

## Alien vascular plants recorded from the Barentsburg and Pyramiden settlements, Svalbard

Nepůvodní taxony cévnatých rostlin v okolí sídel Barentsburg a Pyramiden, Špicberky

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Dedicated to Professor Emil Hadač, a pioneer of Czech botanical research in the Arctic

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A list of alien plant species recorded from Svalbard in the summer of 1988 is presented. Two localities, the Russian settlements of Barentsburg and Pyramiden on the Isfjorden, Spitsbergen, were studied. Prior to this study, almost 60 alien species were recorded from Svalbard by other investigators. During the research reported here, 44 taxa were found, 14 of which are new records for the Svalbard archipelago. Six species are considered to be possibly naturalized; however, it is difficult to assess their naturalization status because of the severity of the climate in the study area. A complete list of species is presented, with information on height and phenological stage of particular specimens. Most of the alien plants recorded at the two settlements belong to the family *Brassicaceae*.

**Key words:** adventive, allochthonous, Arctic, flora, introduced, non-indigenous, plant invasions, Spitsbergen, Svalbard

### Introduction

The expedition “Svalbard 1988”, 13 July to 10 August 1988, funded by the former Czechoslovak Academy of Sciences, focused on cryptogamology, in particular algology, lichenology, and bryology. During short visits to the Russian settlements of Barentsburg and Pyramiden a considerable number of alien species of vascular plants was recorded, some of which were not previously reported from the Svalbard archipelago. A summary of the species recorded is presented in this paper along with detailed information on the phenological stage of individual specimens.

Most floras and checklists only include naturalized taxa; casual alien species are often omitted or reported incompletely or in insufficient detail (Pyšek et al. 2004b). This is true for the previous studies of the flora of Svalbard (e.g. Rønning 1964, 1996, Elven & Elvebakk 1996), which only report naturalized alien species, i.e. those that reproduce in the wild and do not rely on the input of diaspores from elsewhere for their long-term survival (Richardson et al. 2000, Pyšek et al. 2004b). However, complete lists of plants are an important source of information on plant invasions, a field that to a large extent relies on the comparative study of floras (e.g. Lonsdale 1999, Pyšek et al. 2004a). Moreover, some knowledge of casual aliens makes it possible to evaluate species traits that determine invasion success since the majority

of introduced species do not become naturalized because they do not adapt to the local environmental and reproductive barriers (Williamson 1996, Richardson et al. 2000).

### Study area and overview of previous research

The Svalbard archipelago (10–35° E, 74–81° N) covers an area of 62 000 km<sup>2</sup>, the majority of which is covered by ice and snow, and only ca 45% of the archipelago, mainly around the sea coast, is suitable for vegetation. The research on the Svalbard flora and vegetation has a long history, starting with the expeditions of C. J. Phipps (1773–1774), W. Scoresby (1818) and W. E. Parry (1827). Scientific visits are frequent and increasing, and there are numerous publications on the flora (Thannheiser & Möller 1992). Most studies focus on native plants. A flora of Svalbard vascular plants was published by Rønning (1964), and the third edition of this work (Rønning 1996) includes ten species considered or known as possible aliens. Nevertheless, a considerable number of alien species are reported in the many papers published at the end of the 19th and in the 20th centuries (Ekstam 1899, Andersson & Hesselman 1900, Høeg & Lid 1929, Hadač 1941, 1944, Sunding 1961, 1966, Schweitzer 1966).

Lists of alien plant species recorded from Svalbard are given in Hadač (1941) and Rønning (1970). In the latter, 53 species from the settlements of Virgohamn, Ny-Ålesund, Pyramiden, Longyearbyen and Barentsburg are listed. Papers on alien species are also published for other areas of the Arctic. Engelskjøn (1986) lists eight taxa from Bear Island, Pedersen (1972) the aliens (including cultivated species) from Greenland, and Dorogostaiskaya (1972) those from Arctic areas of Russia. Ruderal plant communities in the Arctic were studied only by Hadač (1989) who describes a new order *Phippsio-Cochleariopsietalia*, a new alliance *Cochleariopsion groenlandicae* and a new association *Phippsio-Cochleariopsietum groenlandicae* (all included within the class *Chenopodietea*). These communities are, however, characterized exclusively by native species with no aliens included in the description of these syntaxa.

Seeds of alien plants are transported by a variety of means (Williamson 1996), but in Barentsburg and Pyramiden, the diaspore input is mainly associated with animal farming; seeds are transported in fodder for pigs, cows and poultry. A few can be introduced with building material, goods, human food and attached to clothes of people.

