.0	2.4	0.20	*
	Resting	23.6	9.5	38.1	1.85	*
	Walking	6.9	2.4	17.9	0.93	n.s.
	Mating	0.0	0.0	0.0	0.0	
	Other	2.9	0.0	6.0	0.31	n.s.
Konik (large)						
	Foraging	51.0	25.0	69.0	2.92	***
	Drinking	0.4	0.0	2.4	0.16	n.s.
	Resting	34.8	15.9	66.7	3.08	***
	Walking	10.4	4.8	19.0	0.80	n.s.
	Mating	0.0	0.0	0.0	0.0	
	Other	3.4	0.0	9.5	0.64	n.s.
Konik (small)						
	Foraging	48.5	34.5	60.7	2.48	n.s.
	Drinking	0.4	0.0	1.4	0.18	n.s.
	Resting	32.1	21.8	51.2	2.90	n.s.
	Walking	13.8	6.0	19.2	1.04	n.s.
	Mating	0.0	0.0	0.0	0.0	
	Other	5.1	2.5	8.3	0.45	n.s.

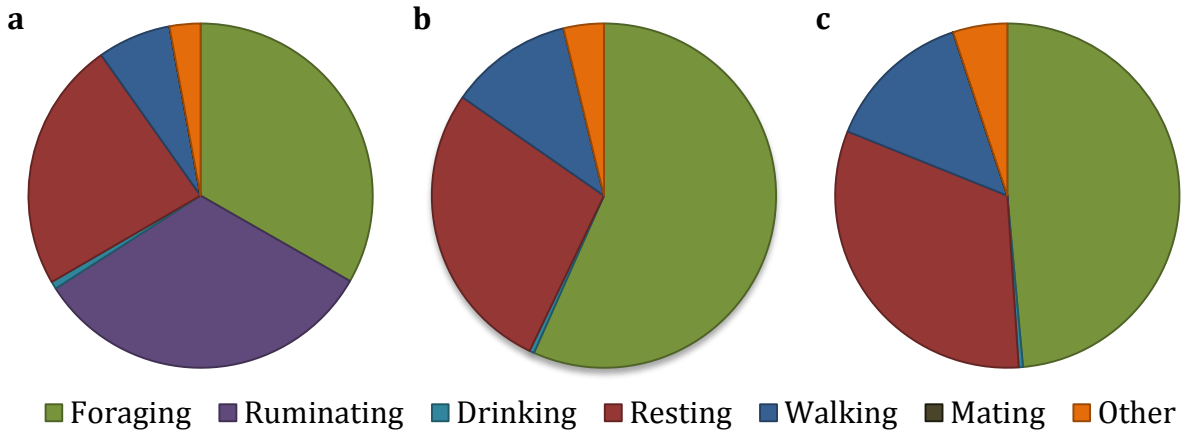

Figure 4.1
Time budget of cattle herd (a), large (b) and small (c) herd of konik based on average percentage of time per day.

4.2 Foraging behavior and habitat use

As shown in the previous section the mean foraging time of the cattle and konik herds was significantly affected by the observed time period. Post-hoc tests show that the cattle as well as the konik herds have significantly higher foraging times in the period November-December compared to July-August. To further investigate the foraging behavior and habitat use, the difference in food intake and average foraging time per habitat type per day is considered as well as the difference in foraging between different vegetation species and grass heights.

4.2.1 Habitat type

A multi-way ANOVA shows a significant effect ($p < 0.001$) of habitat type on the foraging time. Figure 4.2 shows how the foraging time is distributed between the different habitat types in the area. The cattle and konik herds spent most of the time foraging in grassland. Their is no significant difference between the herds; cattle spent on average 84% of the foraging time in grassland and the big and small konik herd spent 90% and 93% respectively. Calculating Jacob's Index for grassland gives values of 0.7, 0.8, and 0.9 respectively which means a very strong preference to grassland.

