University of South-Eastern Norway
Faculty of Technology, Natural Sciences and Maritime Sciences

Master's Thesis

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# *In situ* feeding observations of wild mountain reindeer *(Rangifer tarandus tarandus)* in Setesdal Austhei and Brattefjell-Vindeggen

A unique window into the wild reindeer's behaviour and their use of forested areas.

*The picture on the front page is a screenshot from the videos (NINA), showing wild reindeer in SA feeding on snow-free patches in typical alpine habitats.*

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This thesis is worth 60 study points

# Abstract

Free-roaming wild mountain reindeer (*Rangifer tarandus tarandus*) are by nature shy and difficult to approach and are only observable from a distance in open mountain areas, especially the wild reindeer in Southern Norway who tend to use forested areas in summer and autumn. Only three other studies have used cameras fitted to wild reindeer; only one was on wild mountain reindeer in Norway. The data was sampled from animal-borne videos from March to October from two female reindeer, each in two areas where the reindeer are known to utilize forests for grazing. This provided direct observation of their grazing behaviour and to what extent and what they eat, mainly when they utilize less open forested areas.

The results show that both the reindeer use different forest habitats from early spring till late summer, but that alpine heathlands are important habitats year-round, and dwarf shrub heaths are used frequently in summer too. Mountain birch forests and spruce forests are the most used forest types for feeding; mountain birch forests are the most used in Setesdal Austhei, and the blueberry-dominated spruce forest in Brattefjell-Vindeggen. The most eaten vegetation in both areas was herbs and grasses (graminoids), while the second most eaten was lichen, used for grazing even in summer.

# Contents

# Foreword

This master thesis is part of the master's program in Environmental Science at the University of South-Eastern Norway, at the Department of Natural Sciences and Environmental Health in Bø in Midt-Telemark.

I am grateful to the Norwegian Institute of Nature Research (NINA) for providing the data that this thesis is based on and getting to know these two individuals so well. Norway's wild reindeer, our national treasure, have always been special to me as it is to so many of us, it has been a true pleasure to learn more about them. The many memories I've made during this project will stay with me, especially the memory of the female reindeer in Brattefjell-Vindeggen having her calf on my birthday in May, at almost the exact same time of day too.

I would like to thank Jan Heggenes (USN), who has been my supervisor through these many months of work, and for giving helpful feedback. A very special thanks to Marijanne Holtan (USN), whom I have been so lucky to work with on the same project. All the help with the methods and data has been invaluable, and I would not have stayed as sane during this without our many conversations and the time you took to help and reassure me.

Roland Pape (USN) and Stefanie Reinhardt (USN) helped me identify plant species, and Roland helped translate some very Norwegian vegetation types into English, as well as giving last minute help with GIS.

I learned first-hand how fickle nature can be, and I have been dealing with chronic illness since the year my thesis work started. Because of this, I have spent longer to finish this than planned, and I would have never made it through without my family and dear friends' support, whom I am very, very grateful for.

*Female in Brattefjell-Vindeggen resting with three weeks old calf in May 2019 in sub-alpine birch forest. (Photo: screenshot from video, Norwegian Institute for Nature Research (NINA).*

# 1 Introduction

Wild mountain reindeer (*Rangifer tarandus tarandus*) are large, migratory herbivores that have been grazing the Norwegian mountains for more than 10.000 years (Odland, 2021). Norway has the last remaining populations of the wild European mountain reindeer, considered a national treasure and a key species in alpine ecosystems and biodiversity (Punsvik & Storaas, 2002). Reindeer (*Rangifer tarandus*) were assessed as Near Threatened in Norway as of May 2021 due to small population sizes and ongoing decline (Eldegard et al., 2021). For all the above reasons, Norway has an international responsibility to conserve these ice age survivors in 24 wild reindeer areas in Southern Norway (Kaltenbron et al., 2017; Bjerkely, 2018). Unlike the other ungulates, wild reindeer live in large herds of up to hundreds of individuals, living a nomadic lifestyle (Skogland, 1994). The ecological factors behind this adaptation are the seasonal availability of resources and a way to avoid predation (Skogland 1990). In the low-productive and often extreme alpine environments, they have a cyclical use of areas through the seasons; they are constantly on the move and are grazing extensively (Skogland, 1993), always trying to find the most nutrient-rich and easily reached vegetation (Warenberg, 1997). Thus, wild mountain reindeer need large, continuous areas of habitats and vegetation year-round.

Today, many of the remaining wild reindeer populations in Norway are fragmented into smaller areas due to technical interventions that physically hinder migration. Additionally, the disturbances from humans are so great that they do not dare to cross barriers or follow old migration routes. Most wild reindeer populations in Norway are more or less cut off from their original nomadic migratory pattern (Skogland, 1993).

Alpine environments with long winters and short summers are characterised by substantial seasonal changes in nutrient availability and weather conditions (Frøstrup et al., 2016; Danell et al., 1994). Wild reindeer diets primarily consist of lichens, graminoids, dwarf shrubs, leaves, and fungi (Klein, 1990; Ophof et al., 2013), with their diet in the snow-free season consisting of a greater variety of plant species (Warenberg, 1977). Meadow communities and grass heaths often provide good diversity of preferred plants (Skogland, 1980). Reindeer are opportunistic feeders but prefer fresh and nutritive forage (Mårell et al., 2005). When the snow finally melts in early spring, they often search the early melting southern-faced slopes for new green growth, so-called green-wave surfing

(Rivrud et al., 2018; Skogland, 1984). When available later in the season, reindeer also prefer mushrooms (Skarin et al., 2022).

In most wild reindeer areas, winter grazing is dominated by lichen because they grow on ridges and areas with little or no snow cover, making them easily accessible for reindeer (Romtveit et al., 2021). Lichen can often be as much as 50% of their winter forage, and when abundant, even 80% (Heggeberget et al., 2002). The carrying capacity of a wild reindeer area can be defined as the number of animals that the available natural pastures can support in the long term without reducing future production and yield (Punsvik et al., 2006). Winter is «the season of discontent» because of limited resources and is often a population regulator (Holtan et al., 2023). In winter in the alpine areas, the available vegetation is scarce for two reasons: little plant cover and low productivity, and less availability of forage as determined by snow conditions (Heggberget et al., 2002).
Though reindeer have acquired the rare ability to digest lichen and use this carbohydrate-rich food for energy in the winter (Skogland 1990), lichens lack proteins and other nutrients. Thus, reindeer are typically stressed nutrient-wise come spring, and even more so for the pregnant females (Bevanger & Jordhøy, 2004; Skogland, 1994). Reindeer graze plants other than lichen in winter if an area has little snow cover and is not covered by hard ice (Warenberg, 1982).

Recently, lichen cover was used as a vital factor to classify the quality standard of the different wild reindeer areas in Norway, presumably reflecting winter carrying capacity (Rolandsen et al., 2022). It was stated that other species available in winter should be accounted for because, there is not much lichen in some areas; the animals survive and must rely upon other species besides lichen. This is not included in the quality standard, which only relies on the registered amount of lichen. In a study by Romtveit, Strand et al., 2021, results based on indirect but more detailed high-resolution remote sensing data suggested that wild mountain reindeer in winter preferably forage in habitats/patches with little or no snow cover, regardless of the type of vegetation. Therefore, they suggested that, based on these more detailed analyses, the amount of snow-free patches should be an important predictor of winter carrying capacity rather than simply lichen cover.

Although wild mountain reindeer primarily use alpine habitats, some of the wild reindeer areas in Norway include sub-alpine and forested areas, like Setesdal Austhei and Brattefjell-Vindeggen. From a climate perspective, the treeline is expected to rise (Verall & Pickering, 2020), possibly limiting the availability of alpine habitats. It is difficult to say how this will affect the wild reindeer; on the one hand, increased temperatures lead to milder winters and a longer growing season, and thus better conditions (Rolandsen et al., 2022), but a study by Johansson et al., 2011 on snow profile stratigraphy from Sweden showed an increase in very hard snow layers, harder snow in early winter and more moist snow during spring. Climate change is expected to be especially pronounced in alpine and arctic areas, with higher temperatures, increased precipitation and increased nutrient availability. Climate change will therefore have major impacts on plant production and plant communities in these habitats (Heggberget et al., 2002).

Thus, more detailed insight into large ungulate foraging and behaviour, especially more elusive species like reindeer, may change our understanding, perspectives and management decisions. Improved animal-borne video technology developed in the last decades has made it easier to directly explore ecological phenomena, with a less negative impact on the subject. There have been a few other studies using video cameras mounted on wild reindeer: Newmaster et al., 2013; Thompson et al 2012/2015 and Lyftingsmo, 2016, to my knowledge these are the only ones other than this study.

This project focuses on to what extent and how the wild reindeer use the forested areas; it is known that they may travel down from the alpine mountain to the lower-laying forests as the snow melts and vegetation becomes available in spring. The SA and BV wild reindeer areas were chosen because both populations use the forests for grazing, which is rare in other wild reindeer areas. However, there is a lack of knowledge about what they feed on in forested areas. Another important characteristic of these two areas is their contrasting amounts of lichen. SA has poor winter pastures with little lichen, yet this population are still in good condition (Rolandsen et al., 2022). BV provides amounts of lichen more typical for many other wild reindeer areas. This thesis project is part of the first study on wild reindeer in Norway using direct observation video cameras and GPS-tracking.

Therefore, the specific aims for this study were to

1. To investigate wild reindeer's seasonal area use, especially the use of forested areas, and
2. , foraging preferences in forested areas.

# 2 Study areas

Norway has 24 wild reindeer areas in total, all of these are situated in Southern Norway. These 24 areas are separated, due to natural geographic reasons, but also by human infrastructure and for practical conservation reasons (Punsvik et al., 2006). There are approximately 25 000 reindeer in total in Norway in wintertime (www.villrein.no). Topography and geology play a part in the available vegetation, but the climate is the most important. In the drier habitats in the eastern wild reindeer areas, with less snow, there are traditionally good winter pastures with large amounts of lichen. The wild reindeer areas to the west, has pastures with a wetter coastal climate and more lush vegetation. While the reindeer used to wander freely, searching for suitable seasonal pastures, they are bound within smaller geological areas today (Punsvik et al., 2006). SA and BV were both chosen to pe a part of the NINA study with GPS/camera, since both reindeer herds are known to utilize the forested areas in summer and fall, not much about their area use, or behaviour while down in the woods are known. SA is marked as "2" on the map below, and BV marked as "5" (Figure 1).

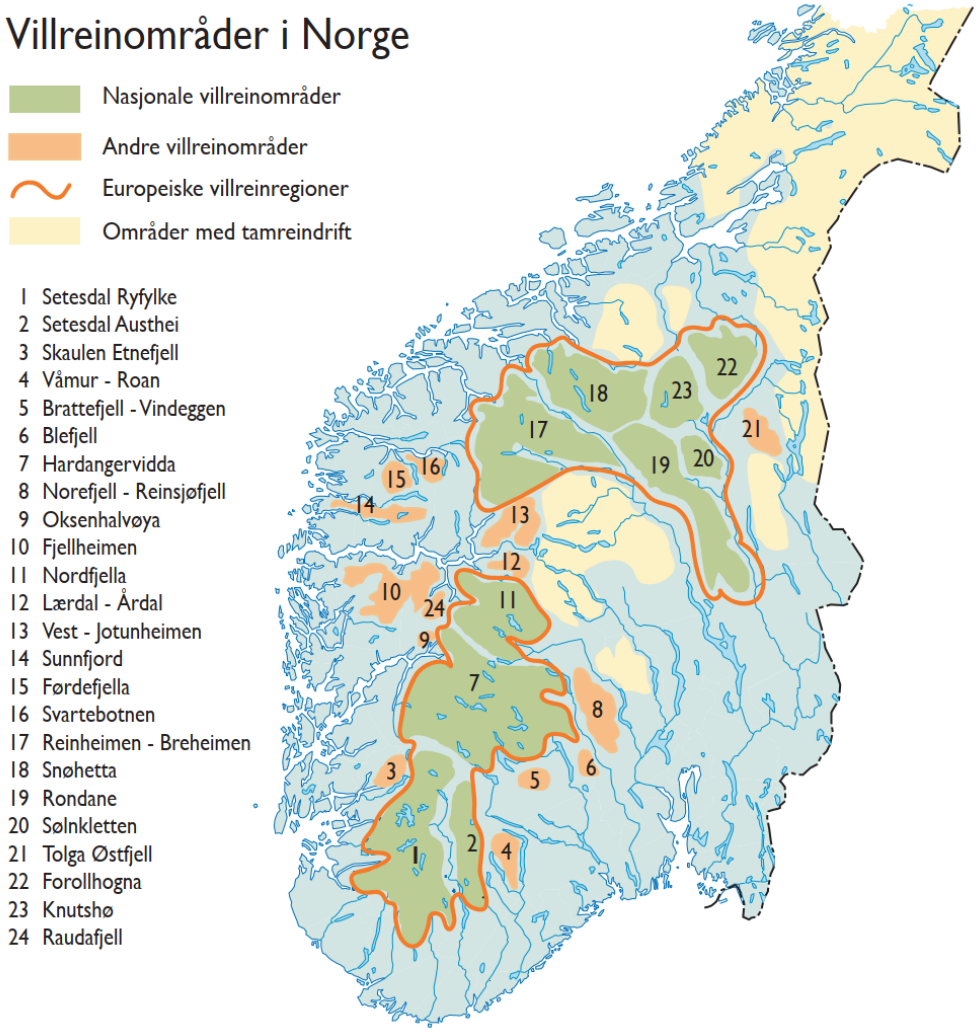

*Figure 1. The 24 wild reindeer areas in Southern Norway. The red line encompassing two larger areas shows the European wild reindeer regions. The areas in green are the national wild reindeer areas, the orange are other wild reindeer areas, and the yellow shows areas with domesticated reindeer. (www.villrein.no)*