Extreme climatic conditions, short growing period, low growth rate and deficiency of nutrients are the main reasons for a slow recovery of natural vegetation in the Arctic. In addition, humans have a strong impact on tundra. High doses of nutrients and introductions of alien species result in profound changes in the environment. Research on how humans affected the vegetation near settlements in polar regions has increased during last decades (see e.g. Krzyszowska 1985, 1989 on the situation near the Polish Polar Station at Hornsund and Ny-Ålesund, respectively).

### Localities studied

The localities studied are the Russian settlements of Barentsburg and Pyramiden on the west coast of Spitsbergen (the largest island of Svalbard), in Isfjorden bay, where the inhabitants were mainly miners.

Barentsburg is located near the mouth of the Isfjorden on the Grønfjorden coast (78°04' N, 14°14' E). It was established as a Dutch settlement in 1920 and bought by the Russians in 1932. In 1988, the total number of inhabitants was about 1200. The majority of the plants were found near a cowshed, pigsties and a small poultry farm, collectively termed “cowshed” in the following list. The number of each item of livestock was about several tens. This area is situated on the northern margin of the settlement at an altitude of ca 50 m a.s.l. Litter with remnants of fodder is deposited on a steep slope (ca 45°) running from the livestock sheds to the sea coast. A minor part of records is from a slope (ca 30°) between the port and dining-hall (termed “port”), at an altitude of ca 30 m. Some records are from the artificial “lawns” composed of a layer of dung with a turf of tundra and sown grass in the centre of the settlement. Plants were recorded on 1, 7 and 9 August 1988.

Pyramiden is situated on the west coast of Billefjorden (78°40'N, 16°27'E), the deepest part of the Isfjorden bay. It was established as a Swedish mine in 1921, and bought by the Russians in 1926. There were ca 1000 permanent dwellers there in 1988, and at present it is abandoned. Plants were recorded in the vicinity of a cowshed and a cattle walk on 18 August 1988.

Climatic conditions were abnormal in 1988, with summer temperatures higher than average (Table 1). Temperatures at Pyramiden, which is situated on the “inner” fjord, were about one degree higher and precipitation higher there than on the west coast.

Table 1. – Summer temperatures (T) and precipitation (mm) recorded at the Barentsburg meteorological station in 1988 (from Brázdil et al. 1992). Average values are based on 1963–1987 period.

Month	Average T (°C)	T <sub>max</sub> (°C)	T <sub>min</sub> (°C)	Difference from average T (°C)	Sum of pre- cipitation (mm)	Difference from average precipitation (%)
May	n.a.	4.4	-13.0	–	n.a.	–
June	1.9	9.4	-2.7	0.3	54.7	234.8
July	6.3	14.0	0.0	0.8	16.0	51.3
August	5.4	14.6	0.5	0.9	34.0	82.9
September	n.a.	9.6	-12.1	–	n.a.	–
VI – VIII	4.5	14.6	-2.7	0.7	104.7	109.6

## Results

In total, 44 taxa were found, 14 of them not reported previously from this area. *Tussilago farfara* is recorded as in this area in Tutin et al. (1976) but without a reference to a primary source. As we were not able to find any other record in the literature, this species is included among the newly reported taxa. This approach is justified as regional data on alien plants in Flora Europaea are quite unreliable (Pyšek 2003). Some specimens were collected only in juvenile stages, and determined or revised by specialists of the relevant groups. Nevertheless, the identification to species or infraspecific level was not possible in some cases.

Most taxa recorded belong to *Brassicaceae* (11), *Asteraceae* (7) and *Poaceae* (5). Other families are represented by 4 (*Polygonaceae*), 3 (*Caryophyllaceae*) or 2 (*Chenopodiaceae*, *Plantaginaceae*, *Ranunculaceae*, *Fabaceae*) taxa. *Geraniaceae*, *Boraginaceae*, *Lamiaceae*, *Malaceae*, *Rosaceae* and *Rubiaceae* are represented by one taxon each.

*List of recorded alien taxa*

Taxa are listed alphabetically. They were determined by the authors, unless stated otherwise. The following characteristics are presented: locality, maximum height, phenological stage (leaves, flower-buds, flowers, fruits) and references to previous records (listed chronologically, with the name under which the taxon was recorded, if this differs from the name used here). Taxa previously not recorded from Svalbard, hence reported as new here, are marked with “!” and general notes on their distribution are provided. Specimens are deposited in the Herbarium of Charles University Prague (PRC). Information on native distribution was taken from Hegi (1979–1998), Hultén & Fries (1986), Meusel & Jäger (1965–1992) and Tutin et al. (1964–1980).

*Achillea millefolium* L.

