UNIVERSITY OF TROMSØ UiT
FACULTY OF BIOSCIENCES, FISHERIES AND ECONOMICS
DEPARTMENT OF ARCTIC AND MARINE BIOLOGY

The diet of polar bears (*Ursus maritimus*) from Svalbard, Norway, inferred from scat analysis

Marianne Iversen

BIO-3910 Master`s thesis in Biology

Northern populations and ecosystems

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Preface

This thesis has been written as an article, for submission to the journal "Polar biology". The manuscript has been prepared as described by "Instructions for authors" on the journals web page, with the exception that diagrams are placed within the text.

Working with this master thesis has been a journey, a journey during which I have learned a lot. It has also been a realization of a life-long dream, namely working with a large carnivore and experiencing it in the wild. This thesis project has given me the opportunity to participate in exciting field work, which has increased my fascination with the Arctic and the creatures that inhabit it.

This thesis is the result of many hours spent in a laboratory filled with the stench of polar bear scats. For a student who has been accustomed to having every single step of a laboratory exercise being carefully laid out and explained before even putting on a lab-coat, the independent work conducted during my MSc has been a rewarding experience. One learns to have confidence in one's own decisions, which is a valuable skill to take into a research career and beyond into life.

I would like to give special thanks to my supervisors at the Norwegian Polar Institute (NPI), Drs. Jon Aars, Christian Lydersen and Kit Kovacs. Without them, this thesis would not be what it is today. I would also like to thank Dr. Tore Haug for serving as my academic supervisor at the University of Tromsø (UiT).

Many people have contributed their expertise to the creation of this MSc thesis, and I would like to thank them all. Inger G. Alsos, Arve Elvebakk and the rest of the employees at the botanical department at Tromsø Museum have helped with the identification of the terrestrial plants found in the polar bear scats. Lutz Bachmann has run DNA-analysis on the seal tissue from the scats. Anne-Grethe Hestnes allowed me to use the microscopes at the Department of Arctic and Marine Biology, UiT. The Institute of Marine Research, Tromsø, for allowing to me use their lab facilities. I also thank everyone who has collected scats thinking that something useful might one day come out of it.

A very special thank you goes out to Jon Aars and Magnus Andersen for letting me participate in the amazing field work they do every spring in Svalbard. It has been one of the highlights in my life so far.

I would like to thank the University of Tromsø, and especially the Department of Arctic and Marine Biology for having provided me with inspiring teachers and memorable experiences. And thank you to Jon Aars and NPI for providing me with the opportunity of doing this MSc thesis.

I am also grateful to my family and good friends; I thank you all for being who you are, and being there for me in good times and in bad.

"Learn from yesterday, live for today, hope for tomorrow.
The important thing is not to stop questioning."

-Albert Einstein-

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Abstract:

The diet of polar bears in the Svalbard area was assessed based analyses of scats (n=119) collected in the Archipelago between 2003 and 2010. Most of the samples were collected in spring. Morphological analysis of the prey remains together with genetic analyses of tissue fragments found in the scats showed that ringed seals (*Pusa hispida*) were the most important prey group present; this seal species occurred in 58% (CI 48.6%-67.0%) of the scats. Ringed seal pups were particularly abundant (45.4%, CI 36.2%-54.8%). Bearded seal (*Erignathus barbatus*) and birds seemed to be minor components in the diet, while Svalbard reindeer (*Rangifer tarandus platyrhynchus*), considering its size and the frequency with which it occurred in the scats (9.2 %), likely plays a more important role in the diet than previously reported. Whether reindeer are hunted actively by the polar bears or occur in the diet via scavenging is uncertain. Terrestrial plants and marine algae occurred more frequently in the polar bear diet than would be expected from accidental ingestion, with 32.8 % (CI 24.4%-42.0%) and 21.8 % (CI 14.8%-30.4%) of scats containing these food items, respectively. It appears that they are eaten deliberately; perhaps to meet nutritional requirements for mineral nutrients or vitamins. This study has shown that scat analysis is a useful method for assessing the diet of this large carnivore, despite the advanced state of digestion of food items in most polar bear scats.

Keywords: polar bears, diet, scatology, ringed seal, Svalbard, reindeer, terrestrial plants

1. Introduction

The polar bear (*Ursus maritimus*) is the most carnivorous ursid and is an apex predator in the Arctic (Amstrup 2003). It has a circumpolar range and an estimated global population size of 20 000-25 000 bears (Obbard et al. 2010). The global range has been divided into several sub-populations based on distribution, movement patterns and genetic analyses, currently19 sub-populations are recognized (Obbard et al. 2010).

Polar bears in Svalbard belong to the Barents Sea sub-population, which was estimated to contain 2,644 animals (95 % CI: 1,899-3,592) in 2004 (Aars et al. 2009). Polar bears in Svalbard display markedly different space use patterns. Some are highly migratory, mainly utilizing the offshore sea-ice east or north-east of Svalbard, while others stay close to the islands within the Svalbard Archipelago throughout the year (Mauritzen et al. 2001).

Despite many years of active research on polar bears in the region, knowledge is still scarce regarding the diet of bears on Svalbard. Diet studies are important in an ecological context as they give insight into trophic interactions and energy flow through food webs. Although the main prey items of the polar bear are well known, knowledge of local variation and temporal change in diet composition is still lacking in many regards.

Diet studies on polar bears generally fall into three categories: those based on observations (Smith 1980, 1985; Smith and Sjare 1990; Stempniewicz 1993; Derocher et al. 2000; 2002; Stempniewicz 2006; Dyck and Romberg 2007); those based on investigations of gastrointestinal or scat content (Lønø 1970; Russell 1975); and those based on biochemical analysis of fatty acids or stable isotopes (Grahl-Nielsen et al. 2003; Thiemann et al. 2007; Thiemann et al. 2008; Hobson et al. 2009).

Most studies of the diet of polar bears have been conducted in the Canadian and Alaskan Arctic. However, with few exceptions, studies show that the food items of polar bears in the North American Arctic and Svalbard are very similar.

Polar bears primarily hunt ice-associated seals, most notably ringed seals (*Pusa hispida*) (Lønø 1970; Smith 1980; Derocher et al. 2002; Thiemann et al. 2008). Bearded seals (*Erignathus barbatus*) and walruses (*Odobenus rosmarus*) are also consumed by bears throughout the Arctic (Lønø 1970; Smith 1980; Calvert and Stirling 1990; Derocher et al. 2002; Thiemann et al. 2008). Other seal species such as harp (*Pagophilus groenlandicus*), hooded (*Cystophora cristata*) and harbor (*Phoca vitulina*) seals are preyed upon in areas where they are available (Lønø 1970; Derocher et al. 2002; Thiemann et al. 2008). In some areas, polar bears also hunt toothed whales such as white whales (*Delphinapterus leucas*) (Smith 1985; Lowry et al. 1987) and narwhals (*Monodon monocerus*) (Smith and Sjare 1990). Despite being highly specialized in hunting ice-associated marine mammals, polar bears are opportunistic feeders. They have been observed hunting in bird rookeries and cliffs where they take eggs and chicks and also occasionally live adult birds (Stempniewicz 1993; Drent and Prop 2008; Rockwell and Gormezano 2009; Smith et al. 2010). Polar bears have also been reported to chase marine birds in the water (Stempniewicz 2006). Observations during the 1980's and 1990's showed that the bears in Svalbard also occasionally take Svalbard reindeer (*Rangifer tarandus platyrhyncus*) (Derocher et al. 2000), despite earlier reports suggesting that this was not the case (Lønø 1970). Rare observations of single polar bears catching freshwater fish have also been reported (Dyck and Romberg 2007). Polar bears also feed on carrion from whales, reindeer, seals, birds and even other polar bears when they come across them. Direct cannibalism among polar bears does also occur. Except for infanticide by males, feeding on conspecifics has often been assumed to be associated with high levels of nutritional stress (Taylor et al. 1985; Derocher and Wiig 1999; Amstrup et al. 2006).

Polar bears have also been documented to feed on marine and terrestrial vegetation, but the energetic contribution of these food items has been considered to be minor (Russell 1975; Ramsay and Hobson 1991). One exception might be energy-rich berries that are consumed by polar bears in some areas in Canada during the summer, when there is no access to marine prey (Derocher et al. 1993; Dyck and Kebreab 2009). In some areas, polar bears also use garbage dumps as feeding grounds for certain parts of the year (Lunn and Stirling 1985; Stirling and Guravich 1988).

This study is a contribution to the knowledge of polar bear diet in Svalbard that supplements previous studies from this area in which the main focus has been on the importance of different seal species as prey (Derocher et al. 2002; Grahl-

Nielsen et al. 2003). The present study analyzed polar bear scat using morphological and genetic methods to do a qualitative assessment of the diet and explore this alternative method. Scat analysis is a non-invasive technique that does not require any animal handling or other disturbance to animals, which if successful may be preferable to other biochemical methods that require live-tissue sampling.

2. Methods

2.1 The study area and collection of scat samples

Polar bear scats (n=119) were collected opportunistically from various sites in Svalbard during the period 2003-2010 (Fig. 1). Most of the scats were collected during spring (n=104, late March until end of late April); 11 scats were collected in summer/autumn (early June until mid September).