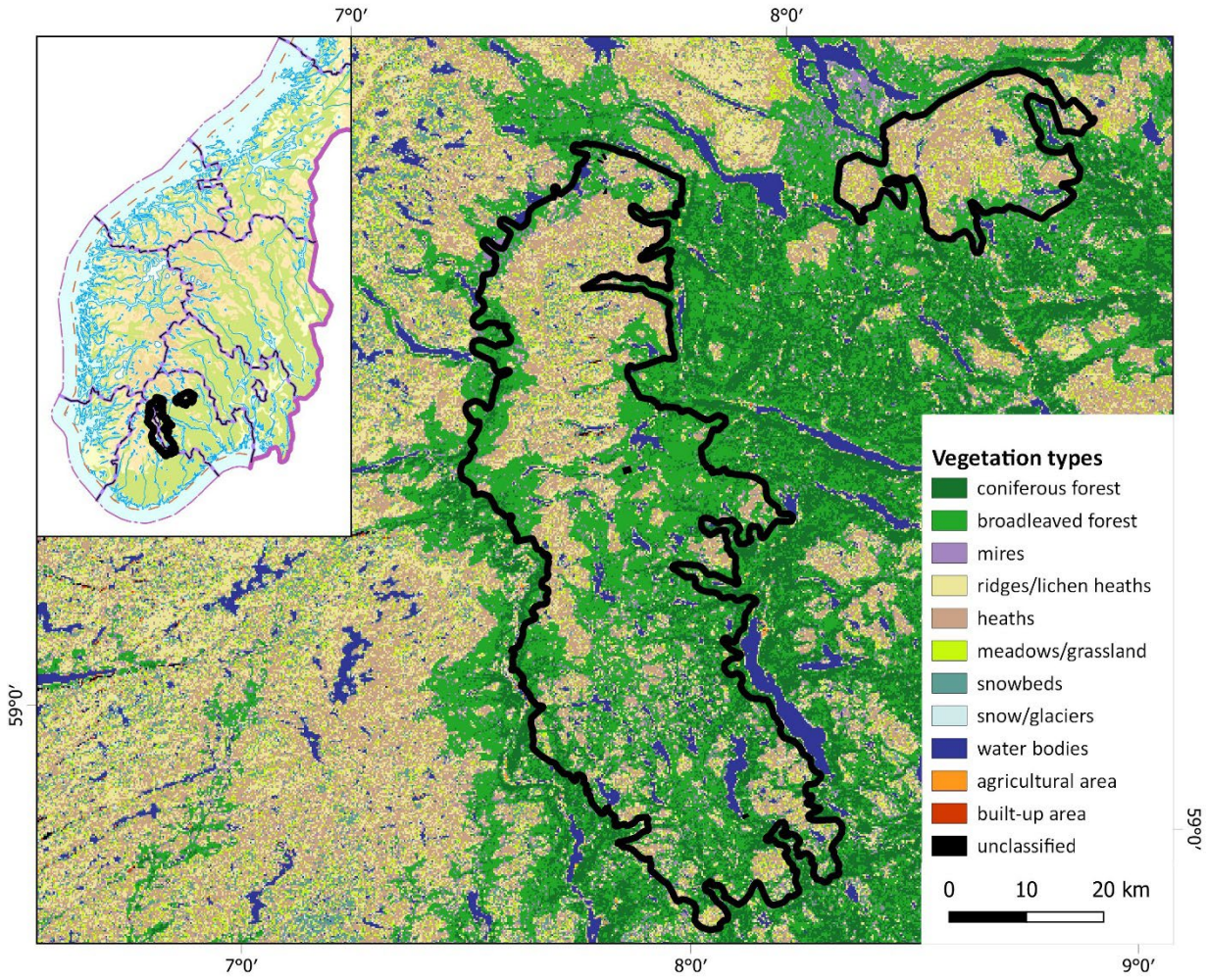


*Figure 2. Vegetation types in Setesdal Austhei (the largest area), and Brattefjell-Vindeggen (Johansen, 2009).*

## 2.1 Setesdal Austhei

With a total area of 2400 $km^2$, it located at 1000-1500 meters above sea level. SA has been a designated wild reindeer management area since 1980, it had domestic reindeer husbandry up until 1979. The area spans six municipalities: Bykle, Valle, Bygland, Vinje, Tokke, and Fyresdal, and by the counties Vestfold and Telemark, and Agder. E134 across Haukelifjell, RV42, and RV9 through Setesdalen forms the northern, southern, and western boundaries (Strand et al., 2010). In SA, seasonal pastures are split by Rv. 45, and the herd must cross Rv. 45 when traveling between the areas. The amount of anthropogenic impact with roads and the development of more and more cabins, give the herds fewer migration routes between their seasonal areas. The highly trafficked Rv. 9 is the probable reason there is less exchange of animals between Setesdal-Austhei and Setesdal Ryfylke.

The northern area (770$km^2$) has many mountain ranges with lichen and is where most of the population has their winter pastures, while the southern part (1600 $km^2$) is more forested and is where they have their summer pastures and calving grounds. The several valleys splitting up the mountain landscape gives opportunities from snow-free areas used for grazing in spring (Punsvik et al., 2016). The winter pastures in the Setesdal Austhei amounts to 1090 $km^2$. 24.0 percent of the winter grazing area consists of impediment or steep areas that are not accessible. The actual available area consists of 24.0 percent of winter grazing pastures. 57 percent (469 $km^2$) of the area is classified as poor, 18 percent (152 $km^2$) as medium, and 25 percent (207 $km^2$) as good, these classifications were done by NINA in their 2022 report “Classification of the ten national wild reindeer areas according to quality standards for wild reindeer”. The most important winter pastures are north of Fv 45 (Figure 3), but there are also areas south of there, as well as areas with birch forests, that are especially important in periods of difficult grazing conditions (Punsvik et al., 2016).

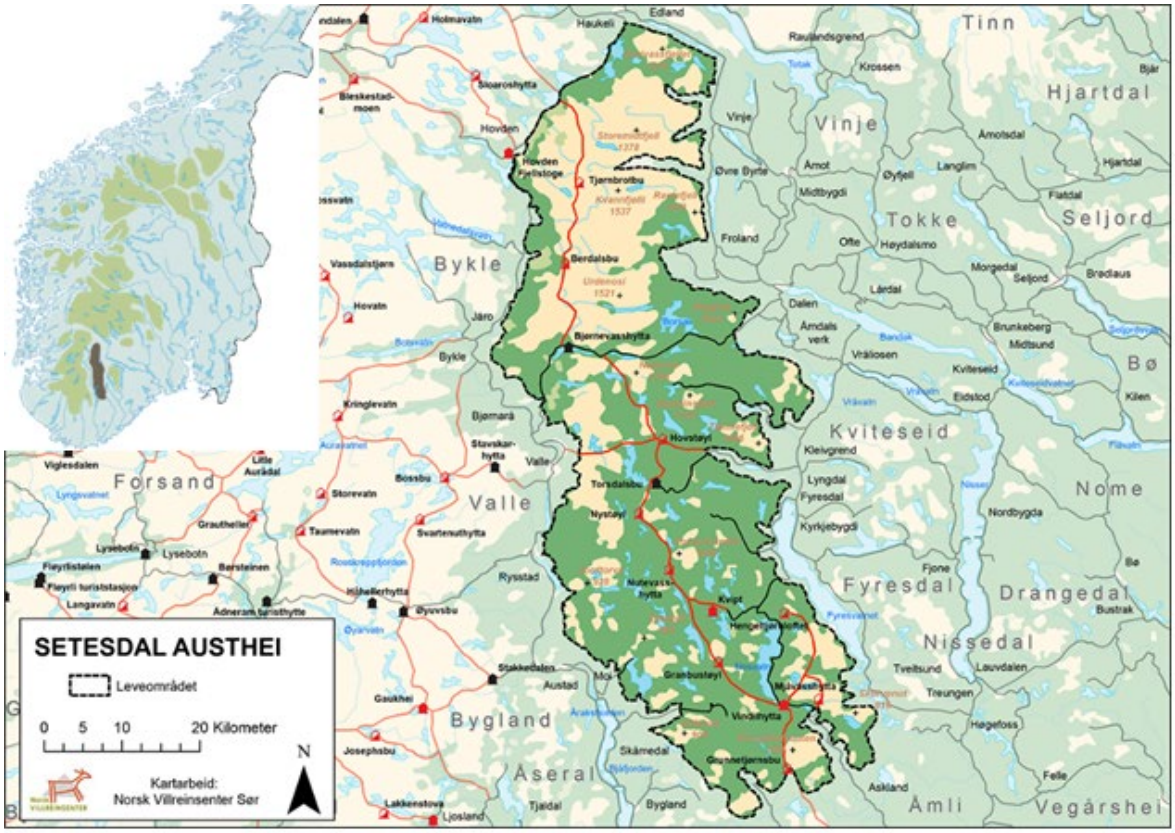


*Figure 3. The Setesdal Austhei wild reindeer area (www.villrein.no) Inset: location in South Norway. The dark green areas are forested areas, the light green shows mire/marshes, and the beige is alpine areas. The black lines inside the area are roads, the one crossing through the whole map is Rv 45, the red lines are trails and cabins.*

SA wild reindeer area was assessed to medium quality in a report by NINA in 2022, however they did not have adequate data over several years to calculate slaughter weight and proportion of bulls in the population. SA is one of the wild reindeer areas that lack any good data on the population structure, in general and the last few years. They did count 404 individuals in 2009, 965 in 2014, 456 in 2017, and 559 in 2019. The population on SA was found to be genetically different to all other populations in the other wild reindeer areas (Rolandsen et al., 2022).

## 2.2 Brattefjell-Vindeggen

The Brattefjell-Vindeggen (BV) wild reindeer area, with a total of 357 km$^2$, encompasses four municipalities, Hjartdal, Seljord, Tinn, and Vinje. BV is the southern tongue of the major Hardangervidda wild reindeer area (Figure 3.) and originally constituted a continuous alpine landscape. However, because of the hydropower regulation of Lake Møsvatn (1906-1911) and construction of the highway the Rv. 37 with associated human activities (e.g., hydropower lines, cabins, road maintenance) across the mountains, the BV area became more or less isolated from the main area Hardangervidda. This is evident from the fact that they today are separate management areas. The current indicated barrier historically had several migration routes for wild reindeer. This population is often said to be a subpopulation of the Hardangervidda population; however it is uncertain to what degree, and when this happened. The considerable tourist development along the highway Rv. 37 has led to a more or less complete cessation of the former reindeer migrations (Bevanger & Jordhøy, 2004; www.villrein.no).