Barentsburg – cowshed: height 23 cm, flower-buds; Barentsburg – port: 12 cm, leaves. Other reports from Svalbard: Ekstam (1899), Høeg & Lid (1929), Hadač (1941), Rønning (1970), Hultén & Fries (1986), Elven & Elvebakk (1996). This species is established at Barentsburg and flowered twice over a 12 year period (A. A. Tishkov, personal communication).

*Alchemilla vulgaris* agg. (cf. *A. subcrenata* Buser) (det. A. Plocek)

Barentsburg – cowshed: 7 cm, 5 leaves. Other reports from Svalbard: Hadač (1941, 1944) sub *A. wichuræ* Bus., Rønning (1996); Elven & Elvebakk (1996) reported several years old individuals of *A. subcrenata* at Barentsburg in 1993.

*Alopecurus pratensis* L.

Barentsburg – port, 35 cm, flowers. Other reports from Svalbard: Hadač (1941, 1944), Rønning (1970), Tutin et al. (1980), Hultén & Fries (1986).

! *Artemisia absinthium* L.

Barentsburg – cowshed: 7 cm, leaves. Notes on distribution: native of SE Europe and W Asia, the northernmost localities are in N Scandinavia (introduced); also introduced into North America (but not the Subarctic) and New Zealand; *A. borealis* and *A. tilesii* are reported from Russian Arctic.

! *Atriplex sagittata* Borkh.

Barentsburg – cowshed: 2.5 cm, 4 leaves. Notes on distribution: native of SE Europe and W and Central Asia, northernmost localities are in central and S Scandinavia, N Russia, Estonia, Siberia (all introduced), also introduced into North America; northernmost European localities of other *Atriplex* species are N Scandinavia and Iceland, *A. hortensis* is known from Svalbard (Jonsell 2001).

*Barbarea vulgaris* R. Br. subsp. *vulgaris*

Barentsburg – cowshed: 50 cm, flowers; Pyramiden – cowshed: 30 cm, flowers and dry immature fruits attacked by a saprophytic fungus *Cladosporium herbarum* (Pers.) Link. Other reports from Svalbard: Rønning (1970), Rønning (1996) and Elven & Elvebakk (1996); the latter authors report large populations at Barentsburg in 1993 and 1996, but according to them the subspecies to which the plants belong (subsp. *vulgaris* or subsp. *arcuata*) is not known.

! *Brassica* sp.

Barentsburg – cowshed: 16 cm, flower-buds. No species of this genus were previously reported from Svalbard.

*Cardamine* cf. *pratensis* L. (det. P. Tomšovic)

Barentsburg – cowshed: 3 cm, leaves. Other reports from Svalbard: Hadač (1944), Hultén & Fries (1986, as subsp. *angustifolia*), Elven & Elvebakk (1996, as subsp. *polemonioides*).

*Chenopodium album* L.

Barentsburg – cowshed: 6 cm, 5 leaves. Other reports from Svalbard: Ekstam (1899), Høeg & Lid (1929), Hadač (1941), Rønning (1970), Hultén & Fries (1986), Elven & Elvebakk (1996), Jonsell (2001, as var. *album*).

*Deschampsia cespitosa* (L.) Beauv.

Barentsburg – cowshed: 32 cm, flowers. Other reports from Svalbard: Høeg & Lid (1929), Hadač (1941, 1944), Rønning (1970), Tutin et al. (1980), Rønning (1996), Elven & Elvebakk (1996).

! *Descurainia sophia* (L.) Prantl (det. J. Dostálek jun., rev. V. Jehlík)

Barentsburg – cowshed, 17 cm, flower-buds. Notes on distribution: native of SE Europe, N Africa and SW Asia, the northernmost localities (all introduced) are in N Scandinavia, Iceland, S Greenland (unripe seeds), also introduced into North America and the Southern Hemisphere (South Africa, New Zealand). *D. sophioides* is reported from the north coast of Asia and W North America.

! *Erodium cicutarium* (L.) L'Hér.

Barentsburg – cowshed: 10 cm, leaves. Notes on distribution: native of the Mediterranean, the northernmost localities (all introduced) are in N Scandinavia, Iceland, N Siberia, S Greenland (seeds not ripe); also introduced into North America and the Southern Hemisphere.

*Erysimum cheiranthoides* L. (det. V. Jehlík, rev. J. Štěpánek)

Barentsburg – cowshed: 4 cm, 10 leaves. Other reports from Svalbard: Høeg & Lid (1929), Rønning (1970), Hultén & Fries (1986).

*Fallopia convolvulus* (L.) Á. Löve

Barentsburg – cowshed: 14 cm, leaves. Other reports from Svalbard: Høeg & Lid (1929), Porsild (1932), Rønning (1970), Hultén & Fries (1986), Elven & Elvebakk (1996), Jonsell (2000).