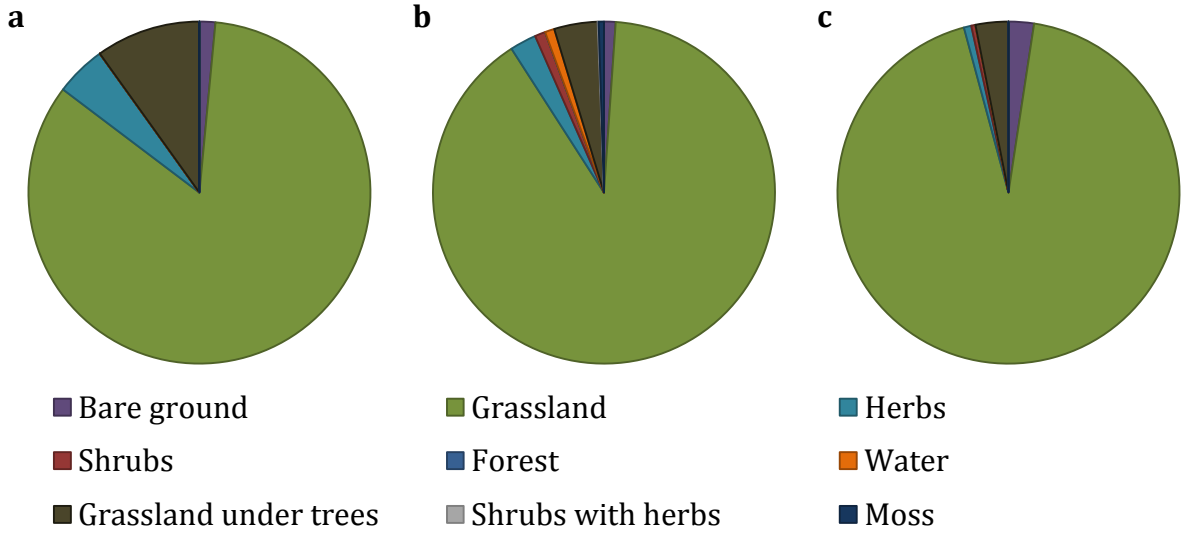

Figure 4.2
Proportion of foraging time spent in different habitat types for the cattle (a), large (b) and small (c) konik herds.

4.2.2 Vegetation type

The cattle and konik herds all feed on grass, herbs, shrubs and tree species. There is a significant difference ($p < 0.001$) between the cattle and both konik herds. On average the cattle feed on grass 71% of the time, while the konik herds both feed on grass 96% of time (Figure 4.3). This difference is largest in the time period July-August. In this period the cattle eat significantly ($p < 0.001$) less grass than in the period November-December (58% and 82% respectively), while the grass intake of both konik herds does not differ significantly between both periods.

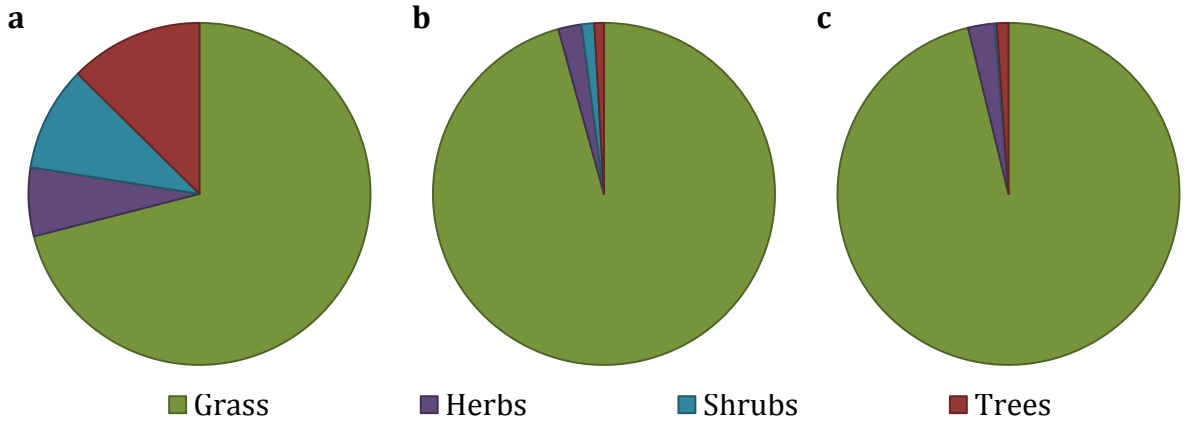

Figure 4.3
Proportion of foraging time spent on different vegetation types for the cattle (a), large (b) and small (c) konik herds.

4.2.3 Grass height

The cattle and konik herds different grass heights: short, hoof, knee and belly. There is a significant difference ($p < 0.001$) between the cattle and both konik herds. On average the cattle feed on hoof-high grass 74% of the time, while the konik herds both feed on hoof-high grass 53% and 64% of time resp. (Figure 4.4). For the cattle there is no significant difference between both periods. For the koniks there is; in the winter period the forage significantly less ($p = 0.042$) in hoof-high grass, they forage more in both short and knee-high grass, although this difference is not significant.

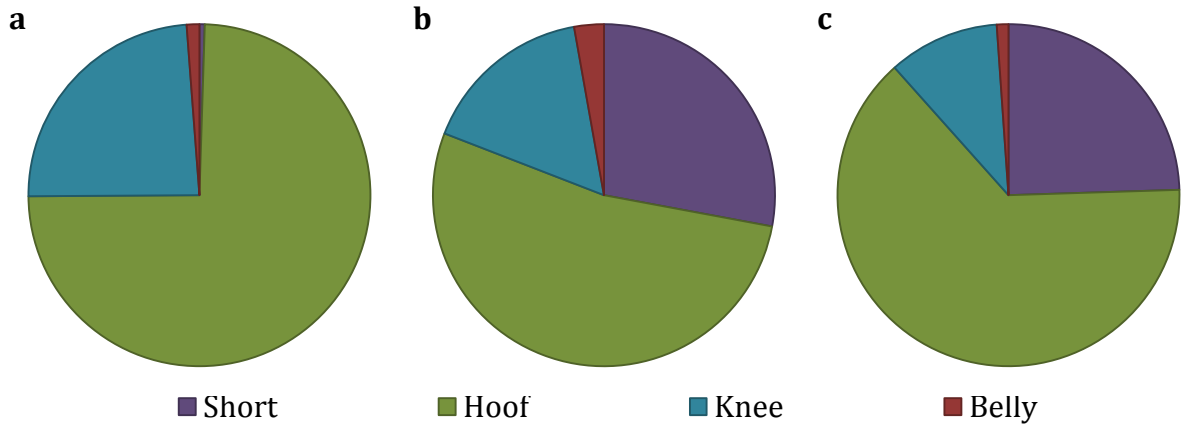

Figure 4.4
Proportion of foraging time spent on different grass heights for the cattle (a), large (b) and small (c) konik herds. Short: <3 cm; Hoof: 3-20 cm; Knee: 20-50 cm; Belly: >50 cm.