The latter sample will hereafter be referred to as summer data. Date of collection for four scats is unknown, and 11 were from unknown locations. The scats were collected mainly during tracking and capture research programmes focused on polar bears during spring field work conducted by the Norwegian Polar Institute. Some of the samples (n=16) were collected during mark-recapture work on polar bears, and in these cases the identity of the bear and thus the age and sex of the individual that deposited the scat is known. These scats were from four adult females (age six years or older), four adult males (age ten years or older), two sub adult females (both four years old) , and six cubs (zero or one year old) (age groups according to Thiemann et al. 2008; see Appendix, Table 1, for further details). Additionally, the sex of eight more adult bears (four females, four males) was determined based on direct observations made of the bears depositing the scats.

A subset of the samples (n=14) originates from a maternity denning survey on Kongsøya in April 2009. These scats were collected either inside the dens or in close proximity to the den and are thus assumed to belong to either the female bear associated with the den or her cubs. Two of these samples were confirmed to be from cubs.

Figure 1 Map showing the locations (and corresponding sample sizes, n) of polar bear scat collections made in Svalbard during 2003 to 2010 (in total 108 samples were from known locations, 11 samples were from unknown locations and are thus not shown on this figure).

2.2 Handling of samples

Scat samples were kept frozen after collection. Samples collected during spring would likely have been exposed to only sub-zero temperatures (average temperature for April 2003-2010 was -8.3 ˚C ± (SD) 4.7 ˚C at Svalbard Airport, (http://eklima.met.no). Samples collected during summer will have experienced above freezing temperatures prior to being collected.

In the lab, the scat samples were weighed and photographed. Subsequently, they were rinsed through a series of three sieves (7 mm, 2 mm, and 1 mm) in order to collect material that should be used for identification of various food items. Material taken out of the sieves was put in plastic bags and stored in the freezer until further analysis. In cases where there was a large amount of material clearly belonging to the same food item, a subsample was collected for use in later identification, while the remaining material was stored separately in the freezer.

Most of the material collected for further identification was found in the upper sieve (7 mm). Here, skin pieces, feathers, larger parts of terrestrial plants and marine algae, claws, teeth, and pieces of bone were collected. In addition, hair also tended to aggregate here in mats. The middle sieve (2 mm) was also useful for collecting hair and smaller pieces of plant material. The bottom sieve (1 mm) tended to become clogged with highly digested material and fecal slough, and rarely contained anything useful for identification of prey. However, in some cases where the feces had a very liquid texture (consisting almost entirely of highly digested material and fecal slough) the bottom sieve was useful in catching the few hairs the feces did contain.

The collected food materials were categorized into 13 main categories (Seals, Polar bear hairs, Birds, Reindeer, Unknown bones, Eggs, Parasites, Terrestrial plants, Marine algae, Gravel, Wood, Plastic and Unknown). Seals, Terrestrial plants and Marine algae were further divided into sub-groups.

2.3 Identification of prey using hair

An initial attempt to identify seal species in the scats by comparing the structure of the hairs found in the feces to specimens from known seal species (ringed, bearded, harbor and harp seal) failed. No species –specific distinguishing features were found. Only hair from ringed seal pups could be clearly separated from the rest of the seal hair by looking at the macroscopic structure. The long, white fetal hair (lanugo) was readily distinguished from the short, stiff hair found on older seals of all species in the Svalbard region. Seal hair was easily distinguished from reindeer hair and the guard hairs of polar bears. Reindeer hair is hollow (Ling 1970), which can easily be seen under a microscope. Polar bear guard hairs stand out compared to other hairs, due to their length and stiffness (measured up to 14 cm long). However, there is a danger of falsely identifying polar bear hairs that are not guard hairs (i.e. hairs from the undercoat) as ringed seal pup hairs. However, in most cases other items such as claws, teeth or skin were present to help definitly identify the prey as a ringed seal pup. In addition, hairs from polar bear self-grooming were usually spread evenly throughout the scat, while hair from prey animals are usually found in dense hairballs (Elgmork 1979).

2.4 Identification of seals to species

Seals were initially recognized as such based on remains such as skin, hair, claws, teeth, and vibrissae. Ringed seal pups were easily identified based on the presence of lanugo as stated above. When darker hairs were found in connection with lanugo, it was assumed that this material was from the mother ringed seal since polar bears often wait by the breathing hole for the mother following a pup kill in order to kill her too (Lydersen, C. and Kovacs, K. M. , unpublished material).

Pieces of seal skin or soft tissue were genetically analysed at the Museum of Natural History in Oslo (n=59). The analysis was performed as follows: Total genomic DNA was extracted from each sample using the commercially available DNA E.Z.N.A. Tissue DNA kit (Omega Bio-tek) following the kit's protocol for isolation of DNA from tissue, but with the incubation of tissue in proteinase K solution being extended overnight at 55°C. Precautions were taken to avoid cross contamination of samples.

Chytochrome oxidase subunit 1 (cox 1) sequences of the target seal species were retrieved from GenBank and manually aligned in BioEdit (Hall 1999). Conserved regions were targeted for designing primer pairs. The degenerate primers were obtained from DNA Technology AS, Risskov, Denmark. Due to significant DNA degradation in the samples, the selected target regions were short (initial attempts targeting longer regions for the PCR amplification failed). The regions selected were a 205 bp fragment (using the primer pair *seal2f5'* –ACTACTGGCCTCCT CYATAGTAG-3' and *seal3r 5'*-GRTATTGAGAYATTGCAGGRGGTT-3'), a 143 bp fragment (using the primer pair *seal4f 5'*-TTCTGATTCTTYGGACAY CCGA-3' and *seal5r 5'*-AAGCCRATRGAYATTATTGCT-3') and a 217 bp fragment (using the primer pair *seal6f 5'*-CCCAACAYTTYCTAGGTCTAT-3' and *seal7r 5'*-GGACATCCRTGYAGTCATTCG-3'). PCR amplification of the target regions was done using AmpliTaq Gold® Fast PCR Master Mix (Applied Biosystems) following the vendor's standard instructions. A protocol starting with a denaturing step of 94˚C for three minutes, followed by 40 cycles of 94˚C for 30s, 40˚C for 15s, 72˚C for 20s completed by an extended period at 72˚C (for two minutes). A very low annealing temperature was used in order to obtain PCR products, as attempts to do PCR amplification at higher temperatures generally failed (also due to the significant degradation of the template DNA).

Purification of the PCR products that were of sufficient quality were done using 10x diluted exoSAP-IT (USB Corporation), and thereafter sequenced following the instructions of the BigDye 1.1 sequencing kit (Applied Bioscience). The nucleotide sequences were then aligned and edited in the software program Sequencher 4.1 (GeneCodes). Among the targeted regions *6/7* was the most useful one for species identification.

The genetic analyses were compared with the morphological analysis, though the value of this comparison was limited by the lack of species diversity determined by the genetic results.

2.5 Identification of plants

The terrestrial plant material was studied using a binocular microscope or when necessary an ordinary microscope, and identified to the lowest possible taxonomic level using comparative material from the herbarium at Tromsø Museum and http://svalbardflora.net (an online flora guide, Tromsø University Museum). Most dicotyledons were determined to species level, but will mainly be referred to as dicotyledons herein (see Appendix 1, Table 3 for a species list). Grasses, sedges, mosses and lichens were generally not determined to the species level (with the exception of some few mosses), but rather they were grouped into the four subgroups mentioned above (see Appendix 1, Table 4 for a species list of mosses).

The marine plants were divided into two subgroups: green algae and red/brown algae, since the latter two taxonomic groupings were hard to separate from each other after having been processed by the polar bear digestive system.

2.6 Data treatment

A binomial distribution approach was used when analyzing the contribution of the various food items (present=1; not present=0) to the polar bears' diet in this qualitative study. The relative occurence of the different food items are presented as percentages with corresponding confidence intervals (CI).

The statistical analyses were run in R, version 2.12.1 (R Development Core Team 2010). Binomial generalized linear models were run in several cases to explore to what extent the response variable (absence/presence) of a prey group or other substance (e. g. gravel, plants) could be explained by other specific contents in the scats or by season. Analysis of variance (ANOVA) was performed on the GLM-models in order to test the significance of the model terms. To calculate 95% confidence intervals (CI) of proportions of scat with specific prey or other items found, the *binom.test* function in program R was used.

No statistical analyses were run using sex or age as variables due to the low sample size of known individuals, even when pooling the adult bears of know identity with the adult bears for which only sex was known.

3. Results

The most abundant prey category found in the scats was seal remains. Seal tissues were found in 67.2% (CI= 58.0-75.6%) of the 119 scats examined (Fig. 2). Terrestrial plants and marine algae were also abundant and were found in 32.8% (CI= 24.4-42.0%) and 21.8% (CI= 14.8-30.4%) of the scats, respectively.