*Galeopsis* cf. *tetrahit* L. (det. J. Holub)

Barentsburg – cowshed: 9 cm, 9 leaves. Other reports from Svalbard: Ekstam (1899), Hadač (1941), Rønning (1970), Elven & Elvebakk (1996).

*Galium aparine* L.

Barentsburg – cowshed: 18 cm, leaves. Other reports from Svalbard: Ekstam (1899), Rønning (1970), Tutin et al. (1976).

! *Helianthus annuus* L.

Barentsburg – cowshed: 7 cm, 4 leaves. Notes on distribution: a widely cultivated plant, native of North America; one locality is reported from Greenland (sterile plants), it is also cultivated in the Far North where it does not mature (Dorogostaiskaya 1972).

*Hordeum* cf. *vulgare* L.

Barentsburg – cowshed: 30 cm, leaves. Other reports from Svalbard: Ekstam (1899), Rønning (1970).

*Lappula* cf. *squarrosa* (Retz.) Dum.

Barentsburg – cowshed: 12 cm, flowers. Other reports from Svalbard: Høeg & Lid (1929, as *L. echinata*), Rønning (1970, as *L. myosotis*), Hultén & Fries (1986, as *L. squarrosa*).

! *Lepidium densiflorum* Schrad. (det. V. Jehlík)

Barentsburg – cowshed: 12 cm, leaves. Notes on distribution: native of North America, the northernmost localities are in N Scandinavia (all introduced), one locality is reported from Greenland (plants with almost ripe seeds, Pedersen 1972); not reported by Hultén & Fries (1986).

! *Malus domestica* Borkh.

Barentsburg – lawns between houses: 8 cm, 6 leaves. Note: In the Far North, seeds germinate and juvenile specimens with a few leaves developed in summer (Dorogostaiskaya 1972).

*Matricaria discoidea* DC. (rev. V. Jehlík)

Barentsburg – cowshed: 8 cm, flowers. Other reports from Svalbard: Rønning (1970), Elven & Elvebakk (1996).

*Medicago* cf. *lupulina* L.

Barentsburg – cowshed: 6 cm, leaves. Other reports from Svalbard: Høeg & Lid (1929, as *M. hispida*), Rønning (1970, as *M. hispidula*).

*Plantago major* L. s.l.

Barentsburg – cowshed: 6 cm, 6 leaves. Other reports from Svalbard: Høeg & Lid (1929), Rønning (1970), Hultén & Fries (1986).

! *Plantago media* L.

Barentsburg – port: 25 cm, flowers. Notes on distribution: native of S, E and Central Europe and W Asia, the northernmost localities are N Fennoscandia (introduced) and N Russia; also introduced into North America (naturalized in E part) and the Southern Hemisphere (New Zealand).

*Poa annua* L.

Barentsburg – cowshed: 15 cm, immature fruits. Other reports from Svalbard: Rønning (1970).

*Poa trivialis* L. (det. J. Chrtek)

Barentsburg – cowshed: 30 cm, immature fruits. Other reports from Svalbard: Hadač (1941, as var. *stricta*), Rønning (1970).

*Polygonum aviculare* L. s.l.

Barentsburg – cowshed: 8 cm, leaves. Other reports from Svalbard: Ekstam (1899), Høeg & Lid (1929), Hadač (1941), Tutin et al. (1964), Rønning (1970), Hultén & Fries (1986), Elven & Elvebakk (1996), Jonsell (2000, as *P. aviculare* subsp. *boreale*).

! *Ranunculus acris* L. subsp. *friesianus* (Jordan) Syme (det. B. Křísa)

Barentsburg – cowshed: 32 cm, flowers; Barentsburg – port: 50 cm, flowers. Note: other reports from Svalbard concern the nominate subspecies only: Høeg & Lid (1929), Hadač (1941, 1944, both as *R. acer*), Tutin et al. (1964, as *R. acris*), Rønning (1970, as *R. acris*), Gugnacka-Fiedor & Noryskiewicz (1982, misidentified as *R. acris* subsp. *borealis*; see Elven & Elvebakk 1996), Engelskjøn (1986, as *R. acris*), Hultén & Fries (1986), Rønning (1996, as subsp. *acris*), Elven & Elvebakk (1996), Jonsell (2001, as subsp. *acris*).

*Ranunculus repens* L. (det. B. Křísa)

Barentsburg – cowshed: 22 cm, leaves. Other reports from Svalbard: Hadač (1944), Tutin et al. (1964), Hultén & Fries (1986), Elven & Elvebakk (1996), Jonsell (2001).

*Raphanus raphanistrum* L.