4.3 Seasonal differences in habitat use

As shown previous there is a difference in time budget, habitat use, and foraging behavior of the Highland cattle and Konik horses between the two observation periods. Data from this study and the other studies performed in the area is aggregated to investigate if this difference is also present between all seasons.

4.3.1 Time budget

Table 4.2 gives an overview of the average time budget of the cattle and konik herds over a year. In general foraging took the main part of the time budget; on average 57% of the observed time for the cattle and 70% for the koniks. Resting, walking and ruminating – the latter only applicable to cattle – are other behaviors which from the majority of the time budget. On average, cattle spent 22% of their day-time ruminating, 15% resting and 4% walking, while konik on average spent 23% of their time resting and 6% walking. Other behaviors including drinking and mating accounted for only 2% of the total daytime for cattle and only 1% for konik. Figure 4.5 illustrates the time budget of the Highland cattle and Konik horses over the whole year and the variation between seasons.

Table 4.2
Percentage of time per day of each behavior by cattle and konik: mean, minimum (min.), maximum (max.) and Standard Error (SE).
Effect of season on mean percentage of time per day: ***: p <0.005; **: p<0.01: *: p<0.05; n.s.: not significant.

Animal Species	Behavior	Time				Effect
		Mean	Min.	Max.	SE	Season
Cattle						
	Foraging	57.4	5.2	98.6	2.34	***
	Ruminating	22.0	0.0	55.2	1.45	*
	Drinking	0.4	0.0	2.7	0.09	*
	Resting	14.9	0.0	42.5	1.41	***
	Walking	4.2	0.0	17.9	0.44	**
	Mating	0.1	0.0	1.4	0.02	n.s.
	Other	1.0	0.0	6.0	0.17	***
Konik						
	Foraging	69.6	25.0	100	1.73	***
	Drinking	0.4	0.0	2.9	0.08	n.s.
	Resting	23.3	0.0	66.7	1.53	***
	Walking	5.7	0.0	19.0	0.53	*
	Mating	0.1	0.0	4.1	0.05	n.s.
	Other	0.9	0.0	9.5	0.21	***