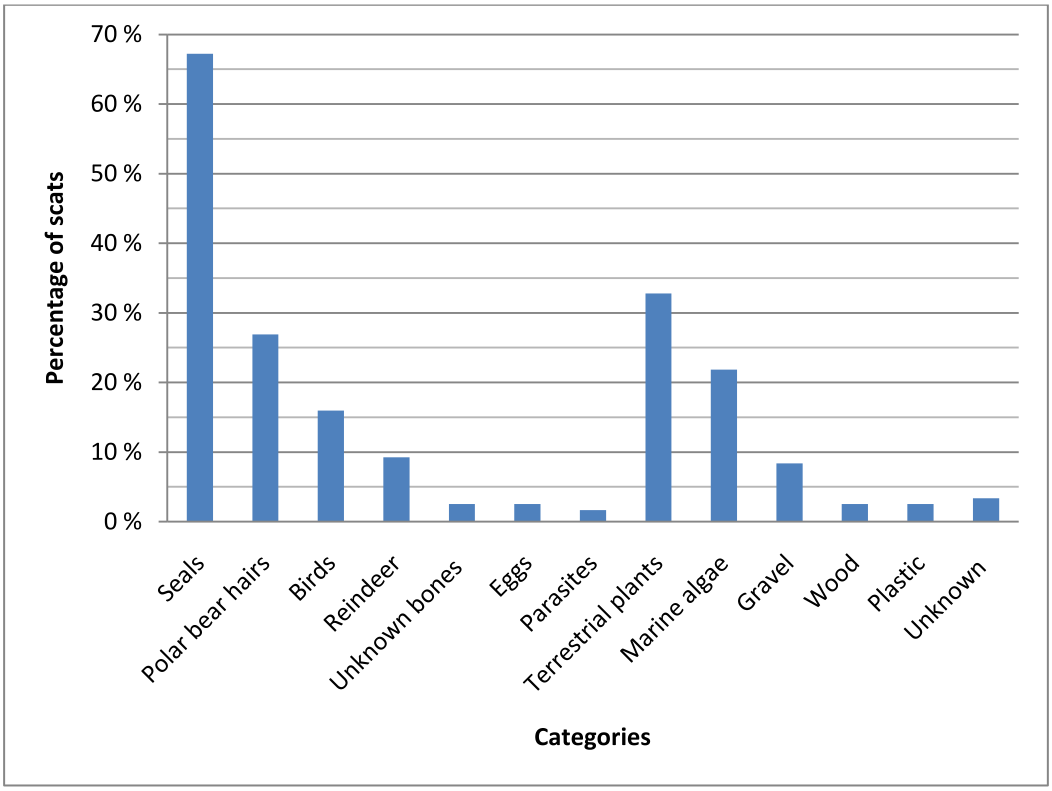

Figure 2 The frequency of occurrence of various items found in polar bear scats from Svalbard (n=119) collected in the period 2003-2010.

Almost half of the scats (45.4%, CI= 36.2-54.8%, n=119) contained only one category of prey (or food items), while the remaining scats contained material from between two and five different categories (Fig. 3). A detailed overview of the findings for each of the 119 individual scats is available in the Appendix (Table 1, but see also Tables 2, 3 and 4 in the Appendix).

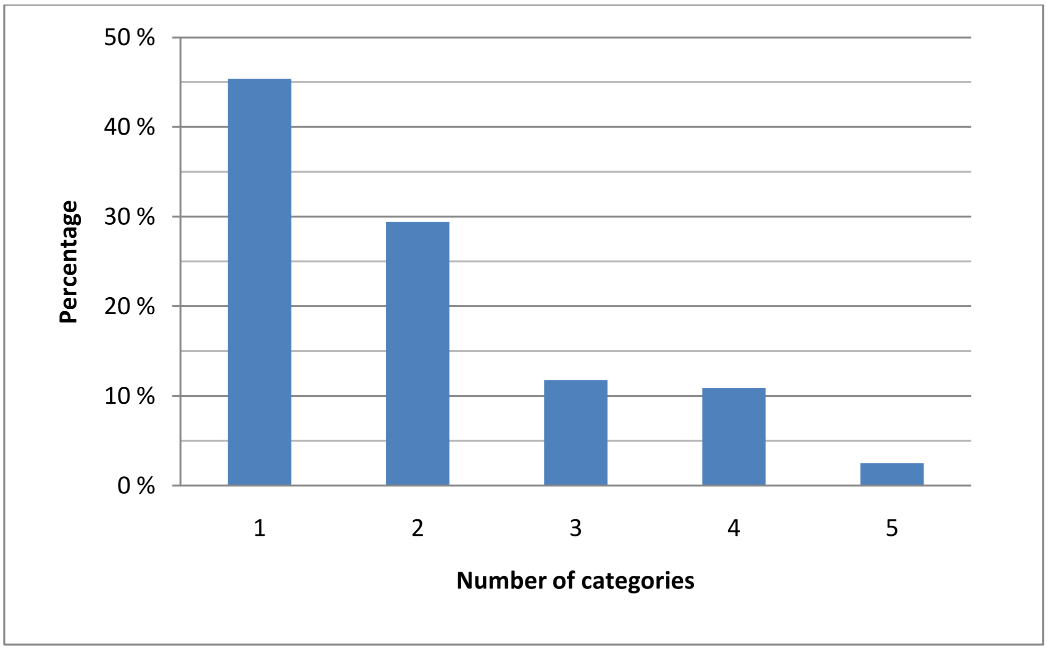

Figure 3 The frequencies at which different "food" categories were found together in polar bear scats (n=119) collected in Svalbard 2003-2010.

The generic category *Seals* (found in 67.2% of the 119 scats) was further divided further into six subgroups based on the morphological and genetic analysis (Fig. 4). Fifty-eight of the 59 samples analyzed genetically were identified as ringed seal; the remaining sample was identified as bearded seal (in this case only soft tissue was retrieved from the scat, making a morphological comparison impossible). From the comparison of the genetic and morphological analysis it was clear that the only seals which could be clearly identified by morphological analysis were the ringed seal pups. Thus, for all juvenile and adult seals only those samples identified by genetic analysis have been put into species categories in the result section, with the exception of when an adult seal was found with a ringed seal pup (see above).

Ringed seals dominated the diet virtually completely. Ringed seal material was found in 58.0% (CI= 48.6-67.0%) of the scats. Ringed seal pups constituted most of this material; pups were identified in 45.4% (CI= 36.2-54.8%) of the scats. Bearded seal was found in only one sample (Fig. 3).

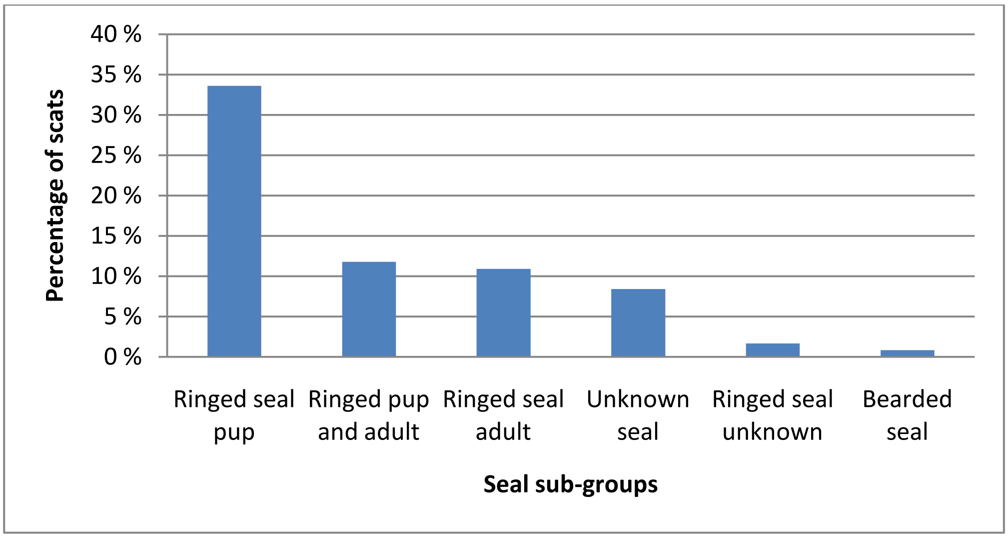

Figure 4 Frequency of occurrence of various subgroups of seal in polar bear scats (n=119) collected in Svalbard 2003-2010.

Remains of birds were found in 16.0% (CI= 9.9-23.8) of the scats; and pieces of eggshell in 2.5% (CI= 0.5-7.2%) of the scats. Two of the scats contained eggshells also contained bird remains.

Reindeer hair was found in 9.2% (CI= 4.7-15.9%) of the scats. Three of the scats containing reindeer were from the 11 scats collected during summer. Remains of seals were not found in any of these three samples, but five of the eight scats with reindeer contents from spring also contained seals. Terrestrial plants (n=8) and algae (n=4) were found in many of the scats that contained reindeer.

Mosses (26.9%, CI= 19.2-35.8%) and grasses (26.1%, CI= 18.4-34.9%) were common among the 32.8% of scat samples that contained terrestrial plant material. Dicotyledons were found in 24.4% (CI= 17.0-33.1%) of the scats (Fig. 5). The mass of different plant material was not quantified but plant material that occurred at highest frequencies in the samples also superficially appeared to have the highest biomass (grass and mosses). The most common dicotyledons included polar willow (*Salix polaris*), Arctic mouse-ear chickweed (*Cerastium* sp.) and starwort (*Stellaria* sp.) species (a full overview can be found in the Appendix). Sixteen (13.4%, CI= 7.9-20.9%) of the scats contained plant material that could not be identified. In many cases, this was due to the absence of identifiable parts such as leaves, flowers and seed capsules. Several plant subgroups were frequently found together (see Appendix).