Barentsburg – cowshed: 17 cm, flower-buds. Other reports from Svalbard: Høeg & Lid (1929), Tutin et al. (1964), Rønning (1970), Hultén & Fries (1986), Elven & Elvebakk (1996).

! *Rorippa palustris* (L.) Besser (det. P. Tomšovic)

Barentsburg – cowshed: 2.5 cm, leaves. Notes on distribution: native of Eurasia, the northernmost localities are in N Scandinavia, a related diploid species *R. islandica* (Oeder ex Murray) Borbás is known from Iceland and the W coast of central Greenland (an old introduction).

! *Rorippa sylvestris* (L.) Besser (det. P. Tomšovic)

Barentsburg – cowshed: 5 cm, leaves. Notes on distribution: native of Europe, N Africa and W Asia, the northernmost localities are Iceland, N Fennoscandia, N Russia, and Greenland (all introduced); introduced also into North America and South America.

*Rumex acetosella* L.

Barentsburg – cowshed: 6 cm, leaves. Other reports from Svalbard: Høeg & Lid (1929), Hadač (1944), Rønning (1970), Hultén & Fries (1986), Elven & Elvebakk (1996), Rønning (1996), Jonsell (2000, as subsp. *acetosella*).

*Rumex* sp. (*R. obtusifolius* L. or *R. longifolius* DC.)

Barentsburg – cowshed: 23 cm, 4 leaves. Other reports from Svalbard: Høeg & Lid (1929, as *R. domesticus* Hartm.), Hadač (1941, as *R. domesticus*), Rønning (1970, as *R. longifolius*), Elven & Elvebakk (1996, as *R. longifolius*), Jonsell (2000, as *R. longifolius*).

! *Silene latifolia* Poiret subsp. *alba* (Miller) Greuter et Burdet (det. F. Krahulec, rev. M. Šourková)

Barentsburg – cowshed: 6 cm, 9 leaves. Notes on distribution: native of Europe, W Asia (Siberia, N Central Asia) and N Africa, an alien plant in N Europe and E North America.

*Sinapis arvensis* L.

Barentsburg – cowshed: 10 cm, flowers. Other reports from Svalbard: Høeg & Lid (1929), Rønning (1970), Hultén & Fries (1986), Elven & Elvebakk (1996).

*Stellaria graminea* L.

Barentsburg – cowshed: 17 cm, leaves; Pyramiden – cowshed: 25 cm, flowers. Other reports from Svalbard: Jonsell (2001).

*Stellaria media* (L.) Vill.

Barentsburg – cowshed: 8 cm, leaves. Other reports from Svalbard: Høeg & Lid (1929), Hadač (1941, 1944), Tutin et al. (1964), Rønning (1970), Engelskjøn (1986), Hultén & Fries (1986), Dorogostaiskaya (1972), Rønning (1996), Elven & Elvebakk (1996), Jonsell (2001).

*Taraxacum* sp. (not the Svalbard native taxa *T. brachyceras* or *T. arcticum*)

Barentsburg – cowshed: 8 cm, leaves; Barentsburg – port: 25 cm, leaves. Other reports from Svalbard: Rønning (1970, as *T. officinale*), Elven & Elvebakk (1996).

*Thlaspi arvense* L.

Barentsburg – cowshed: 13 cm, flowers and immature fruits. Other reports from Svalbard: Ekstam (1899), Høeg & Lid (1929), Rønning (1970), Hultén & Fries (1986), Elven & Elvebakk (1996).

*Tripleurospermum inodorum* (L.) Schultz-Bip. (det. V. Jehlík)

Barentsburg – cowshed: 34 cm, flowers; Pyramiden – cowshed: 20 cm, dry leaves (possibly from the previous year). Other reports from Svalbard: Høeg & Lid (1929), Hadač (1944), Rønning (1970), Tutin et al. (1976), Hultén & Fries (1986), Elven & Elvebakk (1996, as *Matricaria maritima* coll.).

! *Tussilago farfara* L.

Barentsburg – cowshed: 7 cm, leaves. Notes on distribution: native of Europe (the northernmost localities are Ireland, Shetland Islands and N Scandinavia – up to 71°N), W and N Asia and N Africa (mountains), an alien plant in North America. Note: Tutin et al. (1976) report this species occurring in Svalbard, but we were unable to find primary source for this statement.

*Vicia* cf. *sativa* L. (det. A. Chrtková)

Barentsburg – cowshed: 11 cm, leaves. Other reports from Svalbard: Ekstam (1899, as *V. angustifolia*), Rønning (1970, as *V. angustifolia*), Hultén & Fries (1986, as *V. sativa* subsp. *nigra*).