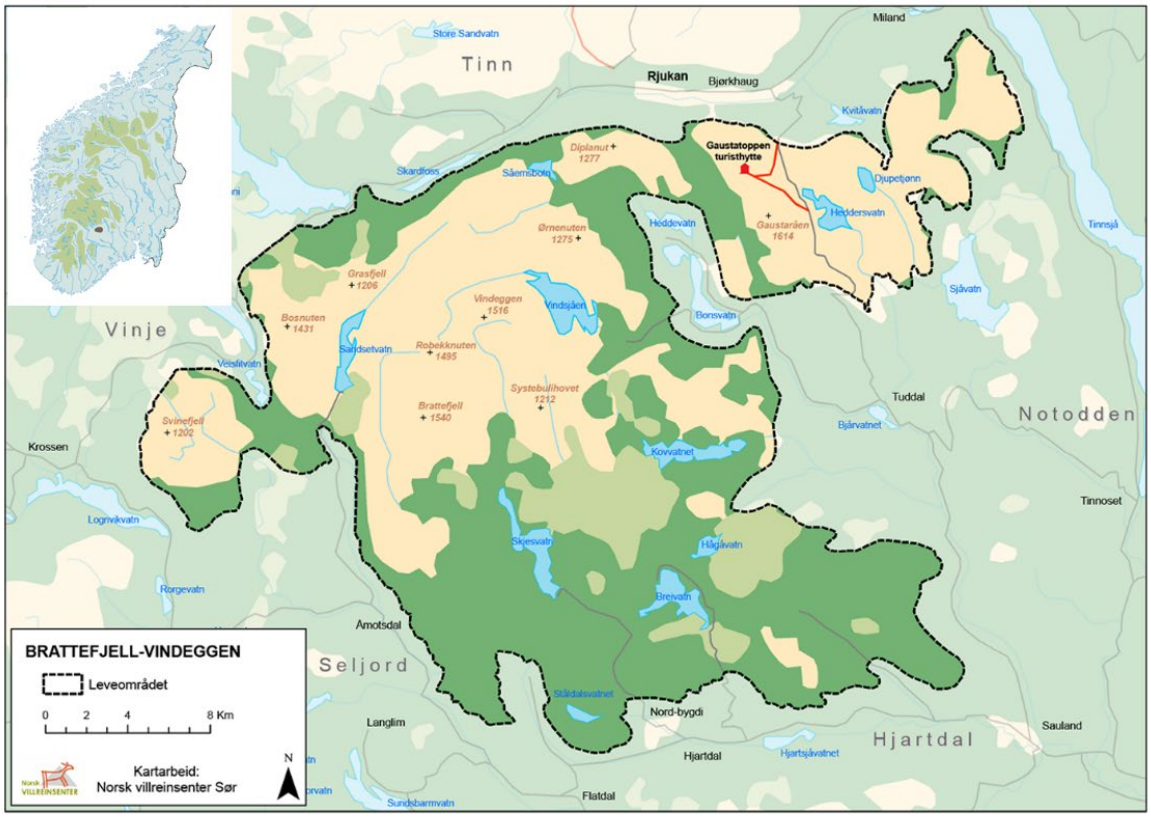

*Figure 4. Brattefjell-Vindeggen wild reindeer area (www.villrein.no). The dark green areas are forested areas, the light green shows mire/marshes, and the beige is alpine areas Inset: location in South Norway.*

In a conversation with Kolbjørn Birkrem, secretary of Brattefjell-Vindeggen villrein og utmarksvalg, May 8th, 2023, I got the data for table 1, and the following paragraph is from a conversation over the phone, and over email.

The winter census shows a dramatic change in the population numbers, since 2018 it has halved, at the same time the calf census and selected shooting are approximately the same. Reindeer die naturally too, and they (BV villrein- og utmarksvalg) are told about dead animals found by others every year, usually about 5-15 animals a year. In theoretical calculations they use a 5% rate as a template for natural deaths. Applying that to both the winter census and the calf census, it still doesn't explain the large decrease in population, so it is possible that reindeer have been migrating to other areas, and if, most likely Hardangervidda.

There is a general lack of collected data on the populations condition, by slaughter weight and jaw samples, this however should get better in the future. Feedback from hunters in BV has been that the animal's weight is less than earlier, especially the females. The winter population size has decreased since 2018, think some of them have wandered out of BV, perhaps over to Hardangervidda. In 2018 the population was 600, this year the winter population was 332 individuals (table 1). Last year the animals were situated higher up in the alpine areas longer than "normal", until sometime in autumn (K. Birkrem, personal communication, May 8th 2023).

BV has relatively rich summer and fall pastures but sparse winter pastures. The seasonal pastures in BV of the total area above the forest border are; 28 % impediment, 21 % autumn, 2 % summer, 36 % spring-early summer, 5 % non-grazed lichen area, 6 % medium worn lichen area and 3 % worn lichen area. Only 14 % lichen in total (Gaare & Hansson, 1990).

There is little of the normal summer pastures such as; willow thickets, Three-leaved Rush heaths with no lichen and snowbed meadows. This Is not a concern since there are many mires in the mountain and the mountain forests. Mires make the most of BVs autumn pastures. The plant communities making up the seasonal pastures are so diverse that BV is not able to maintain the supply of protein-rich vegetation beyond late summer and autumn in normal years. Suggest that the balance between

winter stocking rate and annual growth rate on the lowland pastures is 350-1200 animals if the lichen pastures are in optimal condition (Gaare & Hansson, 1990).

# 3 Materials and methods

There are few detailed studies with direct and detailed observation of wild reindeer, this lack is most likely due to the difficulty of observing wild reindeer. Because they are shy animals living in large open areas, direct observations can only be done at a distance. Moreover, when the two studied herds migrate down to the forests in summer, they are even harder to observe. Therefore, this study uses direct observations from video footage of feeding behaviour, and across two areas with different amounts of lichen.

## 3.1 Data collection

Instrumentation of wild reindeer in Setesdal Austhei and Brattefjell-Vindeggen was carried out on March 19th 2019. A total of 8 animals were tagged, 4 in each area, including one animal with a camera in each area. (FOTS: ID 15116, License # 19/20935) (for details see Strand, Bevanger & Falldorf, 2006; Strand et al., 2011; Strand et al., 2015; Romtveit et al., 2021). The video sampling in this thesis was done as a part of several different research project on wild reindeer by the Norwegian Institute for Nature research (NINA). The work was organized and managed by Roy Andersen along with a veterinarian, the wild reindeer committee had one representative each. The collars were equipped with Vectronics vertrex radio transmitters, a battery pack, and GoPro action camera (version 6) modified and built into the battery pack.

The reindeer in SA fell down a crack between a large boulder and snow/ice. The first video showing her stuck was 05.03.2020, at 15:55, the last video of her stuck, but still alive was 06.03.2020 at 11:55, in the next video at 12:55, she is dead. The reindeer in BV was unfortunately shot by a hunter in early October, and last video of her alive was October 7th.

## 3.2 Classifying data

The animal's behaviour was classified (Table 2) and noted for each video. Since all the videos are only 10 seconds long there was usually one behaviour type per video, if there were more, the dominant behaviour was noted down. This was considered in every video, and by looking at the surroundings,

the general behaviour of the animal and the herd to make the best estimate of the correct behaviour at that moment.

Excel was used to organize and analyse the data, and every video was classified by behaviour, grouped into the main groups of: Lying, standing, walking, running, digging, eating, other and black screen. If the main behaviour was grazing, the video was further analysed in detail; whenever possible the snow cover percentage, vegetation group and type, species present, and grazed species were noted. The data was sorted into can/cannot see what is being eaten, and if it could be seen, what the main vegetation group was noted as lichen, herbs/grasses, tree/bushes, mushroom. If vegetation type (classification below) and species were possible to identify, then those were noted under each relevant vegetation group. All registered species can be seen in table 8 in the appendix. Since it turned out to often be hard to identify species eaten in the videos, but it could often be seen what "Type" of vegetation it was. Often it was obvious that the animal was eating a specific species (which covered the ground), but due to animal movements or the mouth/jaw being in the way, eating was not positively observed directly. To indicate this observational difference, I classified eating observations into positive and uncertain under each vegetation species.

For the directly observed 'vegetation eaten' videos where I found it difficult to identify what species the reindeer ate, or where it was uncertain, Marijanne Holtan (USN), who is doing her PhD on the same project, was consulted. For plant identification Nilsson *et al*. 1995, Holien & Tønsberg, 2008 and Britton, 2008 were used.

Furthermore, Dr. Roland Pape (USN) gave a lot of feedback on identification of different plant species, Dr. Stefanie Reinhardt (USN) also gave help on this.

Vegetation type classifications were from NIBIOs vegetation types after Forest and landscape system for vegetation mapping, and translated with help of Dr. Roland Pape (USN).

Some additions to this vegetation type list was made, ridge, rock/boulder, and mountain birch forest was added as vegetation types. Ridge was added due to several videos where it was clear the animal was on typical ridges, but due to snow or other variables, one couldn't see what type of vegetation was on the ridge, The same reason gave for rock/boulder. Mountain birch forests was also added under birch forests, since it was so prevalent in the videos, and it gives a better picture of the vegetation type. To compare the vegetation types more easily, all the vegetation types got sorted into the main groups used by NIBIO; Snowbeds, alpine heathlands, alpine meadows, broadleaved forest, pine forest, spruce forest, wetlands and swamp forest, and mires and swamps (give reference

again here). All registered vegetation types or both areas are shown in Table 5 and 6 in the appendix. Since many of the vegetation types here are so intertwined and it can be difficult to separate where one ends and another begin, and since many of the vegetation types merge together, some as mosaics. In BV, the camera sometimes got blurry/fogged because of rain in the fall, so it was sometimes only possible to see that the individual was in a "Forest", or "Mire", and the same for spruce, pine or birch forest. Nature can be challenging to quantify sometimes, and vegetation types often meld together, and it can be difficult to separate the different types. This is the reason mosaics of some vegetation types that often melded together was added too. These vegetation mosaics were; lichen/dwarf shrub heath, dwarf shrub heath/snowbed, dwarf shrub/tall forb meadow, and dwarf shrub/grass mire.

*Table 1. All original vegetation types from NIBIO.*

| **1. SNOWBEDS** |
|---|
| 1a Mossy snowbeds |
| 1b Grassny snowbeds |
| **2. ALPINE HEATHLANDS** |
| 2a Frostmark, ridge-type |
| 2b Dry grass-heaths |
| 2c Lichen heaths |
| 2e Dwarf shrub heaths |
| 2f Alpine ling heaths |
| 2g Alpine moist heaths |
| **3. ALPINE MEADOWS** |
| 3a Low forb meadows |
| 3b Tall forb meadows |
| **4. BROADLEAVED FOREST** |
| 4a Lichen- and heather-rich birch forest |
| 4b Blueberry-dominated birch forest |
| 4c Meadow-type birch forest |
| **6. PINE FOREST** |
| 6a Lichen- and heather-rich pine forest |
| 6b Blueberru-dominated pine forest |
| 6c Meadow-type pine forest |
| **7. SPRUCE FOREST** |
| 7a Lichen- and heather-rich spruce forest |
| 7b Blueberry-dominated spruce forest |
| 7c Meadow-type spruce forest |
| **8. MIRES AND SWAMPS** |
| 8a Wetland forest |
| 8b Mire forest |
| 8c Swamp forest, poor type |
| 8d Swamp forest, rich type |

*Table 2. Information about the two female reindeer subjects.*

| Wild reindeer area | Reindeer ID | Sex | Age stage | Start date | End date | Year | Duration per scene | Recordings per day | Seconds recorded |
|---|---|---|---|---|---|---|---|---|---|
| SA | 1126/251 | Female | Adult | Mar-19 | Mar-06 | 2019 | 10 sec | 10 | 15280 |
| BV | 1134/254 | Female | Adult | Mar-19 | Oct-7 | 2019 | 10 sec | 10 | 13880 |

Since the reindeer in SA is known to use a corridor to cross between their seasonal pastures, the GPS coordinates from the female reindeer were looked at Dyreposisjoner.no, and the dates the animal crossed noted (www.dyreposisjoner.no).

During the analysis of the videos from BV a substantial number of reindeer with antlers clearly showed signs of antler gnawing. Since this was noticed during the analysis work, and not a part of the study aims, it was not quantified, but screenshots of some of the videos showing this phenomenon were taken.

# 4 Results

A total of 2935 videos were analysed, 1534 from SA, and 1395 from BV. The video recordings analysed were from 19 March 2019 to 7 October 2020 in both areas, one female reindeer was collared in each area in late March, until the video camera stopped in early October (in BV).

## 4.1 Grazing and vegetation

In May and June, the distribution of videos with grazing is quite similar between the two areas, but in June and July the number of grazing videos increases in BV, while it decreases for SA (Figure 4).

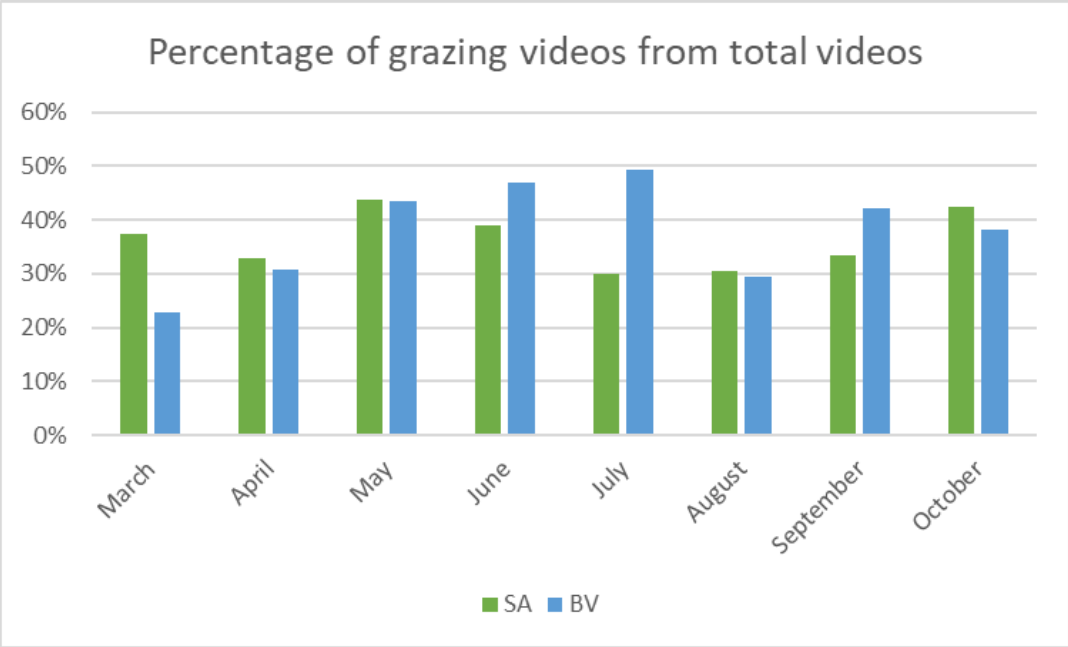


*Figure 4. Distribution of the amount of grazing videos (%).*

In SA, 26.11% of the videos were classified as grazing videos, with 30.43% grazing videos in BV. There is a clear dip in number of grazing videos in SA from May to July, before it flattens out from July to August, with a slight increase towards October (Figure 5). BV has an incline in grazing videos from March till July, with a drop of about 20% from July to August. This is followed by an increase in about 10% from August to September (Figure 5).