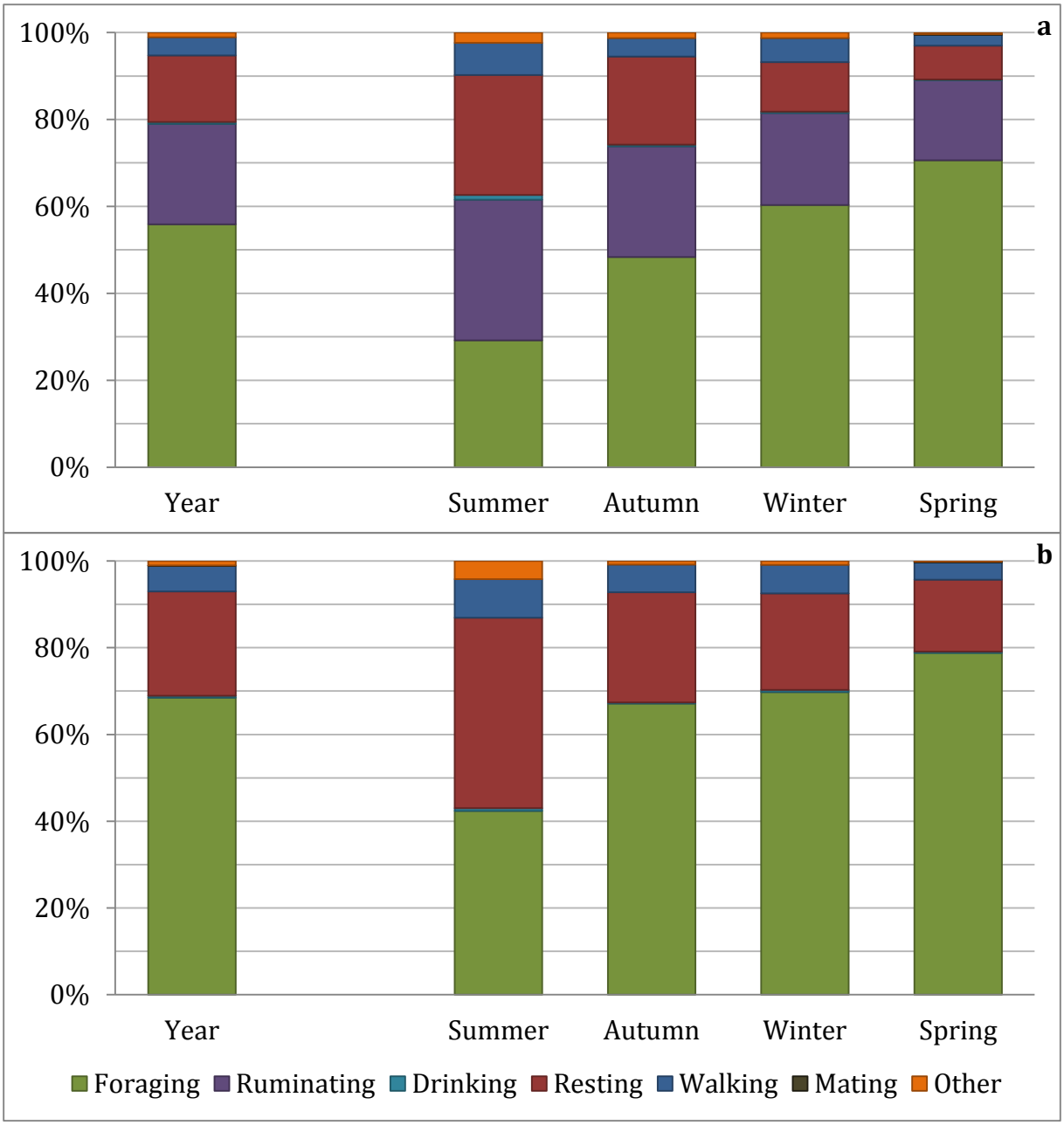

Figure 4.5
Time budget of Highland cattle (a) and Konik horses (b) over an entire year, and in summer (Jun-Aug), autumn (Sep-Nov), winter (Dec-Feb) and spring (Mar-May).

4.3.2 Seasonal difference of behavior

Foraging behavior

The mean foraging time per day of cattle is significantly affected by season ($p < 0.001$). Post-hoc tests show that cattle have significantly lower foraging times in summer compared to the other seasons (summer: 29% per day; autumn: 52%; winter: 61%; spring: 71%). For the koniks mean foraging time per day is also significantly affected by season ($p < 0.001$). In this case post-hoc tests show that the koniks had significantly lower foraging times in summer (summer: 43% per day; autumn: 68%; winter: 70%; spring: 80%).

Resting behavior
The mean resting time of cattle is significantly affected by season ($p < 0.001$). Post-hoc tests show that the resting behavior in summer and autumn is significantly higher than in winter and spring (summer: 28% per day; autumn: 20%; winter: 11%; spring: 8%). For the koniks the mean resting time per day is also significantly affected by season ($p < 0.001$). Post-hoc tests show significantly higher resting times in summer than other seasons (summer: 44% per day; autumn: 25%; winter: 22%; spring: 16%).

Walking behavior
The mean walking time of the cattle is significantly affected by season ($p = 0.009$). Post-hoc tests show that in spring the cattle walk significantly less, and in summer significantly more, when compared with autumn and winter (summer: 7% per day; autumn: 5%; winter:5%; spring:3%). The walking behavior of the koniks is also significantly affected by season ($p = 0.036$). Post-hoc tests show that in summer the koniks walk significantly more and in spring less than in autumn and winter (summer: 9% per day; autumn: 6%; winter:7%; spring: 4%)

Ruminating
The mean time ruminating by cattle is significantly affected by season ($p = 0.029$). Post-hoc tests show that in summer the cattle ruminate significantly more than in other seasons (summer: 32% per day; autumn: 23%; winter: 21%; spring: 18%).

4.3.3 Habitat use
To investigate the habitat use of the cattle and konik horses the average foraging time per vegetation type per day is considered as this is the most important behavioral aspect. Since the vegetation categories 'grassland under trees' and 'shrubs with herbs' are only added since the previous study, they are now considered part of the categories 'forest' and 'shrubs' respectively.

Of all the time the cattle were foraging 56% of this time was in grassland, 17% in shrubs and 14% in herbs. Foraging time in other vegetation types was much lower: 17%, 14% and 13% in shrubs, herbs and forest respectively. The results for the koniks are similar. In this case 65% of foraging time was spent in grassland. In other vegetation types this was lower: 14%, 14% and 6% in shrubs, herbs and forest respectively. Figure 4.6 illustrates how the foraging behavior is distributed between the different habitat types throughout a year and in the different seasons.

Knowing how much time is spent grazing in the different habitat types by the cattle and konik it is possible to calculate Jacobs' sensitivity index to show if there is a preference or avoidance of certain habitat types during each season. Table 4.3 shows these preferences.

Calculating the Jacob's sensitivity index shows if there is a preference over one habitat type over the other for foraging. Table 3.3 shows the preference of cattle and koniks over the year and in the different seasons.

Table 4.3
Jacobs' sensitivity index for cattle (C) and konik (K).
No selection (o): -0.08 < index < 0.08. Avoidance (-): -0.4 < index < -0.08. Strong avoidance (--): index < -0.4. Preference (+): 0.08 < index < 0.4. Strong preference (++): index > 0.4. Shrubs: shrubs & shrubs with herbs; Forest: forest & grassland under trees.