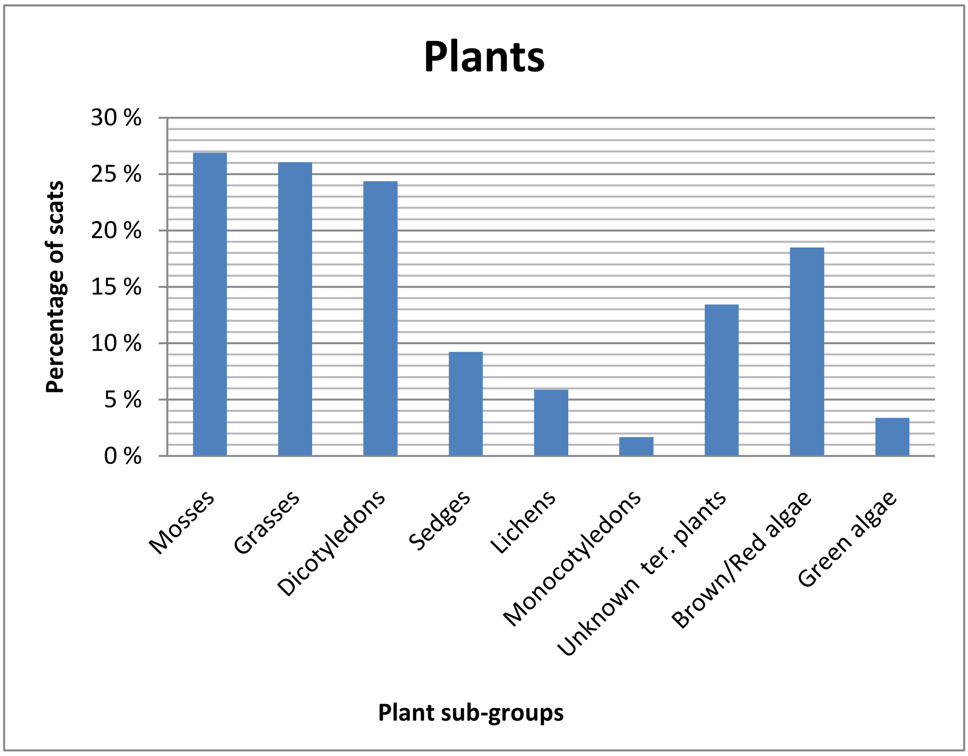

Figure 5 Frequency of polar bear scats collected 2003-2010 from Svalbard (n=119) that contained various plant material.

Marine algae were found in 21.9% of the scat samples; 18.5% (CI= 12.0-26.6%) of these were categorized as brown or red algae, while 3.4% (CI=0.9-8.4%) were identified as green algae. A small piece of a mushroom was also found in one scat.

The maternity den scat samples were few (n=14). Thirteen of these samples (92.9%, CI= 66.1-99.8%) contained polar bear hairs. Plant material was found in nine scats (64.3%, CI= 35.1-87.2%). Surprisingly, two of these scats contained ringed seal. One of the samples which contained polar bear hair and plant material also contained bird remains. Two scats, which were identified in the field to be from cubs of the year, both contained plant material such as grass, sedges and moss. One of these also contained gravel.

From the samples where the identities of the bears were known scats from two different cubs of the year both contained ringed seal in addition to plant material and gravel (these scats were collected at 19th of April 2003 and 17th of April 2010).

Three out of four 1-year olds had consumed seal (unknown species in one, and ringed seal in the two others). In one of these, reindeer hairs and plant material was also found, and in another algae and bird remains. The fourth 1-year old had eaten both terrestrial plants and marine algae.

Two sub-adult females had both eaten ringed seals. In one of the scats a ringed seal pup was found together with remains of an adult ringed seal, algae and plants, and in the other animal ringed seal pup remains were found together with plants and gravel.

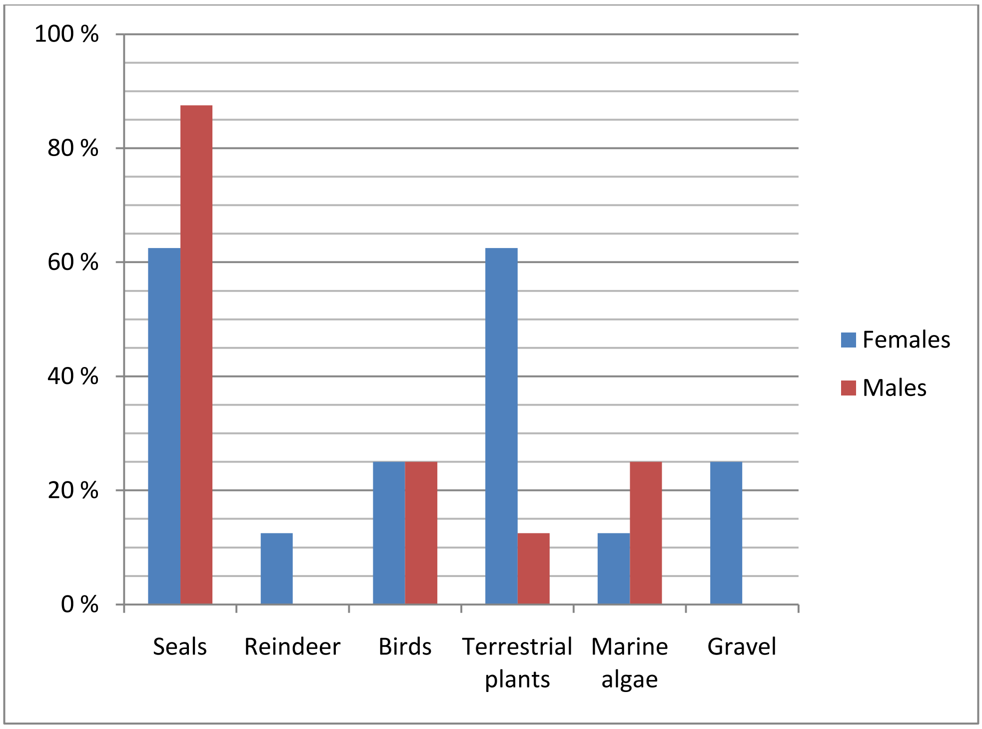

Figure 6 Content of scats, collected from adult female (N=8) and male (N=8) polar bears from Svalbard 2003-2010.

Four of the adult females only had one category of prey in their scat, while each of the other four had three different categories of food items. Six of the adult males had only one category of prey, namely Seals, while two males had three different categories of food items in their scat. The females in the sample also seem to have consumed more plant material than the males.

A significant positive relationship was found between the occurrence of Terrestrial plants and Gravel in the scat material (p-value<0.0001, dev. = 15.778, 1 d. f.). In the 39 samples that had plant material, 23.1% (CI= 11.1-39.3%) also had gravel, compared to only 1.2% (CI= 0.0-6.8%) in the 80 scats without plants.

Also consumption of Reindeer and Terrestrial plants had a significant positive relationship (p-value=0.004, dev. = 8.17, 1d. f.). Of the 39 samples with plant material, 20.5% (CI= 9.3-36.5%) had reindeer in them while among the 80 samples without plant material, only 3.8% (CI= 0.8-10.6%) had reindeer. There was a strong negative relationship between Terrestrial plants and Seals (p-value<0.0001, dev. = 21.367, 1 d. f.). Among the 80 samples that had seal, 18.8% (CI= 10.9-29.0%) also had plants, while in the 39 samples without seal, plants were found in 61.5% (CI= 44.6-76.6%). There was no significant relationship between the total number of scats with ringed seal pups and the total number of scats with ringed seal adults (p-value=0.443, dev. = 0.588, 1 d. f.); the frequency of adult ringed seals in 54 samples with ringed seal pups was 26% (CI= 15.0-39.6%), which is similar to the frequency in 65 samples without ringed seal pups (20%, CI= 11.1-31.8%).

The heavy seasonal bias in sampling, with 104 samples from spring and only 11 from summer (and four unknown dates) prevented a thorough analysis of potential seasonal variation in feeding behaviour of these polar bears. Even so, some patterns seemed to be very pronounced. The fraction of scats with Seal was reduced significantly from 74.0% (CI= 64.5-82.1%) in spring to 9.1% (CI= 0.2-41.3%) in summer (p-value<0.001, dev. = 18.666, 1 d. f.). For Terrestrial plants, the trend was opposite, increasing from 27.9% (CI= 19.5-37.5%) to 72.7% (CI= 39.0-94.0%) from spring to summer (p-value=0.004, dev. = 8.482, 1 d. f.). Neither Marine algae (change from 22.1%, CI= 14.6-31.3%, in spring to 18.2%, CI= 2.3-51.8%, in summer) nor Reindeer (change from 7.7%, CI= 3.4-14.6%, in spring to 27.3%, CI= 6.0-61.0%, in summer) showed significant seasonal variation. Both the categories Birds and Eggs were found more frequently in summer (being found in 13.5%, CI= 7.6-21.6%, and 1%, CI= 0.0-5.2%, respectively, in spring samples to being found in 45.5%, CI=16.7-76.6%, and 18.2%, CI= 2.3-51.8%, of summer samples, p-value 0.016, dev. = 5.759 and 1 d. f. for Birds and p-value 0.014, dev. = 6.089, 1 d. f. for Eggs).