## Discussion

Humans visited Svalbard for about four centuries, with more intensive human activity there (including farming) mainly in the 20th century. Many alien plant species are to be found near the various settlements (Barentsburg, Longyearbyen, Ny-Ålesund, Pyramiden, Virgohamn) and scattered trappers' cabins. There are plenty of records in the literature. A list of the alien plants in Svalbard was published by Rønning (1970) and includes 53 taxa. In total, almost 60 alien species were recorded from Svalbard prior to this study.

However, the majority of these alien species are unable to adapt to extreme conditions; they germinate under suitable conditions, but do not produce flowers and seed. Climate is a major constraint for annual species, as they are unable to complete their life cycle as the growing period is too short. The occurrence of many taxa is thus ephemeral. Nevertheless, some perennial plants can survive winter in a vegetative stage. Only a few aliens are able to survive for a long time and produce ripe seed; these can be regarded as a permanent additions to the Svalbard flora. However, even survival over long periods does not mean that these species are naturalized under the local conditions, and opinions differ on the status of some species (e.g. *Achillea millefolium*). The following taxa are listed by Elven & Elvebakk (1996) as naturalized in Svalbard: *Achillea millefolium*, *Barbarea vulgaris*, *Cakile maritima* subsp. *islandica*, *Deschampsia cespitosa*, *Equisetum arvense* subsp. *arvense*, *Festuca rubra* subsp. *rubra* (status uncertain), *Rumex acetosa* (status uncertain) and *Saussurea alpina*. Rønning (1970) did not include *Cakile maritima* subsp. *islandica*, *Equisetum arvense* subsp. *arvense* and *Saussurea alpina* in his list of introduced taxa, and noted that it was uncertain whether the latter species grew in the wild or was introduced (Rønning 1996). The different opinions are based on the different use of the term “introduction”. In the third edition of his flora of Svalbard, Rønning (1996) reported ten alien species as possibly naturalized: *Alchemilla vulgaris*, *Barbarea vulgaris*, *Deschampsia cespitosa*, *Festuca rubra*, *Poa pratensis*, *Ranunculus acris*, *Rumex acetosa*, *R. acetosella*, *Saussurea alpina* (status uncertain) and *Stellaria media*. However, some perennials on this list survive winter in a vegetative stage and are unable to produce ripe seed. This must be

Table 2. – Characteristics of recorded taxa. Locality: B1 – Barentsburg, cowshed; B2 – Barentsburg, port; B3 – Barentsburg, inner part of the settlement; P – Pyramiden, cowshed. Life history: annual, biennial, perennial. Phenology: B – plant with flower-buds, Fl – plant with flowers, Fr – plant with fruit, L – plant with leaves. Origin: Af – Africa, As – Asia, Eu – Europe, NA – North America.