Habitat	Year		Summer		Autumn		Winter		Spring	
	C	K	C	K	C	K	C	K	C	K
Open ground	+	+	+	-	++	++	+	--	--	--
Grassland	+	++	o	++	+	+	o	+	++	++
Herbs	o	-	-	-	+	+	+	o	--	--
Shrubs	-	-	-	--	-	-	+	-	-	-
Forest	+	-	++	-	o	-	+	+	+	-

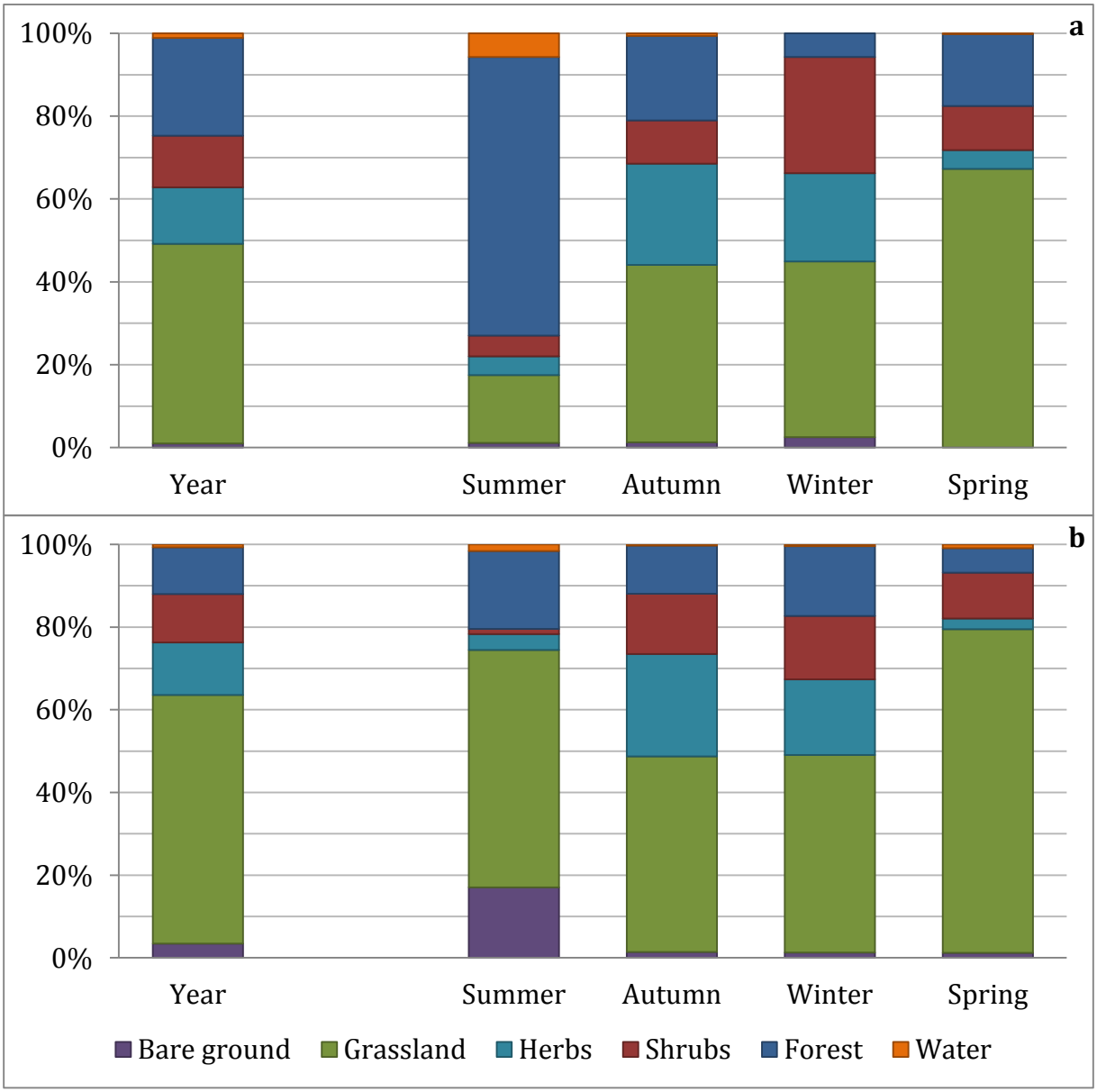

Figure 4.6
Proportion of foraging time spent in different habitat types by Highland cattle (a) and Konik horse (b) over an entire year, and in summer (Jun-Aug), autumn (Sep-Nov), winter (Dec-Feb) and spring (Mar-May).