4. Discussion

The most common prey item for polar bears in Svalbard in spring was ringed seals, especially ringed seal pups. This principal finding is in agreement with previous diet studies from the Svalbard region (Lønø 1970; Derocher et al. 2002), and elsewhere in the Arctic (Thiemann et al. 2008).

The ringed seal is extremely well adapted to a life associated with sea ice (Smith et al. 1990; Kovacs et al. 2011). In spring, they are usually found in areas of land-fast sea ice with deep snow cover (Smith and Stirling 1975). Lairs in the snow are dug above breathing holes by seals of both sexes; these small caves are used both as resting and birthing (pupping) sites (Lydersen and Ryg 1991). The lairs act as a temporary shelter against predators, and for the young pup as a barrier against the harsh Arctic conditions outside of the lair (Smith and Stirling 1975). A single seal usually has several lairs and breathing holes which it moves between in order to reduce predation risk (Lydersen and Gjertz 1986). In Svalbard, prime ringed seal habitat is found deep inside the many fjords, often in close proximity to glacier fronts. Here the ice is stable, and ice-blocks that have been calved from the glacier provide areas where snow can accumulate in sufficient amounts to enable lairs to be dug. Polar bears, and particularly females with cubs of the year, hunt extensively in these areas during spring (Mauritzen et al. 2003; Freitas et al. m. s. in preparation). In Canada polar bears also hunt intensively in ringed seal breeding habitat in spring (Smith et al. 1990). Smith (1980) found that the greatest proportion of kills in ringed seal breeding habitat was pups in their birth lairs. A new born ringed seal pup is easy to catch, but does not represent a lot of energy to a polar bear, even though the energy content increases significantly as the pup grows (Lydersen and Kovacs 1999). However, mothers are often attracted to the kill site due to the strong bong between mothers and pups, which often makes her an easy kill for the polar bear (Smith 1987). A large proportion of the samples analysed in this study were collected in Tjuvfjorden (Edgeøya), in Hornsund and Van Keulenfjorden, all prime breeding areas for ringed seals in Svalbard (Smith and Lydersen 1991). Thus, it is not surprising that a high frequency of ringed seal pups was found in polar bear scats collected from these areas during spring.

In this study, bearded seal remains were only found in one sample, which is a much lower occurrence than reported from previous polar bear diet studies from Svalbard (Lønø 1970; Derocher et al. 2002). However, both of the earlier studies included samples from off-shore areas north and east of Svalbard collected during summer and autumn. This likely explains the discrepancies between these published studies and this study. Lønø (1970) documented that more bearded seal was found in bears shot in the pack-ice than in bears shot on Edgeøya. Mauritzen et al. (2001) hypothesized that the near-shore bears in Svalbard rely more on land-fast sea ice and the ringed seals found there in spring, while the off-shore bears target bearded and harp seals to a greater extent. This hypothesis seems to be supported by the studies of Lønø (1970) and Derocher et al.(2002). Derocher et al. (2002) also suggests that bearded seal are at least as important to polar bears in Svalbard as ringed seal due to the much larger body mass and thus energy content of the former. This study confirms the importance of ringed seal to bears hunting in the fjords with land-fast sea ice in spring; these areas are likely to be particularly important to females with small cubs.

The digestibility of ringed seal by polar bears is high, with a mean apparent digestive efficiency (AD) of 82.2% for dietary dry matter (Best 1985). Blubber has a higher AD-value than protein, and the AD-value for protein is especially low when the ingested materials include larger quantities of skeletal elements and hair (Best 1985). Since polar bears generally only eat the blubber and leave the rest of the seal (Stirling and McEwan 1975), this could potentially lead to an under-representation of ringed seal in a scat based diet study using morphological analysis, since blubber parts are digested to the degree that they are unrecognizable. However, this problem can be solved by using DNA-based methods on this highly digested matter (Dunshea 2009; Valentini et al. 2009). The best results are likely to be obtained using a combination of morphological investigation and DNA-based methods (Casper et al. 2007; Braley et al. 2010) because the combination increases the number of samples yielding dietary information and the amount of information gained from each sample.

It has long been known that polar bears occasionally eat birds and eggs (Lønø 1970; Russell 1975), but these items have never been regarded as a major food source. In the present study, we found bird remains in 16.0% of the samples (and eggshells in only three scats). The low number of scats containing eggs is likely due to the fact that most scats were collected outside the nesting period of birds in Svalbard. Recent studies have, however, reported increased predation by polar bears on nests of various ground-nesting birds (Stempniewicz 2006; Drent and Prop 2008; Rockwell and Gormezano 2009; Smith et al. 2010), which in some cases are interpreted as an effect of climate change since more bears are being stranded on shore for longer periods with declining seasonal extent of sea ice in many parts of the Arctic in recent years (Rockwell et al. 2011).

Reindeer was not considered prey for polar bears in Svalbard by Lønø (1970). However, Derocher et al. (2000) reported seven successful predation events, and six observations of polar bears scavenging on reindeer carcasses. Also, Hedberg et al. (2011) in their study of the composition of polar bear milk, found fatty acids which could be linked to reindeer consumption in two out of 16 samples. In the present study, 9.2% of all scats contained reindeer; eight out of 11 samples were from spring. Whether the reindeers are derived from predation or scavenging is unknown in the context of this study. However, reindeer mortality in Svalbard is highest during late winter and spring (Aanes et al. 2000; Kohler and Aanes 2004); the main reason for death is believed to be starvation (Reimers 1983). Reindeer carcasses might thus be of some importance for polar bears, especially for juvenile bears which have yet to develop good hunting skills. Occurrence of reindeer in the diet was positively correlated with the category Terrestrial plants (eight of 11 samples with reindeer also had plant material), which suggests that plants might be incidentally consumed while eating reindeer. However, it might also be simply that both reindeer and terrestrial plants occur in the same areas and bears may target both.

This study revealed that a high proportion of the scats contained the categories Terrestrial plants (32.8%) and Marine algae (21.9%). The frequency of occurrence of Terrestrial plants was correlated with season; terrestrial plants are more accessible and frequent in summer than in spring. No such correlation was found for Marine algae. Bears are not well-adapted to digest plant matter (Bunnell and Hamilton 1983), they have a typical carnivore digestive system without an appendix, and yet most of them are omnivores and rely heavily on plant matter. The molars of bears are typically omnivorous with a flattened grinding surface (Slater et al. 2010). Polar bears have developed more carnivorous molars through their evolution towards becoming seal-hunting carnivores (Slater et al. 2010), with smaller surface area, making them less suitable for grinding plant matter. Plant material available to polar bears in the Arctic is very different to what is accessible to other species of bears in boreal and temperate areas of the world when it comes to biomass, energy content, and production of fruits and berries. Considering this it is unlikely that plants can contribute much to the energy budget of polar bears (Amstrup 2003).

Some of the plant material ingested by polar bears may be explained as random or accidental intake while feeding on other food items. However, the very high proportion of plant material found in scats in this study suggests that deliberate ingestion is likely to be common. The fact that polar bears eat terrestrial plants when on land for any extended period of time is well documented from Canada (Russell 1975; Derocher et al. 1993). However, Lønø (1970) reported to have found grass or moss in only four out of 172 stomachs from bears in Svalbard. Hansson and Thomassen (1983) reported several incidences of grazing by female polar bears that had just emerged from their maternity dens at Kongsøya, Svalbard. Grazing by females and cubs in spring was also observed on Kongsøya in 2009 and 2011 (Øystein Overrein, pers.comm). Among the scats collected around dens on Kongsøya for this study nine out of 14 contained plant material, which suggests that grazing is a fairly common activity upon coming out the dens.

Consumption of marine algae such as kelp has also been described previously in several studies on polar bears (Lønø 1970; Russell 1975; Stirling and Cleator 1981; Stirling and Guravich 1988), and has also been reported by experienced hunters several places in Greenland (Born et al. 2011). Lønø (1970) reported one stomach containing 8.5 kg of kelp. The results of Lønø (1970) and the present study indicates that ingestion of marine algae is fairly common among polar bears in Svalbard, and again the frequency is too high to be explained by anything other than deliberate foraging.