Taxon	Family	Locality	Life history	Phenology	Origin
<i>Achillea millefolium</i>	Asteraceae	B1, B2	perennial	B, L	Eu, As
<i>Alchemilla vulgaris</i> agg. ( <i>A. cf. subcrenata</i> )	Rosaceae	B1	perennial	L	Eu, As
<i>Alopecurus pratensis</i>	Poaceae	B2	perennial	Fl	Eu, As
<i>Artemisia absinthium</i>	Asteraceae	B1	perennial	L	Eu, As
<i>Atriplex sagittata</i>	Chenopodiaceae	B2	annual	L	Eu, As
<i>Barbarea vulgaris</i> subsp. <i>vulgaris</i>	Brassicaceae	B1, P	perennial	Fl, Fr	Eu, As
<i>Brassica</i> sp.	Brassicaceae	B1		B	
<i>Cardamine cf. pratensis</i>	Brassicaceae	B1	perennial	L	Eu, As, Af
<i>Chenopodium album</i>	Chenopodiaceae	B1	annual	L	Eu, As
<i>Deschampsia cespitosa</i>	Poaceae	B1	perennial	Fl	Eu, As, Af, NA
<i>Descurainia sophia</i>	Brassicaceae	B1	annual	B	Eu, As, Af
<i>Erodium cicutarium</i>	Geraniaceae	B1	annual/biennial	L	Eu, As
<i>Erysimum cheiranthoides</i>	Brassicaceae	B1	annual	L	Eu, As, Af
<i>Fallopia convolvulus</i>	Polygonaceae	B1	annual	L	Eu, As, Af
<i>Galeopsis cf. tetrahit</i>	Lamiaceae	B1	annual	L	Eu
<i>Galium aparine</i>	Rubiaceae	B1	annual	L	Eu, As, Af
<i>Helianthus annuus</i>	Asteraceae	B1	annual	L	NA
<i>Hordeum cf. vulgare</i>	Poaceae	B1	annual	L	
<i>Lappula cf. squarrosa</i>	Boraginaceae	B1	annual/biennial	Fl	Eu, As
<i>Lepidium densiflorum</i>	Brassicaceae	B1	annual/biennial	L	NA
<i>Malus domestica</i>	Malaceae	B3	perennial tree	L	
<i>Matricaria discoidea</i>	Asteraceae	B1	annual/biennial	Fl	As, NA
<i>Medicago cf. lupulina</i>	Fabaceae	B1	annual/biennial	L	Eu, As, Af
<i>Plantago major</i>	Plantaginaceae	B1	perennial	L	Eu, As, Af
<i>Plantago media</i>	Plantaginaceae	B2	perennial	Fl	Eu, As
<i>Poa annua</i>	Poaceae	B1	annual/biennial	Fr	Eu, As, Af
<i>Poa trivialis</i>	Poaceae	B1	perennial	Fr	Eu, As
<i>Polygonum aviculare</i> s.l.	Polygonaceae	B1	annual	L	Eu, As, NA
<i>Ranunculus acris</i> subsp. <i>friesianus</i>	Ranunculaceae	B1, B2	perennial	Fl, Fl	Eu
<i>Ranunculus repens</i>	Ranunculaceae	B1	perennial	L	Eu, As, Af
<i>Raphanus raphanistrum</i>	Brassicaceae	B1	annual	B	Eu, As
<i>Rorippa palustris</i>	Brassicaceae	B1	annual/biennial	L	Eu, As
<i>Rorippa sylvestris</i>	Brassicaceae	B1	perennial	L	Eu, As, Af
<i>Rumex acetosella</i>	Polygonaceae	B1	perennial	L	Eu, As, Af
<i>Rumex</i> sp. ( <i>R. obtusifolius</i> or <i>R. longifolius</i> )	Polygonaceae	B1	perennial	L	Eu, As
<i>Silene latifolia</i> subsp. <i>alba</i>	Caryophyllaceae	B1	perennial	L	Eu, As, Af
<i>Sinapis arvensis</i>	Brassicaceae	B1	annual	Fl	Eu, As, Af
<i>Stellaria graminea</i>	Caryophyllaceae	B1, P	perennial	L, Fl	Eu, As
<i>Stellaria media</i>	Caryophyllaceae	B1	annual/biennial	L	Eu, As
<i>Taraxacum</i> sp.	Asteraceae	B1, B2	perennial	L, L	(Eu, As)
<i>Thlaspi arvense</i>	Brassicaceae	B1	annual/biennial	Fr	Eu, As
<i>Tripleurospermum inodorum</i>	Asteraceae	B1, P	annual/biennial	Fl, L (dry)	Eu, As
<i>Tussilago farfara</i>	Asteraceae	B1	perennial	L	Eu, As, Af
<i>Vicia cf. sativa</i>	Fabaceae	B1	annual	L	Eu, As, Af

considered when evaluating the status of a species in areas with an extreme climate. Some authors suggest that a species should be considered as naturalized if populations are self-sustaining for some period of time (Tutin et al. 1964–1980: 25 years, Pyšek et al. 2004b: 10 years). Persistence over such periods at Svalbard may not be sufficient for a species to be considered as naturalized as some species can persist vegetatively that long without producing seed. Moreover, the fact that some are repeatedly reported over long periods does not mean that they were permanently present; repeated occurrence may be due to repeated introductions. Naturalization of species in such areas is therefore difficult to assess. Nevertheless, the information indicates that six species of the 44 are naturalized: *Achillea millefolium*, *Alchemilla* cf. *subcrenata*, *Barbarea vulgaris* subsp. *vulgaris*, *Deschampsia cespitosa*, *Rumex acetosella* and *Stellaria media*.

Finding a relatively high number of previously unrecorded alien species is surprising. A possible explanation is the nature of the farming carried out in Russian settlements, which is also mentioned by Elven & Elvebakk (1996). However, the authors did not find three of the species (*Capsella bursa-pastoris*, *Poa pratensis*, *Rumex acetosa*) on the list of 12 aliens found by A. A. Tishkov (personal communication) in Barentsburg and Pyramiden in the 1980s. Also, of the list of taxa presented in this paper, 15 were not reported by Rønning (1970).

The most remarkable finds are those of the thermophilous species *Artemisia absinthium*, *Atriplex sagittata*, *Descurainia sophia* and *Helianthus annuus*. However, these species have virtually no chance of surviving for more than a single season (this also holds for the perennial plant *A. absinthium*) and their occurrence is ephemeral.