5. DISCUSSION

Time budget

The time budget of the Highland cattle and Konik horses on Landtong Rozenburg differ significantly when foraging is concerned. The konik herds spent a lot more time on foraging than the cattle herd, which is in line with previous studies performed in temperate coastal areas (Arnold & Dudzinski, 1978; Menard et al., 2002; Lamoot, 2004). During the day (between 9:00 and 16:00h) the koniks spent on average 50% of their time on foraging while the cattle spent 33% of their time grazing. This difference is present between both observation periods as well as between the different seasons. The amount of time foraging by all herds are no extremes. Several studies (Duncan, 1985; vanDierendonck et al., 1996; Lamoot, 2004) report average foraging times between 50 and 70%. Foraging times for cattle are reported between 36 and 48% (Menard et al., 2002). During the summer the cattle as well as both konik herds spent less time foraging, while it increased during winter and the highest levels are recorded during spring. This increased foraging activity is known for feral horses (Duncan, 1985; vanDierenconck et al., 1996; Menard et al., 2002) as well as for cattle (Arnold & Dudzinski, 1978; Menard et al., 2002). The reason for this increased foraging time can be explained by the decreased food quality and availability in winter. For cattle the increased foraging time can also be explained by the inaccessibility of short-grazed grasslands for cattle (Lamoot, 2004).

Habitat use and foraging behavior

Throughout both observation periods the Highland cattle and Konik horses foraged in all habitat types, though most of their foraging time was spent in grassland which was strongly preferred by both cattle and koniks according to Jacobs' sensitivity index (1974). This preference for grassland is also found in other ecosystems where the habitat use of large herbivores has been studied (Menard et al., 2002; Lamoot, 2004). Habitat use was also influence by seasons. Grasslands were less preferred in autumn and winter and foraging for cattle was then transferred to all other habitat types and koniks spent more time foraging in forested areas, though they still spent almost half of the time grazing in grassland. This change in preference for grasslands between seasons can be explained through the lower plant productivity during the non-growing seasons (autumn and winter) (Gordon & Prins, 2008). In addition, blackberry and dewberry (important components of the scrubs and forest undergrowth) still offer green biomass of high quality in late autumn and winter which attracts mainly the cattle to spent more of their foraging time in scrubs and forest in winter. Although both the cattle and the koniks spent most of their foraging time in grassland, the koniks concentrated their foraging more in the grass-dominated area of Landtong Rozenburg. Located in the center of the area is a large grass-dominated area that attracted both konik herds during the observation periods of this study as can be seen in Figure B.2 in the Appendix.

Horses are considered to be true grazers who forage primarily on grasses (Hoffman, 1989; Vulink, 2001). This study confirms this as the both konik herds spent 96% of their foraging time on grass. However the cattle can also be considered true grazers, though they forage less on grass it still constitutes to 71% of their foraging time which has also been found by the study of Lamoot (2004). Interestingly the cattle spent less time

foraging on grass in the summer period (July-August) than they did in the winter period (November-December), 58% and 82% respectively. This is contradictory to other studies on foraging behavior of cattle (Vulink, 2001; Menard et al., 2002; Lamoot, 2004). One explanation that can be given is the fact that the cattle on Landtong Rozenburg have a strong preference towards willow leaves, which are abundant in the summer period.

In the grasslands there was difference visible in the grass heights foraged on by cattle and koniks. In the grasslands both konik herd spent on average 26% of their time foraging on short grass and 58% on grass of 3-20cm. The cattle on the other hand spent under 1% of their time foraging on short grass and 74% on grass of 3-20cm. The study of Menard et al. (2002) also found this difference in grass heights. In winter the cattle stopped grazing on very short grass, while the koniks increased the time spent foraging on short grass. There are two aspects that can explain this difference. First, the as the grassland is a preferred foraging habitat the grazing pressure is high resulting in more short grass in winter, which explains the increased foraging time of the koniks on short grass. Secondly, the cattle are constrained to graze on short grass because of the lack of upper incisors (Illius & Gordon, 1978). Additionally, cattle spent more time foraging on knee-high grass in both periods than both konik herds. The cattle spent on average 24% of their foraging time on knee-high grass, while this was only 13% for the koniks. As suggested by Lamoot (2004) while short grass is a constraint to cattle, it seems that higher grass forms a constraint to the konik horses.

Influence on vegetation

On Landtong Rozenburg grazing management by the Highland cattle and Konik horses is implemented to maintain a diverse, species-rich area. In order to maintain this, the expansion of scrubs and trees needs to be prevented. The differences in habitat use and foraging behavior of the cattle and koniks determine the impact on the vegetation structure. Year-round the koniks spent the majority of their time foraging on grass in grasslands and as they are also better able to forage on short grass they are very suitable to maintain the grassland habitats in the area. However, as their general foraging time is concentrated around the central grassland habitat in the area and their foraging on scrubs and trees is limited, they have very little impact on the scrub invasion into grasslands. Cattle, however, forage on scrubs and trees and spent less of their foraging time in grasslands. Thus the cattle have a potential impact on the vegetation structure of scrubs and trees, by direct consumption but also by opening scrub layers due to their movements. Vulink (2001) found similar results of horses concentrating their habitat use on grasslands, while cattle foraged more over the entire area.

Grazing as a management tool is most effective with a combination of cattle and horses (Vera, 2010). If Konik horses were the only herbivores present in the area, there is far less foraging in scrub and forest habitat as the koniks would avoid densely closed vegetation. By moving through and foraging in scrubs and forest, cattle create gaps and maintain a more open vegetation structure.