The question arises -why would polar bears deliberately ingest plant material which they are not well adapted to digest, particularly when the energy content of plants is negligible compared to seal blubber? Dyck and Kebreab (2009) claimed that it was possible for a small polar bear to maintain its body mass by consuming berries. However, berries are not available in Svalbard in meaningful quantities. One simple explanation for the consumption of plants would be that this is an instinctive response to hunger, and that consuming plant matter provides a feeling of satiation. However, another explanation might be that plants contain minerals and certain vitamins that might be useful nutritionally. Several Arctic plant species contain relatively high levels of vitamins such as B_1, which is not present in quantifiable amounts in seal blubber (Rodahl 1945). Marine algae of the genera *Fucus* are much richer in sodium (Na), potassium (K), calcium (Ca) and manganese (Mg) than seal blubber (Brunborg et al. 2006; Bocanegra et al. 2009). All the previous mentioned elements are important for normal body functioning (Robbins 1983). It is therefore possible that polar bears consume terrestrial plants and marine algae in order to get essential nutrients and vitamins in sufficient amounts. We are not familiar with any studies on the vitamin and mineral demands of polar bears; it would be interesting to study this issue further. The idea that polar bears might eat plants in order to gain minerals and vitamins is especially interesting when considering the grazing of female bears which have recently emerged from their maternity dens. This would also explain why polar bears would spend time diving for marine algae (Lønø 1970; Stirling and Guravich 1988) from which they are unlikely to gain much in terms of energetic rewards. Presence of terrestrial plants in the scats was positively correlated with presence of gravel; which is likely due to accidental ingestion of gravel while grazing. While most gravel was very fine in this study, one scat contained 50 grams of coarse gravel. A study of grizzly bears in Yellowstone Park reports that they practice geophagy (Mattson et al. 1999), which might explain the gravel in the polar bear scats. But this is not considered likely to be common, in light of the small amounts of gravel generally found, and the low frequency of occurrence in the Svalbard samples.

The scats from cubs of the year, collected in the denning areas confirm that cubs of the year participate in grazing after emerging from the den. This has previously only been confirmed by observations on a few occasions (Øystein Overrein, pers.comm). In addition scats from two cubs of the year, collected outside of denning areas, had remains of ringed seals. This documents that polar bear cubs aged three to four months do supplement their milk intake with ingestion of seal tissue. For the remaining scats from polar bears of known sex, sample sizes were too small to draw any firm conclusion with regards to potential gender differences in diet.

The present study has documented that ringed seal, and especially ringed seal pups, are very important for polar bears during spring in Svalbard. Other seal species and birds seem to play only a minor role at this time of the year, while reindeer, considering its size and the frequency with which it occurred in the scats, seems to play a more important role than has previously been reported. Whether the reindeer is actively preyed upon, or predominantly accessed via scavenging remains unknown. Terrestrial plants and marine algae occurred too frequently in the polar bear diet in Svalbard to be considered the result of accidental ingestion, and are likely deliberately ingested, perhaps in order to get essential minerals and vitamins in sufficient amounts. Finally, this study has shown that scat analysis is a useful method for assessing the diet of this large carnivore, especially when combined with genetic techniques providing a more detailed qualitative picture.

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APPENDIX

Table 1 Overview of the findings for each of the 119 polar bear scats collected in Svalbard 2003 -2010, for details on seals and terrestrial plants see the following tables.

Sample no.	Area	Date of collection	Sex, Age	Seals	Polar bear hairs	Birds	Reindeer	Unknown bones	Eggs	Parasites	Terrestrial plants	Marine algae	Gravel	Wood	Plastic	Unknown
1	Van Koylen	20.04.2004	-	1	0	0	0	0	0	0	0	0	0	0	0	0
2	Van Koylen	22.04.2004	-	1	0	0	0	0	0	0	0	0	0	0	0	0
3	Hornsund	11.04.2004	-	1	0	0	0	0	0	0	0	0	0	0	0	1
4	Hornsund	06.04.2004	-	1	0	0	0	0	0	0	0	0	0	0	0	0
5	Hornsund	11.04.2004	-	0	1	0	0	1	1	0	0	1	0	0	0	1
6	Recherchefjorden (Bellsund)	22.04.2004	-	1	0	0	0	0	0	0	0	0	0	0	0	0
7	Van Koylen	20.04.2004	-	1	0	0	0	0	0	0	0	0	0	0	0	0
8	Burgerbukta (Hornsund)	07.04.2004	-	1	1	0	0	0	0	1	1	0	0	0	0	0
9	Van Koylen	20.04.2004	-	1	0	0	0	0	0	0	0	0	0	0	0	0
10	Hornsund	07.04.2004	-	1	1	0	0	0	0	0	0	0	0	0	0	0
11	NA	NA	-	0	1	0	0	0	0	0	0	1	0	0	0	0
12	Van Koylen	20.04.2004	-	1	0	0	0	0	0	0	0	0	0	0	0	0
13	Hornsund	11.04.2004	-	1	0	0	0	0	0	0	0	0	0	0	0	0
14	Van Koylen	22.04.2004	-	1	0	0	0	0	0	0	0	0	0	0	0	0
15	Hornsund	11.04.2004	-	1	0	0	0	0	0	0	0	0	0	0	0	0
16	Hornsund	05.04.2004	-	1	1	1	0	0	0	0	1	0	0	0	0	0
17	Van Koylen	22.04.2004	-	1	0	0	1	0	0	0	1	1	0	0	0	0
18	NA	NA	-	1	1	0	0	0	0	0	0	0	1	0	0	0
19	Hornsund	17.04.2004	-	1	0	0	0	0	0	0	0	0	0	0	0	0

Sample no.	Area	Date of collection	Sex, Age	Seals	Polar bear hairs	Birds	Reindeer	Unknown bones	Eggs	Parasites	Terrestrial plants	Marine algae	Gravel	Wood	Plastic	Unknown
20	Hornsund	12.04.2004	-	1	0	0	0	0	0	0	0	0	0	0	0	0
21	Van Koylen	20.04.2004	-	1	0	0	0	0	0	0	0	0	0	0	0	0
22	Hornsund	11.04.2004	-	1	0	0	0	0	0	0	0	0	0	0	0	0
23	Burgerbukta (Hornsund)	07.04.2010	-	1	0	0	0	0	0	0	0	0	0	0	0	0
24	Hornsund	06.04.2004	-	0	1	0	0	0	0	0	0	1	0	0	0	0
25	Van Koylen	20.04.2004	-	1	0	0	0	0	0	0	0	0	0	0	0	0
26	Hornsund	11.04.2004	-	1	0	0	0	0	0	0	0	0	0	0	0	0
27	Hornsund	06.04.2004	-	1	0	0	0	0	0	0	0	0	0	0	0	0
28	Recherchefjorden (Bellsund)	22.04.2004	-	1	0	0	0	0	0	0	0	0	0	0	0	0
29	Van Koylen	20.04.2004	-	1	0	0	1	0	0	0	1	1	0	0	0	0
30	Recherchefjorden (Bellsund)	22.04.2004	-	0	0	0	1	0	0	0	1	1	0	0	0	0
31	Van Koylen	20.04.2004	-	1	0	0	0	0	0	0	0	0	0	0	0	0
32	Hornsund	11.04.2004	-	1	0	0	0	0	0	0	0	1	0	0	0	0
33	Burgerbukta (Hornsund)	07.04.2004	-	1	0	0	0	0	0	1	0	1	0	0	0	0
34	Hornsund	04.04.2004	-	1	0	1	0	0	0	0	0	0	0	0	0	0
35	Hornsund	11.04.2004	-	1	0	0	0	0	0	0	0	0	0	0	0	0
36	Hornsund	11.04.2004	-	1	0	0	0	0	0	0	0	0	0	0	0	0
37	Hornsund	12.04.2004	-	0	1	0	0	0	0	0	0	1	0	0	0	0
38	Van Koylen	20.04.2004	-	1	0	1	0	0	0	0	0	0	0	0	0	0
39	Hornsund	11.04.2004	-	1	0	0	0	0	0	0	0	0	0	0	0	0
40	Nordøya	05.09.2009	-	0	0	0	0	0	0	0	1	0	1	0	0	0
41	Kapp Koburg, Kongsøya	08.08.2003	-	0	0	0	0	0	0	0	1	0	0	0	1	0
42	Austfjorden	09.04.2007	F, 13	1	1	0	1	0	0	0	1	0	0	0	0	0