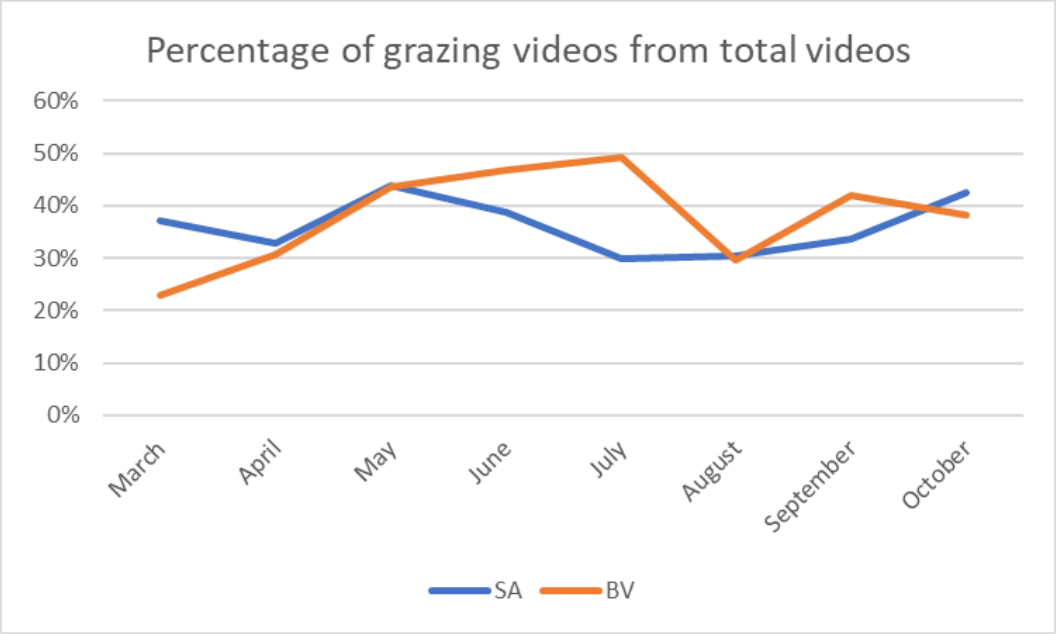


*Figure 5. Distribution of the amount of grazing videos (%), variation of grazing videos throughout the study period.*

The frequency of grazing by time of day (Figure 6), are virtually identical, there are only a few variations, and those variations are as small as 1 or 2 difference in number of times. These results are from the two different wild reindeer, living in the two completely separated wild reindeer areas.

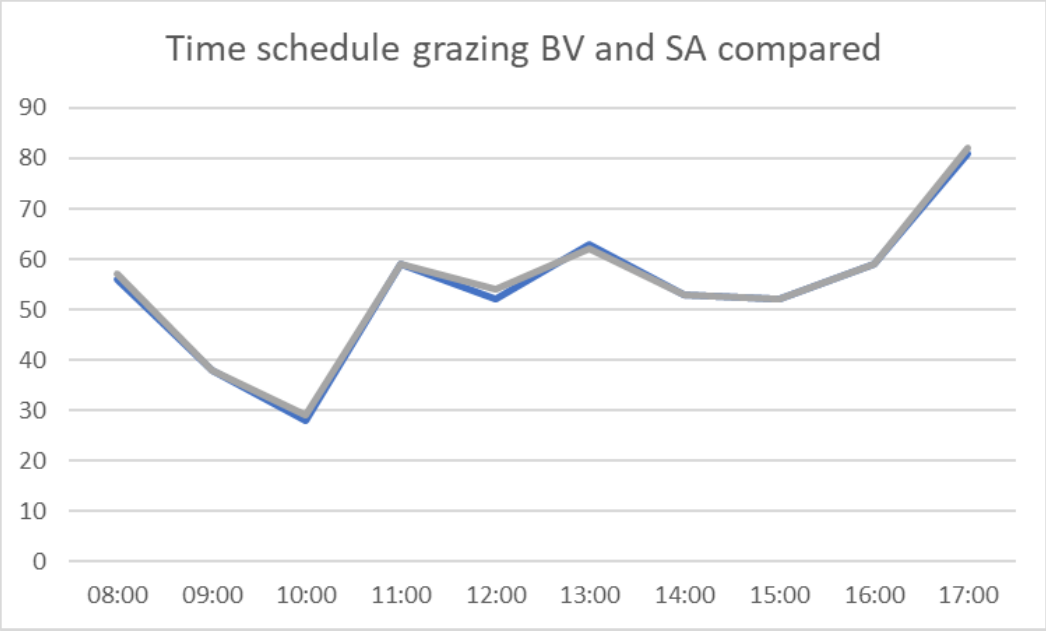


*Figure 6. The number of times grazing videos was registered, at what time of day.*

Alpine heathlands are the most used main vegetation type in both SA (298) and BV (164), broadleaved forests are the second most used in SA (148), and the third most used in BV (88). The second most used type for BV is spruce forests (133), while there was no grazing registered in pine or spruce forests in SA.

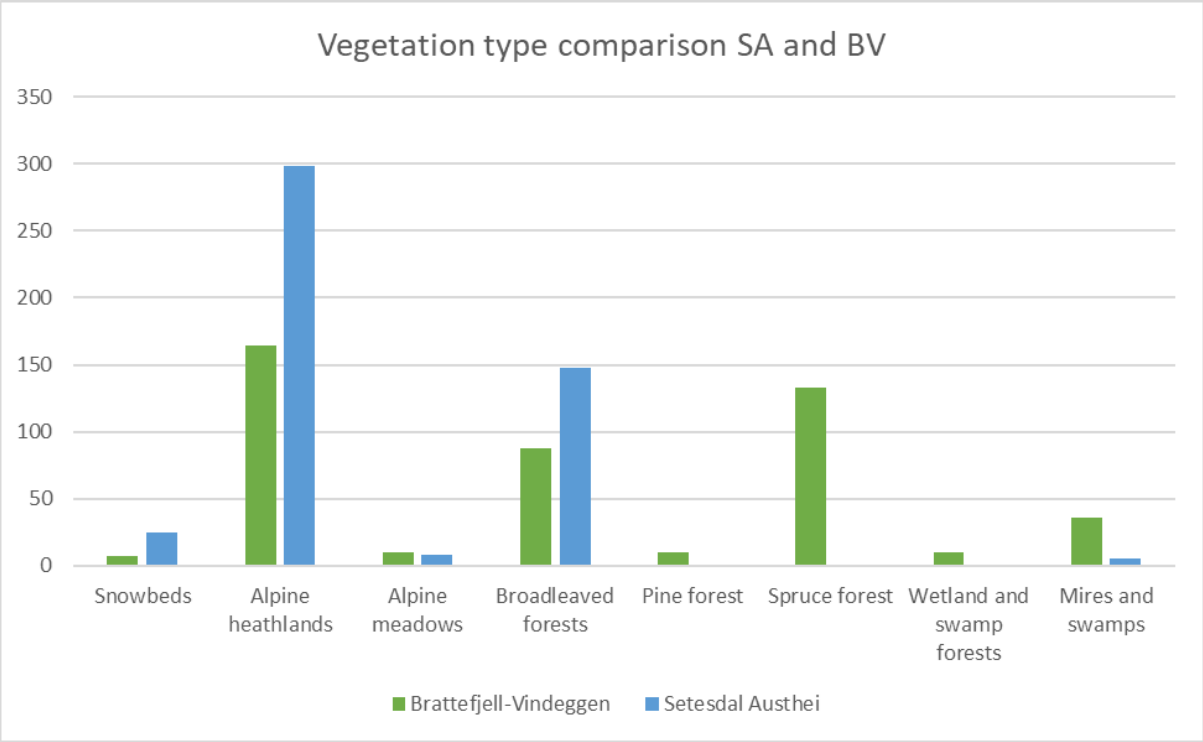


*Figure 7. The most used vegetation types for grazing in both SA and BV, using the main vegetation categories.*

The three most used vegetation types in SA are respectively Dwarf shrub heaths, mountain birch forests and lichen heaths,(Figure 8) while in BV the three most used are dwarf shrub heaths, blueberry-dominated spruce forest, and mountain birch forest (Figure 9).

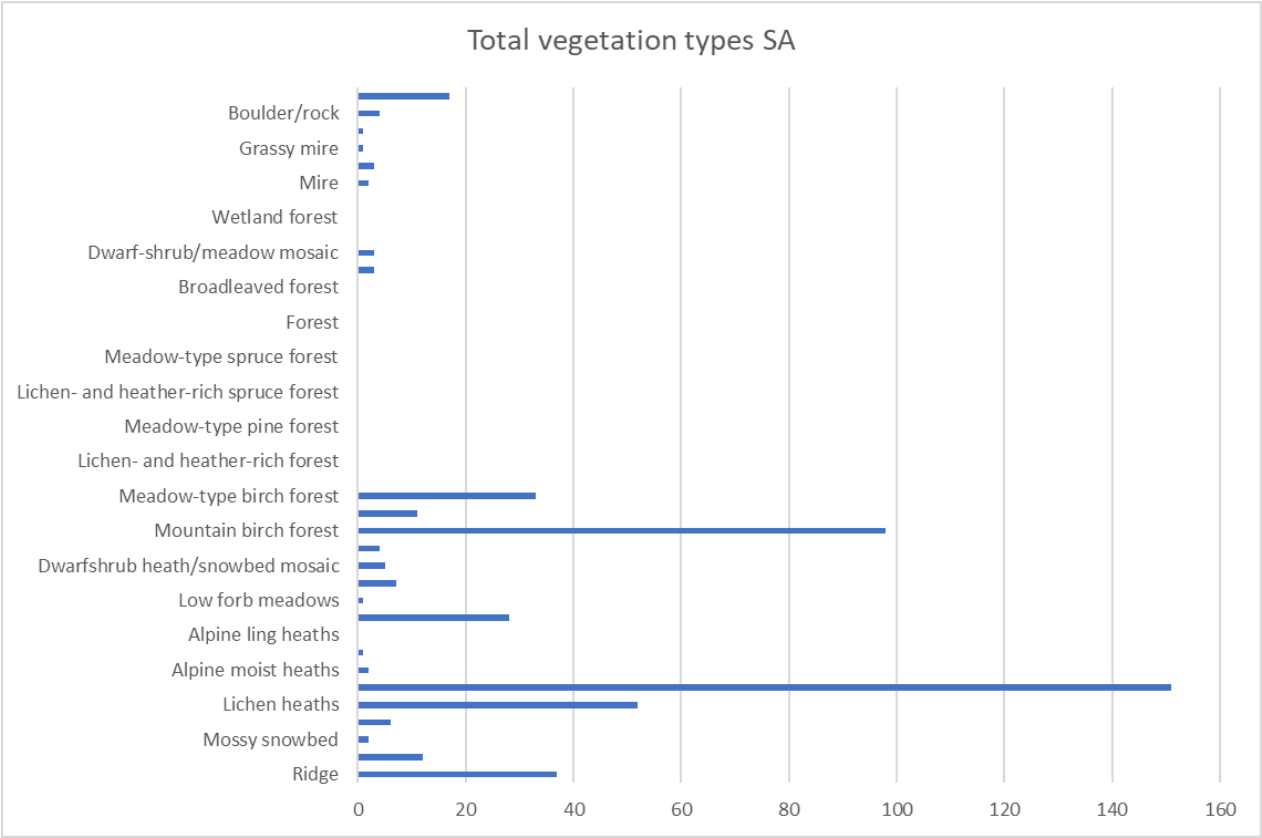


*Figure 8. All registered vegetation types used for grazing in SA, this includes the types of mosaics and the few more "general" types, as explained in methods.*