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APPENDIX

Appendix A: Fieldwork protocol and observation form

A.1 Protocol

Temperature	In degrees Celsius
Clouds	1 < 10% 2 10 – 50% 3 50 – 75% 4 > 75% (fog)
Precipitation	0 Dry 1 Light rain 2 Moderate rain 3 Heavy rain 4 Snow/Hail
Cover	1 Open 2 Half shadow 3 Full shadow
Vegetation	0 Open ground 1 Grassland 2 Herbs 3 Shrubs 4 Forest 5 Water 6 Grassland under trees 7 Shrubs with herbs 8 Moss
Activity	1 Foraging 2 Ruminating 3 Drinking 4 Resting 5 Walking 6 Heat/Mating 7 Other
Grazing	0 n/a 1 Grass 2 Herbs 3 Shrubs 4 Woody
Color grass	0 n/a 1 Yellow/Brown 2 Green 3 Mix of Green/Yellow
Length grass	0 n/a 1 Shortly grazed (< 3cm) 2 Hoof (3 – 20cm) 3 Knee (20-50cm) 4 Belly (> 50cm)
Grass species	0 n/a 1 Wood Small-reed 2 Common reed 3 Other 4 Mix of Wood Small-reed/Common reed 5 Mix of Wood Small-reed/Grass
Herbs species	0 n/a 1 Creeping thistle 2 Ragwort 3 Nettle 4 Hemp agrimony 5 Great burdock 6 Other
Shrub species	0 n/a 1 Eglantine rose 2 Blackberry/Dewberry 3 Creeping willow 4 Other
Woody parts	0 n/a 1 Branches/Twigs 2 Bark 3 Leaves
Woody species	0 n/a 1 Willow 2 Poplar 3 White abele 4 Elderberry 5 Alder 6 Silverberry 7 Sea-buckthorn 8 Other

A.2 Observation form

Date:

Cattle/Konik Large/Small
Summertime/Wintertime

Time	Temperature (°C)	Clouds	Precipitation	Cover	Vegetation	Activity	Feeding	Color grass	Length grass	Grass species	Herb species	Shrub species	Woody parts	Woody species	GPS-coordinates Remarks