Sample no.	Area	Date of collection	Sex, Age	Seals	Polar bear hairs	Birds	Reindeer	Unknown bones	Eggs	Parasites	Terrestrial plants	Marine algae	Gravel	Wood	Plastic	Unknown
43	Lamontøya	22.04.2009	F, 4	1	0	0	0	0	0	0	1	1	0	0	0	0
44	Widjefjorden	06.04.2009	Cub, 1	1	0	0	1	0	0	0	1	0	0	0	0	0
45	Kapp Ruth	28.08.2007	-	0	1	1	0	0	0	0	1	0	0	1	0	0
46	Lomfjorden	06.04.2009	F, 16	1	0	1	0	0	0	0	0	1	0	0	0	0
47	Woodfjorden	01.07.2009	-	0	0	0	1	0	0	0	0	0	0	0	0	0
48	Sørkapp	19.04.2005	M, 10	1	0	0	0	0	0	0	0	0	0	0	0	0
49	NA	18.04.2009	F	0	1	0	0	0	0	0	1	0	0	0	0	0
50	Hidalen, Kongsøya	12.04.2009	F	0	0	0	0	0	0	0	1	0	0	0	0	0
51	Blåbukta	NA	-	0	1	0	0	0	0	0	1	0	0	0	0	0
52	Halvmåneøya	26.04.2003	Cub, 1	1	0	1	0	0	0	0	0	1	0	0	0	0
53	Rykeyse	25.04.2003	-	1	0	0	0	0	0	0	0	0	0	0	0	0
54	Rykeyse	26.04.2003	-	1	0	0	0	0	0	0	0	0	0	0	0	0
55	Tjuvefjorden, Edgeøya	16.04.2004	-	1	0	0	0	0	0	0	0	1	0	0	0	0
56	Halvmåneøya	25.04.2003	-	1	0	0	0	0	0	0	0	0	0	0	0	0
57	Isbukta	27.04.2003	-	1	0	0	0	0	0	0	0	1	0	0	0	0
58	Isbukta	27.04.2003	-	1	0	1	0	0	0	0	0	0	0	0	0	0
59	NA	17.04.2003	-	1	0	0	0	0	0	0	0	0	0	0	0	0
60	NA	17.04.2003	-	1	0	0	0	0	0	0	0	0	0	0	0	0
61	Hornsund	10.04.2003	M	1	0	0	0	0	0	0	0	0	0	0	0	0
62	Sonklarbreen	20.07.2003	-	0	1	1	0	1	0	0	0	0	1	0	0	0
63	Tjuvefjorden, Edgeøya	17.04.2003	-	1	0	1	0	0	0	0	0	0	0	0	0	0
64	Recherchefjorden (Bellsund)	16.07.2003	-	0	0	0	0	0	0	0	1	0	0	1	0	0
65	Hopen	26.04.2003	F, 12	0	0	1	0	0	0	0	1	0	1	0	0	0

Sample no.	Area	Date of collection	Sex, Age	Seals	Polar bear hairs	Birds	Reindeer	Unknown bones	Eggs	Parasites	Terrestrial plants	Marine algae	Gravel	Wood	Plastic	Unknown
66	Sørkapp	31.03.2007	Cub, 1	0	0	0	0	0	0	0	1	1	0	0	0	1
67	Kvalvågen	19.04.2003	-	1	0	0	0	0	0	0	0	0	0	0	0	0
68	Emil'janovbreen	22.04.2003	-	1	0	0	0	0	0	0	0	0	0	0	0	0
69	Hornsund	09.04.2003	-	1	0	0	0	0	0	0	0	0	0	0	0	0
70	Hornsund	09.04.2003	-	0	0	0	0	0	0	0	0	1	0	0	0	0
71	Tjuvefjorden, Edgeøya	16.04.2003	M	0	0	1	0	0	0	0	1	1	0	0	1	0
72	Tjuvefjorden, Edgeøya	15.04.2003	-	1	0	0	0	0	0	0	0	1	0	0	0	0
73	Tjuvefjorden, Edgeøya	18.04.2003	-	0	1	1	0	0	0	0	0	1	0	1	0	0
74	NA	27.04.2003	-	1	0	0	0	0	0	0	0	0	0	0	0	0
75	Kvalvågen	19.04.2003	COY	1	0	1	0	0	0	0	1	0	1	0	0	0
76	Hornsund	10.04.2003	F	1	0	0	0	0	0	0	0	0	0	0	0	0
77	Emil'janovbreen	22.04.2003	F	1	0	0	0	0	0	0	0	0	0	0	0	0
78	Tjuvefjorden, Edgeøya	18.04.2003	M, 12	1	0	0	0	0	0	0	0	0	0	0	0	0
79	Tjuvefjorden, Edgeøya	17.04.2003	-	1	0	0	0	0	0	0	0	0	0	0	0	0
80	Tjuvefjorden, Edgeøya	16.04.2003	-	0	0	1	0	0	0	0	0	1	0	0	0	0
81	Tjuvefjorden, Edgeøya	16.04.2003	M	1	0	1	0	0	0	0	0	1	0	0	0	0
82	Kvalvågen	19.04.2003	-	1	0	0	0	0	0	0	1	1	1	0	0	0
83	Tjuvefjorden, Edgeøya	18.04.2003	-	1	1	0	0	0	0	0	0	0	0	0	0	0
84	Wichebukta	21.04.2003	Cub, 1	1	1	0	0	0	0	0	0	0	0	0	0	0
85	Hornsund	10.04.2003	-	1	0	0	0	0	0	0	0	0	0	0	0	0
86	Kvalvågen	19.04.2003	-	1	0	0	0	0	0	0	0	0	0	0	0	0
87	Tjuvefjorden, Edgeøya	17.09.2003	-	1	0	0	0	0	0	0	0	1	0	0	0	0
88	Hornsund	09.04.2003	M, 13	1	0	0	0	0	0	0	0	0	0	0	0	0

Sample no.	Area	Date of collection	Sex, Age	Seals	Polar bear hairs	Birds	Reindeer	Unknown bones	Eggs	Parasites	Terrestrial plants	Marine algae	Gravel	Wood	Plastic	Unknown
89	Tjuvefjorden, Edgeøya	17.04.2003	-	1	0	0	0	0	0	0	0	1	0	0	0	0
90	Tjuvefjorden, Edgeøya	15.04.2003	-	1	0	0	0	0	0	0	0	1	0	0	0	0
91	NA	15.04.2003	-	1	0	0	0	0	0	0	1	0	0	0	0	0
92	Franzøya	29.07.2003	-	0	0	0	0	1	0	0	1	0	0	0	0	0
93	Edgeøya	24.04.2008	F, 4	1	0	0	0	0	0	0	1	0	1	0	0	0
94	NA	NA	-	1	0	0	0	0	0	0	0	0	0	0	0	0
95	Engeløya	25.07.2003	-	0	1	1	0	0	1	0	1	0	0	0	0	0
96	Søre Castrénøya	Summer 2010	-	0	0	1	1	0	1	0	1	0	0	0	1	0
97	Søre Castrénøya	Summer 2010	-	0	0	1	1	0	0	0	1	1	0	0	0	0
98	Genevrabukta	13.04.2010	F, 6	1	0	0	0	0	0	0	1	0	1	0	0	0
99	Heimland	14.04.2010	-	0	0	0	0	0	0	0	1	0	0	0	0	0
100	Heimland	14.04.2010	M	1	0	0	0	0	0	0	0	0	0	0	0	0
101	Dunerbukta	13.04.2010	-	1	0	0	0	0	0	0	0	0	0	0	0	0
102	Yoldiabukta	17.04.2010	COY	1	1	0	1	0	0	0	1	0	1	0	0	0
103	Kvalrossøya	24.03.2010	M, 23	1	0	0	0	0	0	0	0	0	0	0	0	0
104	Heimland	08.04.2010	-	0	0	0	1	0	0	0	1	0	0	0	0	0
105	NA	16.04.2009	-	0	1	0	1	0	0	0	0	0	0	0	0	0
106	Bogen, Kongsøya	25.04.2009	-	0	1	0	0	0	0	0	1	0	1	0	0	0
107	Kongsøya	26.04.2009	-	0	1	0	0	0	0	0	1	0	0	0	0	0
108	Bogen, Kongsøya	25.04.2009	-	0	1	0	0	0	0	0	0	0	0	0	0	0
109	Hårfagrehaugen, Kongsøya	24.04.2009	-	0	1	0	0	0	0	0	0	0	0	0	0	0
110	Kongsøya	26.04.2009	-	0	1	0	0	0	0	0	0	0	0	0	0	0
111	Hårfagrehaugen, Kongsøya	24.04.2009	-	0	1	0	0	0	0	0	1	0	0	0	0	0

Sample no.	Area	Date of collection	Sex, Age	Seals	Polar bear hairs	Birds	Reindeer	Unknown bones	Eggs	Parasites	Terrestrial plants	Marine algae	Gravel	Wood	Plastic	Unknown
112	Kongsøya	24.04.2009	-	0	1	0	0	0	0	0	0	0	0	0	0	0
113	Bogen, Kongsøya	25.04.2009	-	0	1	0	0	0	0	0	0	0	0	0	0	1
114	Kongsøya	01.04.2009	-	0	1	0	0	0	0	0	1	0	0	0	0	0
115	Kongsøya	26.04.2009	-	1	1	0	0	0	0	0	1	0	0	0	0	0
116	Kongsøya	26.04.2009	-	1	1	0	0	0	0	0	1	0	0	0	0	0
117	Hårfagrehaugen, Kongsøya	24.04.2009	-	0	1	1	0	0	0	0	1	0	0	0	0	0
118	Kongsøya	27.04.2009	-	0	0	0	0	0	0	0	1	0	0	0	0	0
119	Kongsøya	April 2009	-	0	1	0	0	0	0	0	1	0	0	0	0	0
SUMS				80	32	19	11	3	3	2	39	26	10	3	3	4

Table 2 Seal material found in polar bear scats collected in Svalbard 2003-2010.