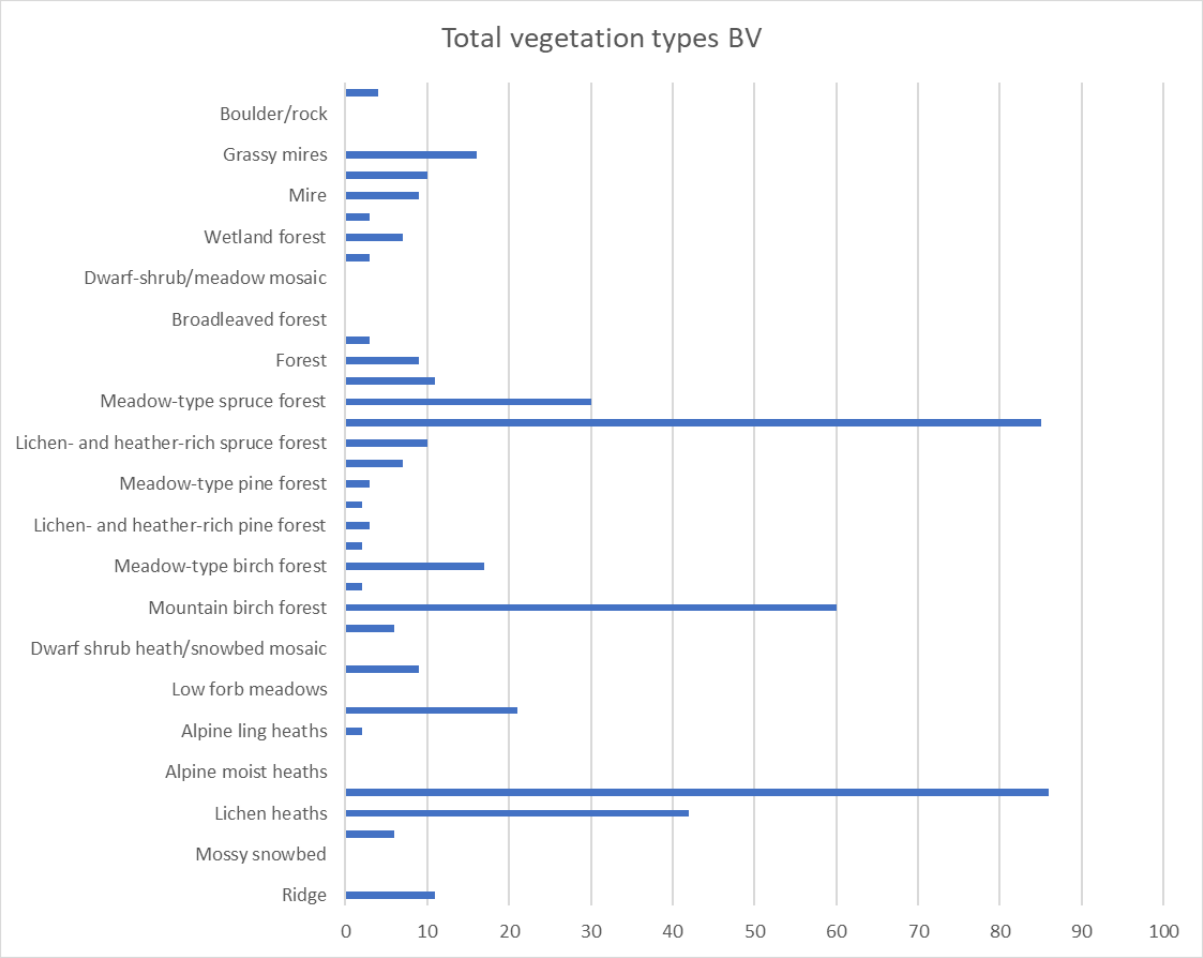


*Figure 9. All registered vegetation types used for grazing in BV, this includes the types of mosaics and the few more "general" types, as explained in methods.*

SA: March and April, alpine heathlands are most used for grazing, and in May there is a large increase of grazing in broadleaved forests. For all the months, alpine heathlands and broadleaved forests dominate as the most used (Figure 10).

BV: Alpine heathlands are the most used from March to June, but broadleaved forests increase in the same period and is the second most used, in June they are practically used an equal amount. Spruce forests dominate as the most used from July until October and has an increase from being registered 4 times in June, to 54 in July (Figure 11).

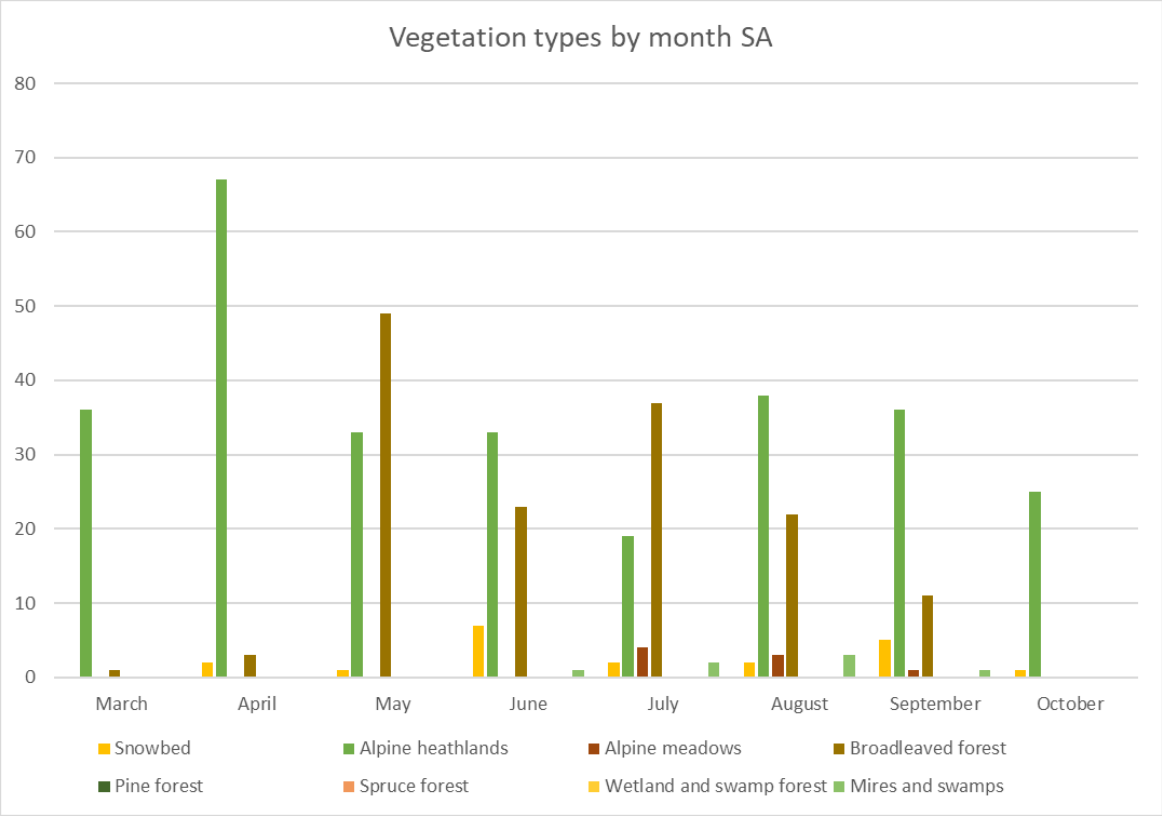


*Figure 10. Variations in vegetation types in SA, (shown in main vegetation categories) used for grazing from March till October.*

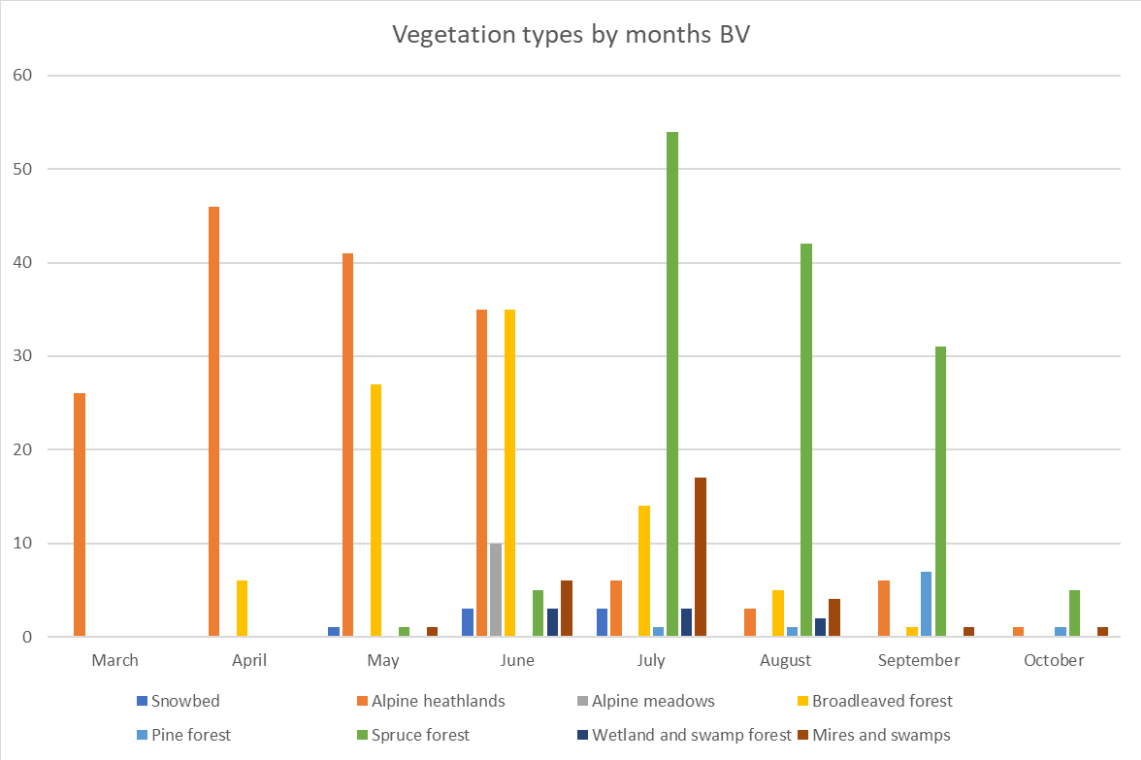


*Figure 11. Variations in vegetation types in BV, (shown in main vegetation categories) used for grazing from March till October.*

## 4.1 Plant species/lichen species eaten.

Herbs and grasses (graminoids) were the most eaten major vegetation groups for both animals in both areas. In SA there was a drop in June (Figure 13) in eaten vegetation (grass/herbs, lichen), when June was the month with most eaten vegetation for BV (grass/herbs, lichen), (Figure 14).

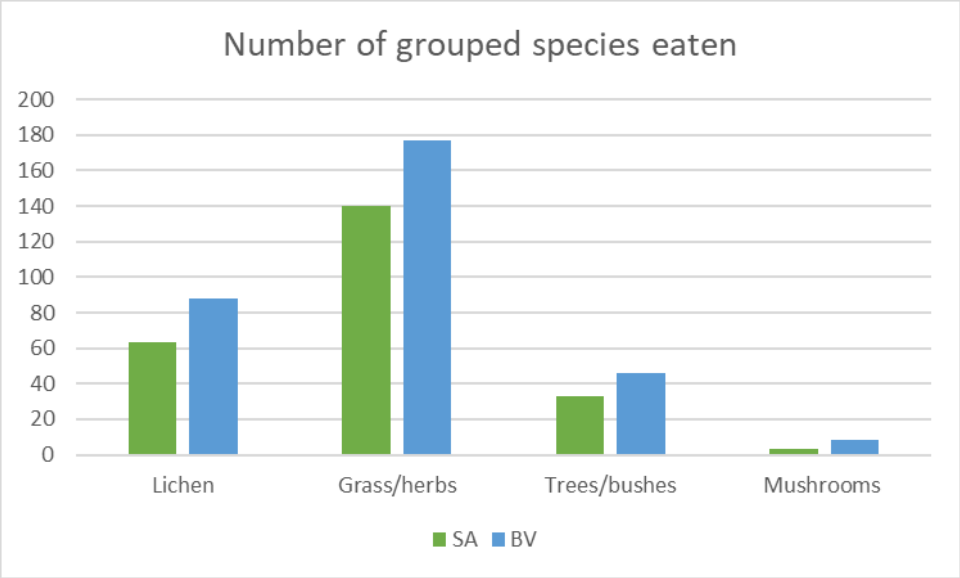


*Figure 12. All vegetation eaten for the whole period of the study, comparing the two areas SA and BV. These are grouped into the major vegetation groups.*