Appendix B: Additional figures

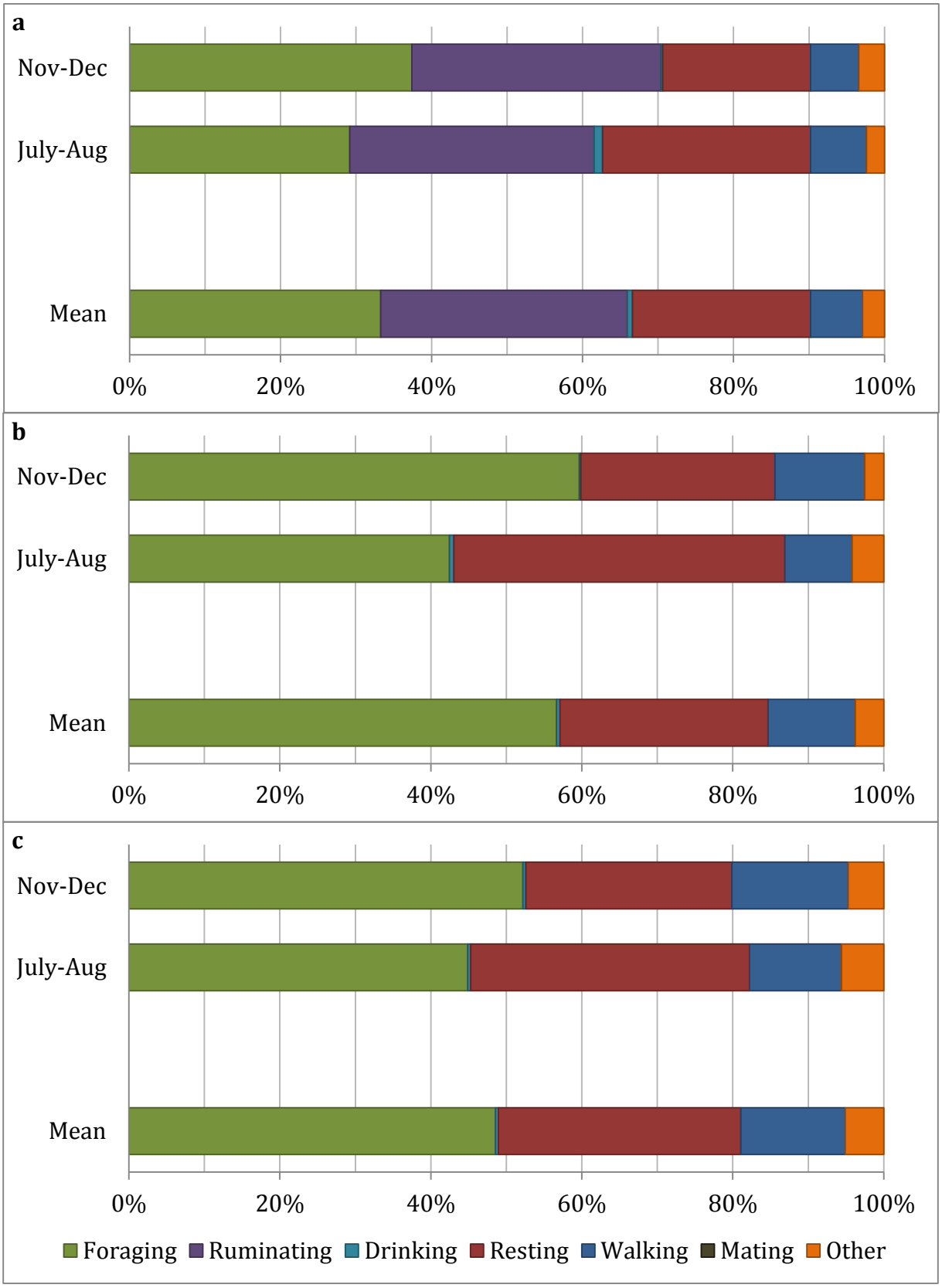

Figure B.1
Time budget of the cattle (a) and konik herds (b: big herd; c: small herd). Percentages are based on mean time per day.

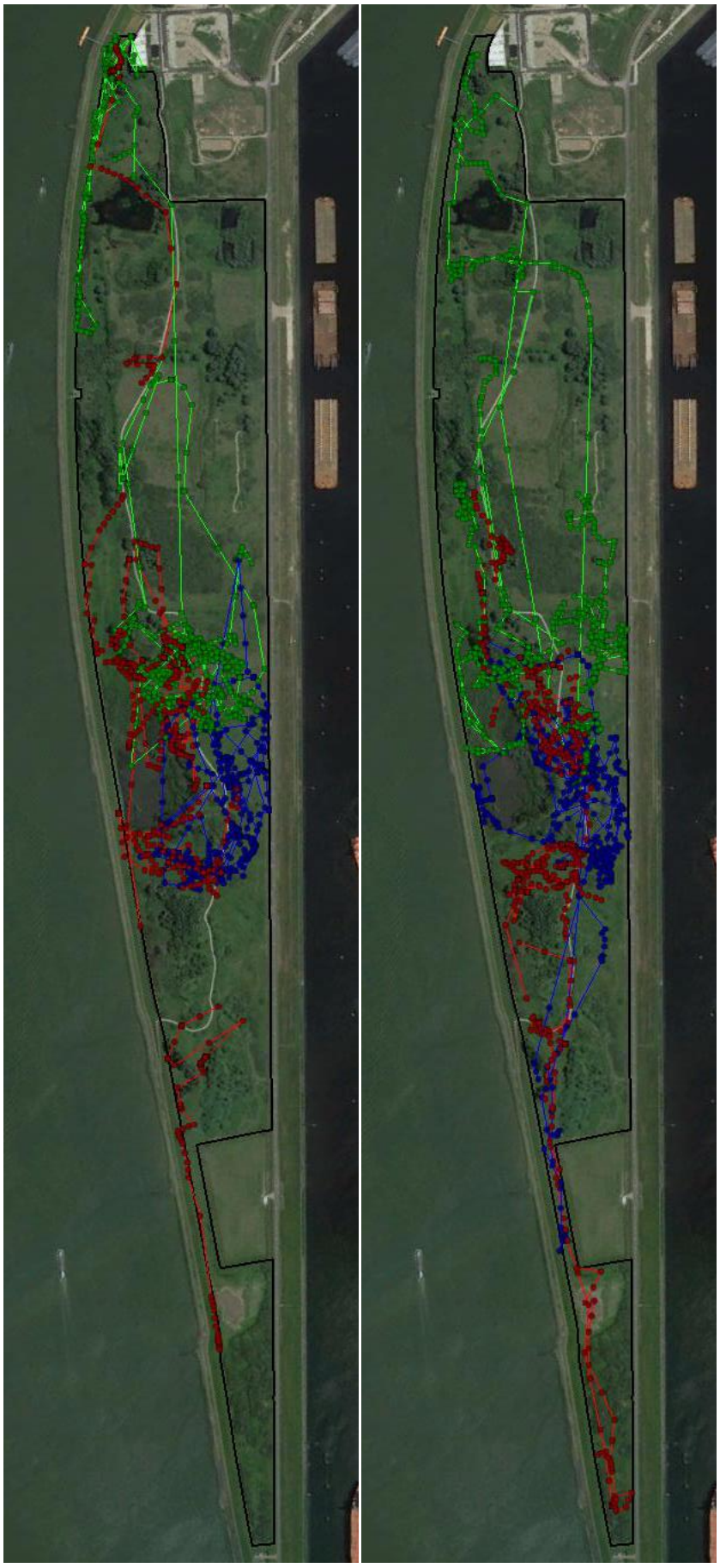

Figure B.2
GPS data of the cattle (red), large (green) and small (blue) konik herds.
Upper picture: Summer period (July-August)
Lower picture: Winter period (November-December)

More additional data and figures are digitally available through the supervisor MJ Wassen (M.J.Wassen@uu.nl)