On the other hand, plants with flowers and seed have a higher probability of surviving. Four of them were found with fruit (Table 2), and some probably produced ripe seed in late summer. Some perennial species might be able to survive winter, especially in localities with slightly warmer microclimates, e.g. in dung near cowsheds.

The localities studied differed from each other. The highest species diversity and abundance of aliens were recorded on the farm at Barentsburg (40 taxa, i.e. 91% of the aliens). Many animals were kept there in the 1980s. However, the intensity of farming at Pyramiden was very low compared to Barentsburg. So, only three alien species (*Barbarea vulgaris*, *Tripleurospermum inodorum* and *Stellaria graminea*) were found at Pyramiden, and none of them only there. The port at Barentsburg is another potential source of alien plants. Species diversity was low there compared to the farm at Barentsburg (three species were found at both localities), but higher than at Pyramiden. In total, six taxa (14%) were found around the port at Barentsburg, four of them only there. *Malus domestica* was found only next to the houses in the centre of Barentsburg. Probably, the origin of the seedlings were cores of apples eaten by the Russian inhabitants.

A high proportion of alien taxa found on the farm at Barentsburg indicate fodder for pig, cow and poultry as the main source of the propagules of alien species. The diversity of alien plants in the area is positively correlated with farming intensity.

The origin of the alien taxa is rather uniform, nearly all are natives of Eurasia (Table 2) or adjacent areas (primary distribution range of some species extends to Africa, but mainly the mountains of North Africa). The authors tried to identify the region in Russia from which the fodder for livestock was transported to Svalbard, but Soviet officials said this information was secret because of its strategic importance.

## Souhrn

Botanický výzkum Špicberk probíhá již třetí století a více než sto let je věnována pozornost i nepůvodním taxonům zavlečeným člověkem. Dosud bylo publikováno téměř 60 druhů nepůvodních rostlin (souhrnné soupisy publikovali Hadač 1941 a Rønning 1970). Autoři příspěvku se zúčastnili expedice „Svalbard 1988“ vedené J. Komárkem a financované tehdejší ČSAV. Navštívili ruské osady Barentsburg a Pyramiden, kde sledovali výskyt nepůvodních rostlin. Celkem nalezli 44 taxonů, z toho 14 dosud nebylo ze Špicberk publikováno (*Artemisia absinthium*, *Atriplex sagittata*, *Brassica* sp., *Descurainia sophia*, *Erodium cicutarium*, *Helianthus annuus*, *Lepidium densiflorum*, *Malus domestica*, *Plantago media*, *Ranunculus acris* subsp. *friesianus*, *Rorippa palustris*, *Rorippa sylvestris*, *Silene latifolia* subsp. *alba*, *Tussilago farfara*). Kromě lokalit zjištěných druhů jsou uvedeny též údaje o velikosti rostliny a vývojovém stádiu (listy, květní pupeny, květy, plody). Polární léto v navštíveném roce bylo mimořádně teplé; příznivé podmínky v průběhu vegetační sezóny umožnily vyklíčení semen i dosažení vyšších vývojových stádií jednotlivých rostlin. Nejpočetněji byly zastoupeny čeledi *Brassicaceae* (11 taxonů), *Asteraceae* (7) a *Poaceae* (5). Další čeledi byly zastoupeny 4 (*Polygonaceae*), 3 (*Caryophyllaceae*) nebo 2 taxony (*Chenopodiaceae*, *Plantaginaceae*, *Ranunculaceae*, *Fabaceae*). Jediným taxonem byly zastoupeny čeledi *Geraniaceae*, *Boraginaceae*, *Lamiaceae*, *Malaceae*, *Rosaceae* a *Rubiaceae*. Většina zástupců nepůvodních rostlin však není schopna přežít extrémní podmínky, a představují tak pouze efemérní součást špicberské flóry. Schopnost tvořit zralá semena a dlouhodoběji přežívat je v tak extrémních podmínkách, jaké představují Špicberky, obtížné zhodnotit. Jako potenciálně naturalizované lze nicméně z nalezených rostlin označit následující taxony: *Achillea millefolium*, *Alchemilla* cf. *subcrenata*, *Barbarea vulgaris* subsp. *vulgaris*, *Deschampsia cespitosa*, *Stellaria media*. Nejvíce nepůvodních taxonů (91 % z celkového počtu nalezených) bylo nalezeno na okraji osady Barentsburg, kde se nacházelo hospodářské zázemí obyvatel (kravín, vepřín, drůbežárna) s velmi intenzivním způsobem chovu. Nejzajímavější nálezy představují teplomilné druhy *Artemisia absinthium*, *Atriplex sagittata*, *Descurainia sophia* a *Helianthus annuus*.

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