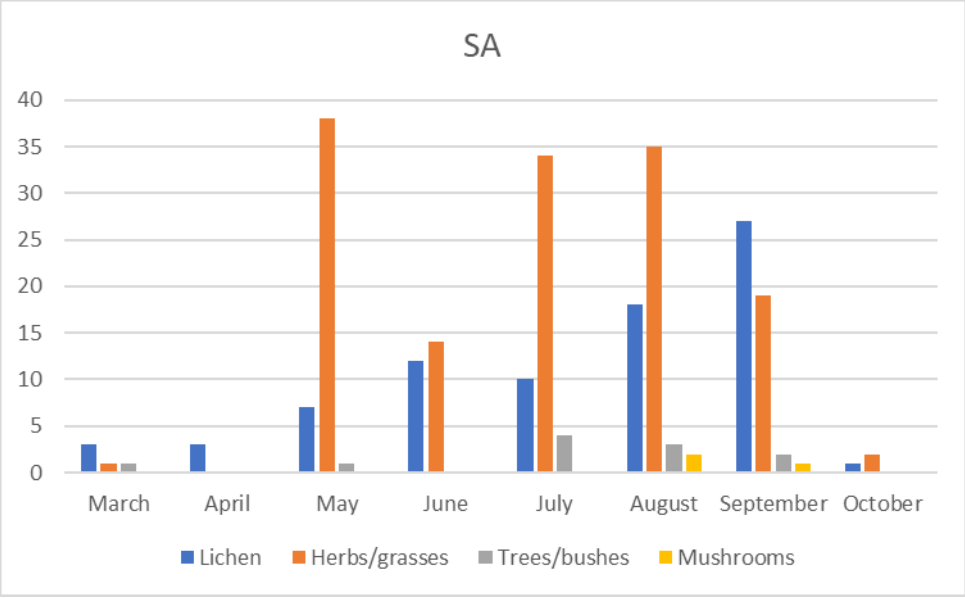


*Figure 13. All vegetation eaten in SA, distributed by month and number of times eaten. These also show the main vegetation groups.*

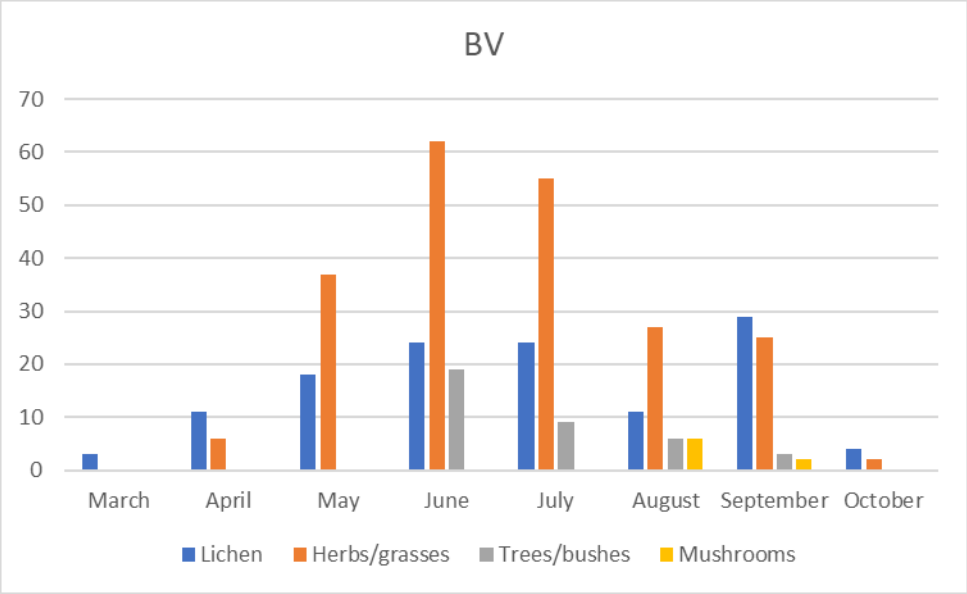


*Figure 14. All vegetation eaten in BV, distributed by month and number of times eaten. These also show the main vegetation groups.*

The most eaten lichen was reindeer lichen for both animals with 27 certain observations in SA (36, uncertain and certain), and 33 certain observations in BV (41, uncertain and certain). In the main vegetation group herbs/grasses, grasses were the most grazed for both areas. For herbs, *Gentiana purpurea* was most grazed in SA, 38(39), and in *Rumex acetosa* 22(22) in BV. *Betula nana* was the tree species they ate most of, followed by the berry bushes: *Vaccinium myrtillus* and *uliginosum* (Table 8 in appendix).

## 4.2 Behaviour

For both animals, eating was the most observed behaviour, followed by lying and walking. Percentage wise behaviour for SA was eating: 36%, lying 34%, walking 14%, standing 10%, running 3%, other 2%, black screen 0%, digging 0%.

For BV they were: eating 45%, lying 36%, walking 9%, standing 4%, other 4%. Running 1%, black screen 1%, digging 0%.

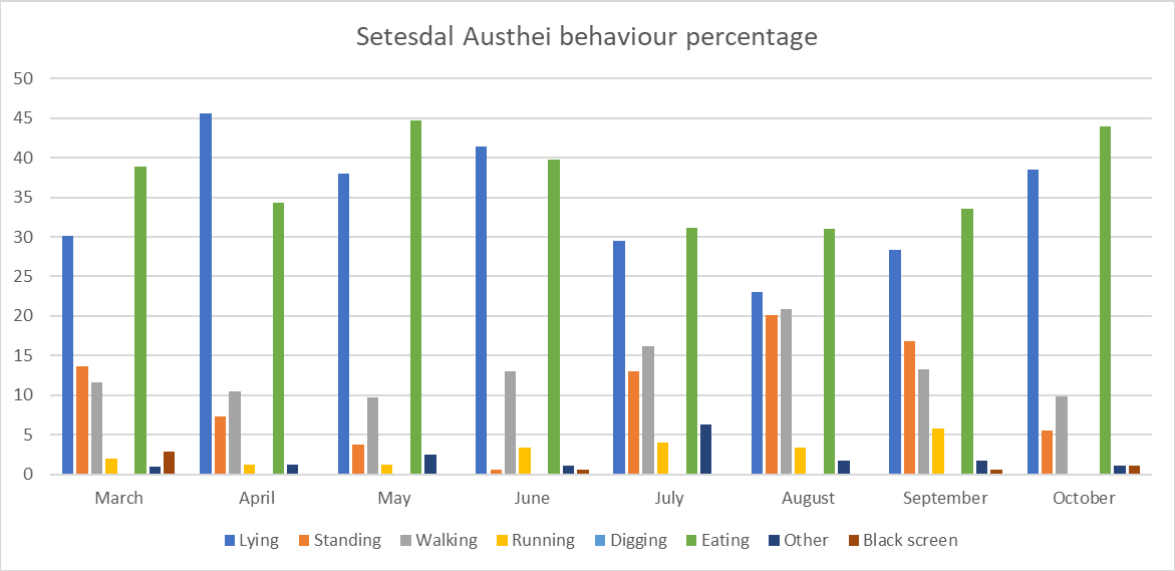


*Figure 15 All registered behaviours from SA, grouped into the main behaviour categories.*

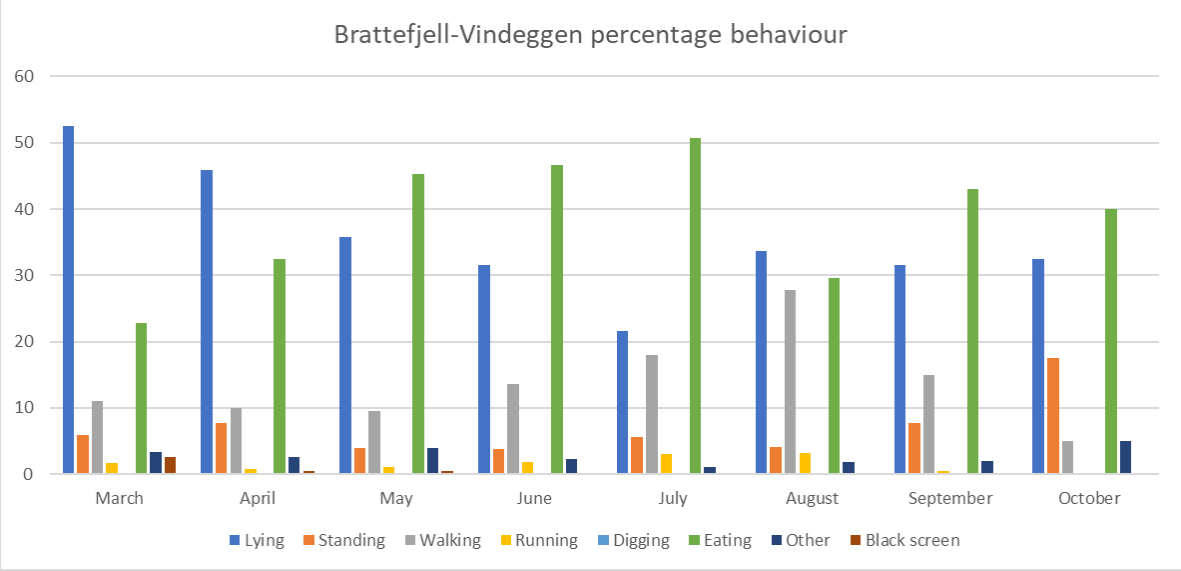


*Figure 16 All registered behaviours from BV.*

Both animals had an increase in walking/running behaviour observed, and a decrease in eating in August. They both also had an increase in eating from May and until this decrease in August (Figure 17, 18).

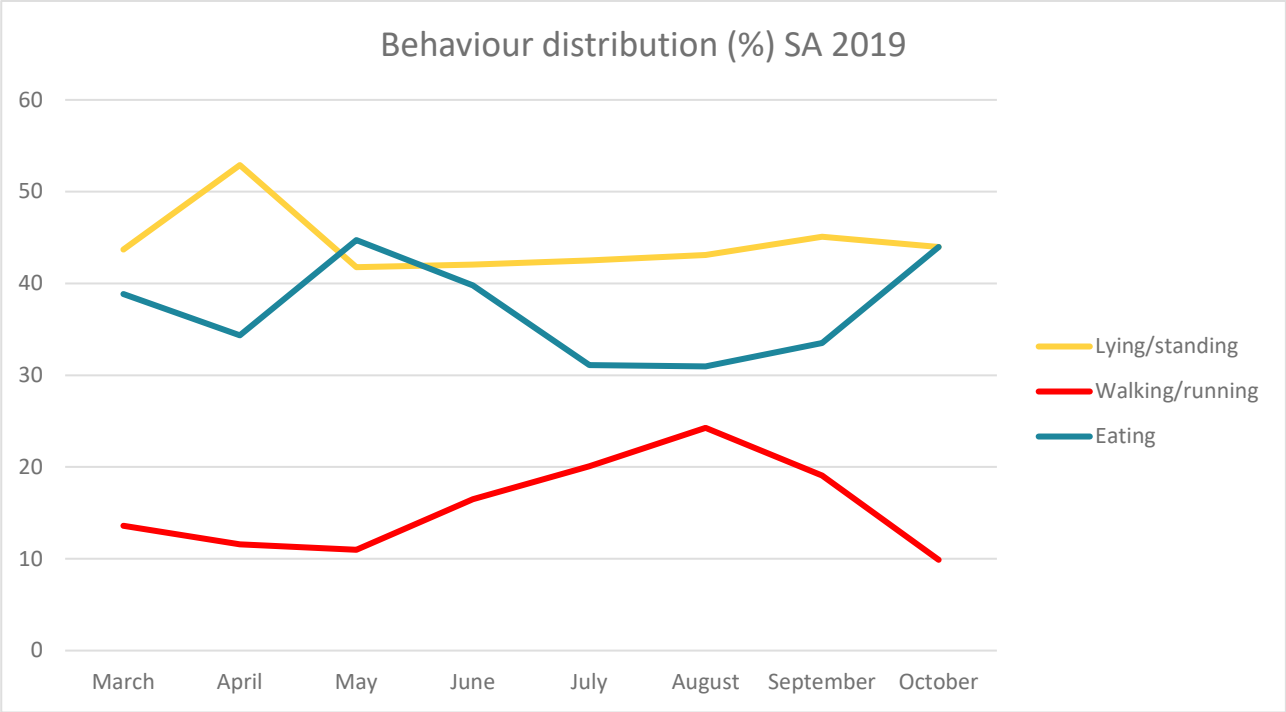


*Figure 17. Variations in behaviour by month, in SA, where the classified behaviour is all grouped into three main categories.*