Sample no.	Ringed seals total	Ringed seals genetics	Ringed seals pup	Ringed seals adult	Bearded seal genetics	Seals sp.
1	1	1	1	0	0	0
2	1	1	1	0	0	0
3	1	1	1	0	0	0
4	1	1	1	0	0	0
5	0	0	0	0	0	0
6	1	1	1	0	0	0
7	1	1	0	1	0	0
8	1	1	0	1	0	0
9	1	1	1	1	0	0
10	1	1	1	1	0	0
11	0	0	0	0	0	0
12	1	1	1	1	0	0
13	1	1	1	0	0	0
14	1	1	1	0	0	0
15	1	1	1	0	0	0
16	1	1	0	1	0	0
17	1	0	1	1	0	0
18	1	0	1	0	0	0
19	1	1	1	0	0	0
20	1	1	1	0	0	0
21	1	1	1	1	0	0
22	1	1	1	0	0	0
23	1	1	0	1	0	0
24	0	0	0	0	0	0
25	1	1	1	1	0	0
26	1	1	1	0	0	0
27	1	1	1	0	0	0
28	1	1	1	0	0	0
29	1	1	1	0	0	0
30	0	0	0	0	0	0
31	0	0	0	0	0	1
32	0	0	0	0	0	1
33	0	0	0	0	0	1
34	1	1	0	1	0	0
35	1	1	1	0	0	0
36	1	1	1	0	0	0
37	0	0	0	0	0	0
38	1	1	1	0	0	0
39	1	1	1	0	0	0
40	0	0	0	0	0	0
41	0	0	0	0	0	0

Sample no.	Ringed seals total	Ringed seals genetics	Ringed seals pup	Ringed seals adult	Bearded seal genetics	Seals sp.
42	1	1	1	0	0	0
43	1	1	1	1	0	0
44	1	0	1	0	0	0
45	0	0	0	0	0	0
46	1	1	1	0	0	0
47	0	0	0	0	0	0
48	0	0	0	0	1	0
49	0	0	0	0	0	0
50	0	0	0	0	0	0
51	0	0	0	0	0	0
52	1	1	1	0	0	0
53	1	1	1	0	0	0
54	1	1	1	1	0	0
55	0	0	0	0	0	1
56	1	1	1	0	0	0
57	1	0	1	0	0	0
58	1	1	0	1	0	0
59	1	1	1	1	0	0
60	1	1	1	0	0	0
61	1	1	0	0	0	0
62	0	0	0	0	0	0
63	1	1	1	0	0	0
64	0	0	0	0	0	0
65	0	0	0	0	0	0
66	0	0	0	0	0	0
67	0	0	0	0	0	1
68	1	1	0	1	0	0
69	1	1	0	1	0	0
70	0	0	0	0	0	0
71	0	0	0	0	0	0
72	1	1	1	1	0	0
73	0	0	0	0	0	0
74	0	0	0	0	0	1
75	1	1	1	0	0	0
76	1	1	1	0	0	0
77	1	1	0	1	0	0
78	1	1	1	1	0	0
79	1	0	1	1	0	0
80	0	0	0	0	0	0
81	1	1	0	0	0	0
82	1	1	1	0	0	0
83	1	1	1	0	0	0

Sample no.	Ringed seals total	Ringed seals genetics	Ringed seals pup	Ringed seals adult	Bearded seal genetics	Seals sp.
84	0	0	0	0	0	1
85	1	1	0	1	0	0
86	1	0	1	1	0	0
87	0	0	0	0	0	1
88	0	0	0	0	0	1
89	1	0	1	0	0	0
90	1	0	1	0	0	0
91	1	0	1	1	0	0
92	0	0	0	0	0	0
93	1	1	0	1	0	0
94	1	1	1	0	0	0
95	0	0	0	0	0	0
96	0	0	0	0	0	0
97	0	0	0	0	0	0
98	1	0	1	0	0	0
99	0	0	0	0	0	0
100	1	1	1	0	0	0
101	1	1	1	0	0	0
102	1	0	1	0	0	0
103	0	0	0	0	0	1
104	0	0	0	0	0	0
105	0	0	0	0	0	0
106	0	0	0	0	0	0
107	0	0	0	0	0	0
108	0	0	0	0	0	0
109	0	0	0	0	0	0
110	0	0	0	0	0	0
111	0	0	0	0	0	0
112	0	0	0	0	0	0
113	0	0	0	0	0	0
114	0	0	0	0	0	0
115	1	1	0	1	0	0
116	1	1	0	1	0	0
117	0	0	0	0	0	0
118	0	0	0	0	0	0
119	0	0	0	0	0	0
SUM	69	58	54	27	1	10

Table 3 Terrestrial plant material found in polar bear scats collected in Svalbard 2003-2010.

	SAMPLE NUMBER																																								Total
TERRESTRIAL PLANTS	**8**	**16**	**17**	**29**	**30**	**34**	**40**	**41**	**42**	**43**	**44**	**45**	**49**	**50**	**51**	**64**	**65**	**66**	**71**	**72**	**75**	**82**	**91**	**92**	**93**	**95**	**96**	**97**	**98**	**99**	**102**	**104**	**106**	**107**	**111**	**114**	**115**	**116**	**117**	**118**	**119**	**N=39**
Grasses																																										N=31
Poa arctica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Poacae sp.	1	1	1	1	1	0	1	1	1	0	1	1	1	1	1	1	1	0	1	0	1	0	0	1	1	0	1	0	1	1	1	0	1	0	1	1	1	1	1	1	1	31
Festuca cf.baffinensis	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Sedges																																										N=11
Luzula nivalis	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Luzula confusa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Luzula sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
Unknow sedge	0	0	0	0	1	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	1	0	0	0	0	0	9
Moss	0	0	0	1	1	0	1	1	1	1	0	1	1	1	1	1	1	0	1	0	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	N=32
Lichen	0	1	0	0	0	0	0	0	0	0	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	N=7
Dicotyledons																																										N=29
Dryas octopetala	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	2
Caryophyllacea sp.	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2
Stellaria longipes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	1	0	0	1	0	8
Cerastium arcticum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	1	6

	SAMPLE NUMBER																																								Total
TERRESTRIAL PLANTS	**8**	**16**	**17**	**29**	**30**	**34**	**40**	**41**	**42**	**43**	**44**	**45**	**49**	**50**	**51**	**64**	**65**	**66**	**71**	**72**	**75**	**82**	**91**	**92**	**93**	**95**	**96**	**97**	**98**	**99**	**102**	**104**	**106**	**107**	**111**	**114**	**115**	**116**	**117**	**118**	**119**	**N=39**
Cerastium regilii/Stellaria humifusa	0	1	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	1	0	1	0	1	0	1	14
Oxyria digina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Salix polaris	0	0	0	1	0	0	0	0	1	1	0	1	0	1	1	1	1	0	0	0	1	0	1	0	0	1	1	0	1	1	0	0	0	0	1	0	0	0	0	0	0	15
Saxifraga cespitosa	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	7
Saxifraga oppositifolia	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	6
Saxifraga sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	5
Dicotyledons sp.	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	4
Monocotyledon	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	N=2
Unknown	0	0	0	1	1	1	0	0	1	0	0	0	0	0	1	1	1	0	0	0	0	1	0	0	0	1	0	1	1	0	1	1	1	0	0	0	1	0	1	0	0	N=16
Fungi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	N=1

Table 4 Mosses found in polar bear scats collected in Svalbard 2003-2010 (this material represents only a subsample of the total collected material – taken to this refined level of taxonomic identification).

MOSS	**Sample no.**												
Species	**16**	**43**	**45**	**49**	**50**	**92**	**96**	**99**	**106**	**111**	**117**	**118**	**Total**
Aulacomnium turgidum	0	0	0	1	1	0	0	0	1	1	0	0	4
Brachythecium turgidum	0	0	0	0	0	1	0	0	0	0	0	0	1
Bryum pseuditriquetrum	0	0	0	0	0	0	0	0	1	0	0	0	1
Cetrariella deliseri	0	0	1	0	0	0	0	0	0	0	0	0	1
Cinclidium arcticum	0	0	0	1	0	0	0	0	0	0	0	0	1
Cyrtomnium hymenophyllum	0	0	0	0	0	1	0	0	0	0	0	0	1
Dicranum sp.	0	0	0	0	1	0	0	0	0	0	0	0	1
Hylocomnium splendens	0	0	0	0	0	0	0	0	0	1	0	1	2
Sanionia uncinata	0	0	0	0	0	0	1	0	1	0	0	0	2
Sphaerophorus globosus	0	0	1	0	0	0	0	0	0	0	0	0	1
Timmia austriaca	0	1	0	0	0	0	0	0	0	1	0	1	3
Tomentypnum nitens	0	0	0	0	0	0	0	0	0	0	0	1	1
Philonotis tomentella	0	0	0	0	0	0	0	0	0	0	1	0	1
Plagiumnium ellipticum	0	0	0	0	0	1	0	0	0	0	0	0	1
Polytrichastrum alpinum	0	1	1	0	1	0	1	1	0	1	1	1	8
Pseudophebe pubescens	0	0	1	0	0	0	0	0	0	0	0	0	1
Umbillicaria arctica	0	0	0	0	0	0	1	0	0	0	0	0	1
Umbillicaria cylindrica	0	0	1	0	0	0	0	0	0	0	0	0	1
Umbillicaria hyperborea	1	0	0	0	0	0	1	0	0	0	0	0	2