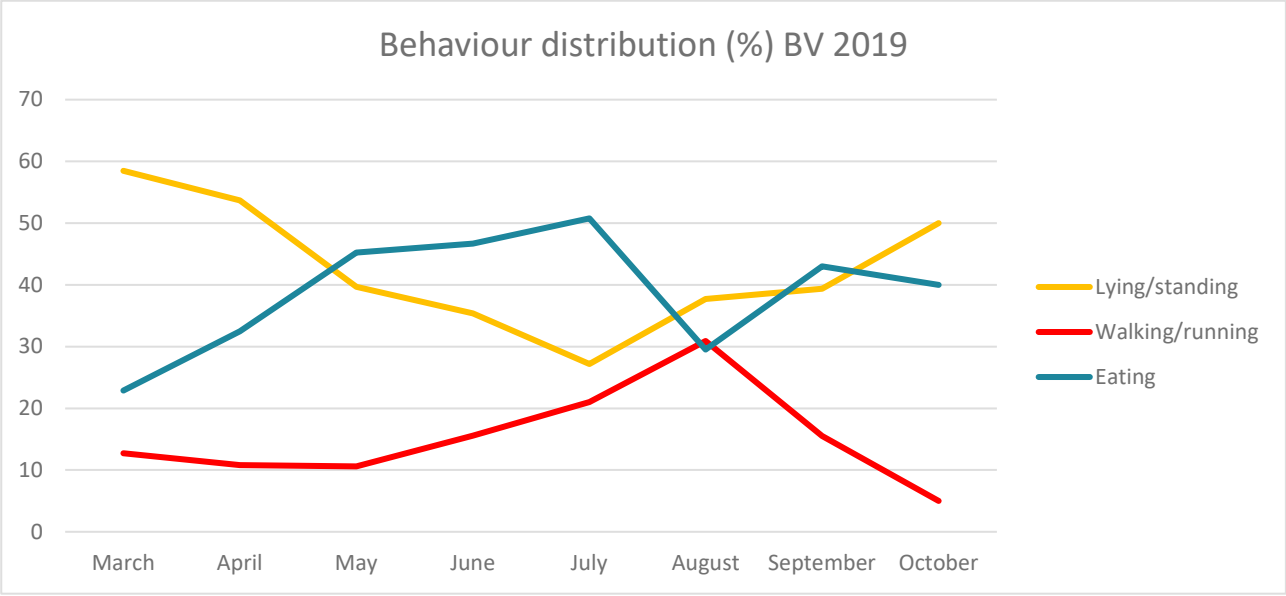


*Figure 18. Variations in behaviour by month, in BV, where the classified behaviour is all grouped into three main categories.*

### 4.2.1 Corridor crossing between seasonal pastures in SA.

Using Dyreposisjoner.no, one can see that the female reindeer in SA (all points in Figure 19 are from female ID 1126/251) migrated from their alpine winter pastures in the north (north of Rv. 45, the red

line in Figure 17 and Figure 4) to more forested summer pastures in the south (south of Rv.45) as early as the 25th of March 2019. They also cross back into the alpine area in the north, from south of Rv. 45 21.07.2019 09:00, to the north of Rv.45 21.07.2019 10:00. Then they cross south again from north of Rv.45, on the 28.01.2020 09:00, to the south of the road 28.01.2019 10:00. The animal then stayed south of Rv.45 until it's last recorded position 05.03.2020 15.00.

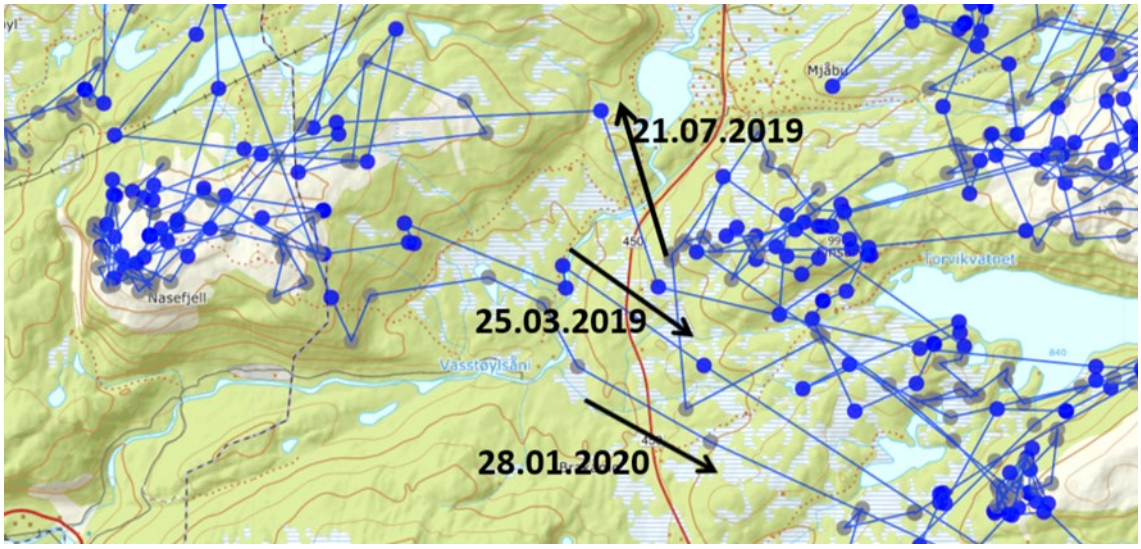


*Figure 19. Screenshot from www.dyreposisjoner.no, 27/06/2022. Edited to show when reindeer in SA crossed Rv.45 Setesdal Austhei.*

### 4.2.2 Antler gnawing

In BV there were many reindeer with antlers that were severely gnawed down. Most of the females had antlers showing signs of gnawing, and several only had small stubs left. In comparison, hardly any signs of antler gnawing were seen in SA.

# 5 Discussion

## 5.1 What did they eat most?

Grouped into the broader vegetation groups, both animals from SA and BV ate herbs and grasses the most, followed by lichens, trees and bushes and then mushrooms. Herbs and grasses were the most common food source May to September, when lichen took over as most eaten by both animals. They both ate lichen throughout the whole period, including the snow-free months.

Both reindeer were observed eating mushrooms in the forest; the reindeer in BV ate mushrooms somewhat more often than the reindeer in SA. Species identification of the mushrooms eaten was impossible as either the animal's muzzle covered most of the mushrooms or the reindeer crumbled them into pieces. It is also difficult to identify mushrooms in these videos, as the underside/gills of the mushroom are important for identification, two of them could look like *Boletus edulis*, and one like a mushroom in *Lactarius*.

*Gentiana purpurea* and in *Rumex acetosa* were the herbs observed eaten most times, and 19 different herbs/grasses was registered, as well 8 different trees/bushes (Table 8 in appendix).

The reindeer ate 9 species of lichen; the most eaten were reindeer lichen for both areas. The two reindeer lichen species, *Cladonia arbuscula* and *Cladonia rangiferina* were grouped into "reindeer lichen" since it is impossible to tell the two apart in most videos due to their overall similarity and the changing lighting. Lichen was eaten year-round, and in some situations, the two reindeer chose lichen over green vegetation in summer. One possible reason for this consumption of nitrogen-poor lichen, even in summer when more nutritionally optimal forage is available, could be the need to maintain the microorganisms complex in their rumens, that enables able to digest lichen (Aagnes et al. 1995; Klein 1990; Thompsson, 2014).

## 5.2 Where did they graze?

The two wild reindeer mainly use the forests for grazing from May and through the summer until use declines from August to September, and the results show that these habitats are clearly important during the snow-free months in both areas.

In SA, sorted into broader vegetation groups, alpine heathlands and deciduous forests are the most used vegetation types for feeding. In BV, alpine heathlands are most frequently used for grazing from

March to June, and the use of deciduous forests also increases during this period. Spruce forest dominates as most used from July to October and increases significantly from June to July. Graminoids and herbs are an important part of the diet for both animals and are the most common food source in both SA and BV.

In both areas, the animals utilize bare patches for food in wintertime rather than digging in the snow. One animal was observed “cratering”, but most simply use their muzzle to move the fresh/light snow out of the way; this is consistent with results from Romtveit et al. 2021, where they found a strong preference for snow-free or snow-poor areas in winter. Because the videos for this study are only from March until October, it is possible they may need to resort to digging in the months with greater amounts of snow.

## 5.3 Behaviour

As shown in figure 6, time schedule grazing BV and SA, there is almost a complete overlap in what time of day they ate the most often, despite being two different animals in two completely different and separate areas. Was this just a statistical coincidence, or could wild reindeer’s behaviour, in areas with few predators be so similar?

The data presented in figure 4 and 5, show a clear dip in the number of times the animals ate in August and an increase in running and walking. Large amounts of flying insects could be a reason the reindeer had to move more and therefore have less time to graze. There was also an increase in grazing videos from March to May, which coincides with the snowmelt and the tendency of reindeer to follow the wave of green vegetation in the spring, using southern-facing slopes where the snow melts the earliest to find green shoots.

### 5.3.1 Antler gnawing

Most female reindeer with antlers in BV had some degree of antler gnawing. Several animals in BV only had small stubs left of their antlers; this degree of antler gnawing was not observed in SA, and the difference in antlers was astonishing. Antler gnawing is a known phenomenon among the wild reindeer herds in Norway, and Mysterud et al. theorizes that antler gnawing may have led to the CWD outbreak in Nordafjella.

## 5.4 Method

The results show that this method of using mounted cameras for direct observation works, however due to several technical difficulties explained below, many videos with grazing behaviour didn't yield usable data.

Several factors often made it difficult to see what the animal was eating. In spring, when the animal still has a thick fur coat and there is still significant snow cover, it is very challenging to see what they eat. The animals' chin/jaw and fur almost cover the screen in many videos. One can barely glimpse lichen, crowberry, or other typical ridge vegetation. Snow covering the vegetation also made it difficult, and sometimes the lens itself is covered in snow. Even when they graze on bare patches, the head/fur of the animal is often in the way. When small pieces of lichen or grass are seen in a small window in the video, it is most likely what the animal is eating, but as it cannot be seen properly, one can't say for certain. In the late summer and autumn, there is more rain and fog, and the camera was often very blurry; this was mainly seen in the latest months of videos in BV.

In the summer, the amount of green vegetation was sometimes an issue. Often, when the animal puts its head down between all this vegetation, it is difficult to discern which species it ate. The animals were also often very eager, moving their heads quickly and grabbing bites of different vegetation as they grazed, making it hard to identify which species were eaten. Many times, one could only be sure that the animal was eating grass/herbs, but it was not clear which species or what plant. Plant identification on camera is challenging, which made it necessary to simplify some by combining them into broader groups. One example of this is grass/sedge/reed species: most of the time, one could only identify it as "Grass" unless it is very easy to recognise, such as *Carex bigelowii.* This uncertainty was the reason for getting fewer registrations of species than one would like from this large number of videos, and the hours it took to analyse.

The GPS data from both camera reindeer was supposed to be handled and analysed, but due to the Covid-19 pandemic this was not possible. Combining these direct observations, along with remote data from GPS logs, and overlaying them onto detailed vegetation maps would work well to improve and simplify this method.

## 5.5 Adapting to a changing climate

Although plant productivity in the mountains may increase, carrying capacity for reindeer in winter may decrease, due to a compression of winter range as well as more continuous range use as the overlap of summer and winter areas increase. If these changes happen, reindeer may need to include more vascular plants in their winter diet. Winter habitats may become more marginal, while summer conditions may improve due to increased plant productivity. Extreme winters with large amounts of snow might become more common in Norwegian wild reindeer areas, further reducing winter grazing availability. In short, climatic warming is not likely to be beneficial to the reindeer populations in Norway (Heggberget et al. 2002).

# 6 Conclusion

This study aimed to study the feeding behaviour of the wild reindeer in SA and BV and to gain more knowledge about their use of forested areas. The two reindeer from SA and BV eat graminoids/herbs the most, with lichen following. The increase in graminoids/herbs in April-May coincides with them following the "green wave" of spring vegetation, but they both continue some grazing on lichen even in summer. The most eaten lichen is "reindeer lichen", i.e., *Cladonia rangiferina* and *Cladonia arbuscula.* Both eat large amounts of grass/graminoids, and other than grasses, in SA, *Gentiana purpurea* was registered eaten 38 times, and *Rumex acetosa* 22 times in BV. Both reindeer use dwarf shrub heaths and forests the most for grazing, in SA primarily mountain birch forest and BV spruce forest (blueberry dominated). They start using the forested areas in April-May but still utilize the alpine heathlands throughout the summer/fall. Videos give valuable and exciting results about wild reindeer behaviour, habitat use and grazing behaviour. Mounted cameras provide a good insight into the everyday life of wild reindeer, especially behavioural data. Technical challenges sometimes make it difficult to determine species, and discerning what they ate was often impossible due to these technical issues. A possible alternative could be combining the GPS locations with good vegetation maps over the wild reindeer, perhaps along with detailed activity budgets. Combining those data with some videos giving direct observations on behaviour and feeding would provide a clear and detailed picture of their grazing and general behaviour and land use.

Awareness of the current threats towards Norwegian wild mountain reindeer has increased in recent years, with the outbreak of CWD and their being assessed as near threatened in Norway in 2021. Good knowledge about wild reindeer grazing and habitat preferences, managing and conserving species, protecting habitats, and ensuring their access to suitable grazing and living areas year round according to their seasonal migration patterns are all key steps to protecting this species. How they will adapt to future climate change is uncertain; therefore, it is important to gather more knowledge about possible alternative habitats for their grazing and living areas and their ability to thrive/survive in changed alpine habitats and plant communities.

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# Appendix

## Tables

*Table 3. Population count of the winter population of reindeer in Brattefjell-Vindeggen (Kolbjørn Birkrem (Secretary for Brattefjell-Vindeggen villrein- og utmarksvalg, May 8th 2023).*

| | Winter census | Calf census | Selected shooting | Quota/percent felled% |
|---|---|---|---|---|
| 2012 | 371 | 130 | 50 | 125/ 40% |
| 2013 | 417 | 117 | 55 | 140/ 39,3% |
| 2014 | 435 | 127 | 51 | 130/ 39,2% |
| 2015 | 481 | 130 | 68 | 175/ 38,9% |
| 2016 | 529 | 139 | 83 | 240/ 34,5% |
| 2017 | 575 | 172 | 93 | 280/ 33,2% |
| 2018 | 600 | 175 | 118 | 400/ 29,5% |
| 2019 | 554 | 146 | 125 | 450/ 27,5% |
| 2020 | 466 | 120 | 124 | 450/ 27% |
| 2021 | 390 | 100 | 82 | 250/ 32% |
| 2022 | 304 | 98 | - | - |
| 2023 | 332 | - | - | - |

*Table 4. All registered vegetation types in SA.*

| **Setesdal Austhei** | |
|---|---|
| **1. SNOWBEDS** | 11 |
| 1a Mossy snowbeds | 2 |
| 1b Grassny snowbeds | 5 |
| *Mosaic/mix* | 7 |
| **Total** | **25** |
| **2. ALPINE HEATHLANDS** | |
| *Ridge* | 37 |
| 2a Frostmark, ridge-type | |
| 2b Dry grass-heaths | 1 |
| 2c Lichen heaths | 52 |
| 2e Dwarf shrub heaths | 151 |
| 2f Alpine ling heaths | |
| 2g Alpine moist heaths | 2 |
| ***Mosaic/mix*** | 55 |
| **Total** | **298** |
| **3. ALPINE MEADOWS** | |
| 3a Low forb meadows | 1 |
| 3b Tall forb meadows | 6 |
| *Mosaic/mix* | 1 |
| **Total** | **8** |
| **4. BROADLEAVED FOREST** | 5 |
| *Birch forest* | 5 |
| *Mountain birch forest* | 94 |
| 4a Lichen- and heather-rich birch forest | 11 |
| 4b Blueberry-dominated birch forest | 28 |
| 4c Meadow-type birch forest | |
| *Mosaic/mix* | 5 |
| **Total** | **148** |
| **6. PINE FOREST** | |
| *Pine forest* | |
| 6a Lichen- and heather-rich pine forest | |
| 6b Blueberru-dominated pine forest | |
| 6c Meadow-type pine forest | |
| *Mosaic/mix* | |
| **Total** | 0 |
| **7. SPRUCE FOREST** | |
| *Spruce forest* | |
| 7a Lichen- and heather-rich spruce forest | |
| 7b Blueberry-dominated spruce forest | |
| 7c Meadow-type spruce forest | |
| *Mosaic/mix* | |
| **Total** | 0 |
| **8. MIRES AND SWAMPS** | |
| 8a Wetland forest | 1 |
| 8b Mire forest | |
| 8c Swamp forest, poor type | |
| 8d Swamp forest, rich type | |
| *Mosaic/mix* | |
| **Total** | 1 |
| **9. MIRES AND SWAMPS** | |
| *Mire* | 1 |
| 9a Dwarf-shrub mires | 3 |
| 9b Tufted clubsedge mires | |
| 9c Grassy mires | 1 |
| *Mosaic/mix* | |
| **Total** | **5** |
| **Other** | 60 |
| **NA** | 48 |

*Table 5. All registered vegetation types in BV*

| Brattefjell-Vindeggen | |
|---|---|
| **1. SNOWBEDS** | 1 |
| 1a Mossy snowbeds | |
| 1b Grassny snowbeds | 6 |
| *Mosaic/mix* | |
| **Total** | **7** |
| **2. ALPINE HEATHLANDS** | |
| *Ridge* | 11 |
| 2a Frostmark, ridge-type | |
| 2b Dry grass-heaths | 1 |
| 2c Lichen heaths | 42 |
| 2e Dwarf shrub heaths | 86 |
| 2f Alpine ling heaths | 2 |
| 2g Alpine moist heaths | |
| ***Mosaic/mix*** | 26 |
| **Total** | **168** |
| **3. ALPINE MEADOWS** | |
| 3a Low forb meadows | |
| 3b Tall forb meadows | 9 |
| *Mosaic/mix* | |
| **Total** | **9** |
| **4. BROADLEAVED FOREST** | |
| *Birch forest* | 6 |
| *Mountain birch forest* | 61 |
| 4a Lichen- and heather-rich birch forest | |
| 4b Blåueberry-dominated birch forest | 2 |
| 4c Meadow-type birch forest | 16 |
| *Mosaic/mix* | |
| Total | **85** |
| **6. PINE FOREST** | |
| *Pine forest* | |
| 6a Lichen- and heather-rich pine forest | |
| 6b Blueberru-dominated pine forest | 2 |
| 6c Meadow-type pine forest | 2 |
| *Mosaic/mix* | |
| **Total** | 4 |
| **7. SPRUCE FOREST** | |
| *Spruce forest* | 7 |
| 7a Lichen- and heather-rich spruce forest | 9 |
| 7b Blueberry-dominated spruce forest | 83 |
| 7c Meadow-type spruce forest | 31 |
| *Mosaic/mix* | 1 |
| **Total** | **131** |
| **Coniferous forest** | **8** |
| **8. MIRES AND SWAMPS** | |
| 8a Wetland forest | 5 |
| 8b Mire forest | 2 |
| 8c Swamp forest, poor type | |
| 8d Swamp forest, rich type | |
| *Mosaic/mix* | |
| **Total** | **7** |
| **9. MIRES AND SWAMPS** | |
| *Mire* | 9 |
| 9a Dwarf-shrub mires | 10 |
| 9b Tufted clubsedge mires | |
| 9c Grassy mires | 17 |
| *Mosaic/mix* | 1 |
| **Total** | **37** |
| **Other** | 31 |
| **NA** | 48 |

*Table 6. Vegetation types registered in the different months for Setesdal Austhei.*

| Setesdal Austhei | March | April | May | June | July | August | September | October |
|---|---|---|---|---|---|---|---|---|
| 1. Snowbeds | | | | | | | | |
| Ridge | 12 | 5 | 4 | | 1 | | 2 | 13 |
| Lichen heaths | 8 | 20 | 3 | 3 | 2 | 4 | 9 | 3 |
| Dwarf-shrub heaths | | 31 | 21 | 29 | 15 | 25 | 22 | 8 |
| Alpine moist heaths | | | | | | 2 | | |
| Dry grass heaths | | | 1 | | | | | |
| Lichen/dwarfshrub heath mosaic | | 11 | 4 | 1 | 1 | 7 | 3 | 1 |
| Dwarfshrub heath/snowbed mosaic | | | | | 1 | 3 | | 1 |
| Snowbed | | 1 | | 4 | 1 | 2 | 3 | 1 |
| Mossy snowbed | | | | 1 | | | 1 | |
| Grassy snowbed | | 1 | 1 | 2 | 1 | | 1 | |
| Birch forest | | 2 | | | 2 | | | |
| Mountain birch forest | 1 | 1 | 44 | 14 | 19 | 13 | 6 | |
| Blueberry-dominated birch forest | | | | 5 | 2 | 1 | 3 | |
| Meadow-type birch forest | | | 5 | 4 | 14 | 8 | 2 | |
| Broadleaved forest | | | | | | | | |
| Low forb meadows | | | | | 1 | | | |
| Tall forb meadows | | | | | 3 | 3 | 1 | |
| Dwarf shrub/tall forb meadow mosaic | | | | | | 2 | 1 | |
| Dwarf-shrub/meadow mosaic | | | | | 3 | | | |
| Wetland forest | | | | | | | | |
| Mire | | | | 1 | | | 1 | |
| Dwarf shrub mire | | | | | | 3 | | |
| Grassy mire | | | | | 1 | | | |
| Dwarf shrub/grass mire mosaic | | | | | 1 | | | |
| Boulder/rock | | 3 | 1 | | | | | |
| Annet | | | 6 | 4 | 7 | | | |

*Table 7. Vegetation types registered in the different months for Brattefjell-Vindeggen.*

| Brattefjell-Vindeggen | March | April | May | June | July | August | September | October |
|---|---|---|---|---|---|---|---|---|
| Ridge | 6 | 3 | 1 | 1 | | | | |
| Lichen heaths | 11 | 19 | 7 | 3 | 1 | | 1 | |
| Dwarf-shrub heaths | 4 | 18 | 27 | 26 | 4 | 2 | 4 | 1 |
| Dry grass heaths | | | 1 | | | | | |
| Lichen/dwarfshrub heath | 5 | 6 | 5 | 4 | 1 | | | |
| Alpine ling heaths | | | | 2 | | | | |
| Rishei/snøleie | | | | | | | | |
| Snowbed | | | 1 | | | | | |
| Grassy smowbed | | | | 3 | 3 | | | |
| Birchforest | | | 3 | 3 | | | | |
| Mountain birch forest | | 6 | 23 | 18 | 5 | 2 | | |
| Blueberry-dominated birch forest | | | | | | 2 | | |
| Meadow-type birch forest | | | | 9 | 6 | | 1 | |
| Broadleaved forest | | | | | | 1 | | |
| Tall forb meadows | | | | 9 | | | | |
| Dwarf shrub/tall forb meadow | | | | 1 | | | | |
| Dwarf-shrub/meadow | | | | | | | | |
| Coniferous forest | | | | | | | 3 | 5 |
| Pine forest | | | | | | | 2 | |
| Meadow-type pine forest | | | | | | | | |
| Blueberry-dominated pine forest | | | | | | 1 | 1 | |
| Lav- og lyngrik furuskog | | | | | 1 | 1 | 1 | 1 |
| Spruce forest | | | 1 | | 1 | 2 | 3 | |
| Lichen- and heather-rich spruce forest | | | | | 6 | 2 | 1 | |
| Blueberry-dominated spruce forest | | | | 4 | 31 | 23 | 25 | |
| Meadow-type spruce forest | | | | | 16 | 13 | 2 | |
| Wetland forest | | | | 3 | 2 | | | |
| Mire forest | | | | | | | 2 | |
| Mires and swamps | | | | 1 | 1 | 3 | 4 | |
| Dwarf-shrub mires | | | | 3 | 4 | 1 | 1 | 1 |
| Grassy mires | | | 1 | 2 | 11 | | 1 | |
| Dwarf brush/grass mire | | | | | 1 | | | |
| Boulder/rock | | | | | | | | |
| Annet | | | | 7 | 6 | 8 | 16 | |

*Table 8. All observed eaten plant species for both Setesdal Austhei and Brattefjell-Vindeggen.*

| Vegetation eaten | | |
|---|---|---|
| | Setesdal Austhei | Brattefjell-Vindeggen |
| **Lichen** | **63** | **88** |
| *Alectoria* | 0 | 1(1) |
| *Cetraria islandica* | 4(5) | 19(21) |
| *Cladonia furcata* | 0 | 1(1) |
| *Cladonia stellaris* | 0 | 2(3) |
| *Cladonia unicalis* | 1(9) | 1(4) |
| *Grey lichen (?)* | 2(2) | 0 |
| *Hypogymnia* | 0 | 11(14) |
| *Reindeer lichen* | 27(36) | 33(41) |
| *Umbilicaria* | 5(10) | 3(3) |
| | | |
| **Herbs/grasses** | **140** | **177** |
| *Alchemilla alpina* | 3(3) | 2(2) |
| *Anemone nemorosa* | 0 | 4(5) |
| *Carex bigelowii* | 2(2) | 1(1) |
| *Chamaepericlymenum suecicum* | 4(6) | 2(2) |
| *Cirsium heterophyllum* | 2(2) | 1(1) |
| *Fern* | 0 | 1(1) |
| *Fragaria vesca* | 0 | 1(1) |
| *Gentiana purpurea* | 38(39) | 2(2) |
| *Geranium sylvaticum* | 2(2) | 6(12) |
| *Grass* | 30(30) | 103(103) |
| *Lysimachia europaea* | 1(1) | 0 |
| *Maianthemum bifolium* | 4(4) | 2(2) |
| *Melampyrum pratense* | 7(8) | 5(5) |
| *Narthecium ossifragum* | 1(1) | 0 |
| *Oxalis acetosella* | 0 | 1(1) |
| *Phegopteris connectilis* | 0 | 1(1) |
| *Potentilla erecta* | 6(8) | 12(13) |
| *Rumex acetosa* | 11(5) | 22(22) |
| *Solidago virgaurea* | 5(19) | 1(2) |
| | | |
| **Trees/bushes** | **33** | **46** |
| *Arctous alpina* | 2(2) | 0 |
| *Betula nana* | 13(13) | 18(18) |
| *Betula pubescens* | 5(6) | 1(1) |
| *Rubus chamaemorus* | 0 | 3(4) |
| *Salix herbacea* | 4(6) | 3(4) |
| *Sorbus aucuparia* | 0 | 2(6) |
| *Vaccinium myrtillus* | 0 | 7(12) |
| *Vaccinium uliginosum* | 6(6) | 1 |
| | | |
| **Mushrooms** | **3** | **4** |
| ? | 3(3) | |
| *Boletus edulis?* | 0 | 2(2) |
| *Lactarius?* | 0 | 1(1) |
| White mushroom | 0 | 1(1) |