New records of alien plant species rare in the Russian Arctic (Murmansk region, NW Russia)

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Abstract

This paper deals with new records of both unintentionally introduced (*Bromus japonicus*, *Cichorium intybus*, *Iva xanthiifolia*, *Onobrychis viciifolia*) and escaped (*Hylotelephium telephium*) vascular plant species that are rare in the Russian Arctic. Three of them (*B. japonicus*, *H. telephium*, and *O. viciifolia*) are novel for the alien flora of the city of Murmansk. The data were obtained by the author during fieldwork in Murmansk municipal region in 2018. Geographical coordinates, a description of the location, habitats, quantity characteristic, vegetative stage of the species are listed for every occurrence. The information about general distribution, life form characteristics, the primary origin of the species is compiled as well. Proposal pathways of the introduction of the reported aliens are established. Regarding the invasion status, all presented aliens are considered to be casual.

Key words: alien species, non-native species, vascular plants, Murmansk, Fennoscandia, urban flora

List of abbreviations: TUR – Herbarium of the University of Turku, L&Y M – Herbarium Liisa & Yrjo Mäkinen, PTZ – Herbarium of the Forest Research Institute, Karelian Research Centre, Russian Academy of Sciences, Petrozavodsk, LE – Herbarium of the Komarov Botanical Institute, Saint-Petersburg.

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Introduction

Although the rate of invasion in high latitudes remains low (Ellis et al. 2012), not more but new alien plants are being recorded (Kozhin and Sennikov 2022). The introduction of new alien species is mainly associated with human activities and climate warming (Lassuy and Lewis 2013, Wasowicz et al. 2019). On the one hand, global warming contributes to the local expansion of the populations of some native thermophilic plants in the Arctic (Markovskaya et al. 2013). On the other hand, an increase in temperature opens up more opportunities for alien species mainly originating from warmer areas to invade territory beyond Arctic Circle (Alsos et al. 2015, Lembrechts et al. 2016). On the other hand, experimentally confirmed data have shown that anthropogenic disturbances of the soil and vegetation cover are another important factor in successful invasions at high latitudes (Lembrechts et al. 2016). Central European cities are known to be characterized by a wide variety of disturbed habitats, and their floras are considered the starting points of invasions to the surrounding areas (Pyšek 1998, Gaggini et al. 2017). Research carried out on the Svalbard island has also shown that settlements are a predictor for the biodiversity of alien flora at high latitudes (Alsos et al. 2015). In Greenland, occurrences of established and casual alien plants are confined mainly to disturbed habitats in and near settlements (Daniëls 2015). This trend is also true for the Russian Arctic (Morozova and Tishkov, 2021). Murmansk is not the exclusion from the above trend.

Murmansk is the most populated of all cities located north of the Arctic Circle. It is the administrative center of the Murmansk region located in the far northwestern part of European Russia. This port city is situated on both banks of the Kola Bay of the Barents Sea. According to Köppen climate classification (Köppen 1936), the territory of Murmansk is located in the subarctic climatic zone (Dfc), which is characterized by long cold winters and short cool summers. The climate of the Murmansk region is characterized by frequent weather changes due to the proximity of the Gulf Stream in the west and arctic cold fronts in the east. Warmer air from the Atlantic brings abundant precipitation in summer, cloudy weather, and warmer temperatures in winter. The cold Actic air flows cause a strong temperature decline and frost (Ilyashuk et al. 2013). Marshall et al. (2016) noted that during 1966-2015, the Murmansk region experienced one of the highest regional warming rates. According to them, the monthly surface air temperature in the region increased statistically significantly by 2.3°C over this 50-year period. In addition, warming is expected to continue further into the twenty-first century (Collins et al. 2013). The changes also affected the seasonal distribution of precipitation in the region (Marshall et al. 2016).

The average temperature for 1985-2015 in Murmansk in January was -11°C, in July +13°C (Fig. 1). The annual precipitation ranges from 330 to 660 mm [*see* the Other Sources – 16]. Murmansk has been affected by global warming in recent decades, similar to other Arctic area. For example, July 2018 had an average high of 24.3°C [17].

The first finds (Tur, L. & Y. M) of some vascular plant species were published by Mäkinen (2002). The result of a fairly complete study of vascular plants in Murmansk was an annotated floristic list compiled by Menshakova and her colleagues more than 10 years ago (Menshakova et al. 2009). It included 312 vascular plants species and contained data on the life form, habitat, some features of the ecology, and collection sites for rare species. Data on invasive and potentially invasive species, their distribution in Murmansk city and the Murmansk region are

given in subsequent publications (Menshakova 2011, 2014). Only a few reports of alien species have been published over the last 10 years (Kravchenko 2011, Kozhin et al. 2016, Rudkovskaya 2020, Kozhin and Sennikov 2022). The high dynamics of urban flora, mainly provided by neophytes (Pyšek 1998), which commonly prefer to invade anthropogenic habitats, suggests the discovery of some new vascular plant species in Murmansk.

During a floristic survey of the territory of Murmansk in 2018, the author of this paper recorded 61 species, documented by 98 collected specimens. After examination of obtained herbarium material, literature, open access herbarium data, and reliable data presented in global database GBIF [7], it turned out that some species are new to the flora of Murmansk.

This paper focuses on new records of both unintentionally introduced and escaped vascular plant species that are rare in the Russian Arctic. Three of them are novel items in the flora of the city of Murmansk. The first appearance of an alien species in a new locality outside its original range can be considered as the first step in the process of local invasion (Kornaś 1990, Kowarik 1995). Tzvelev (Tzvelev 2012) emphasized the need to register every new occurrence of rare alien species, as they are expected to be observed in future. In addition, accounting for such alien species makes it possible to assess the level of synanthropization of the flora of the territory. The data presented here contribute to the geographic distribution of some alien plant species and may serve as a contribution to the "Flora of Russian Lapland" project (Kozhin and Sennikov 2022).

Fig. 1. Graph of monthly max. and min. means of air temperature (°C) together with average monthly precipitation (mm) for Murmansk. Average means are based on weather reports collected during 1985–2015 [9].

Material and Methods

During the floristic survey of the city of Murmansk (Fig. 2), field surveys were made to places where the discovery of new species was most likely. The locations comprised a railway station and railway tracks, gas stations, roadsides, a fruit and vegetable market, the territory of the sea terminal, as well as residential areas. Collections were made and records done where appropriate. Each reported record has an associated specimen stored in the Herbarium of the Forest Research Institute, Karelian Research Centre, Russian Academy of Sciences, Petrozavodsk (PTZ). The naming followed mainly the World Flora Online [15]. *Hylotelephium telephium* is considered sensu lato. Herbarium material has been examined by the below-specified experts. *Bromus japonicus* Houtt. was identified by A. Kravchenko (PTZ). *H. telephium* was confirmed by V. V. Byalt (LE). The Serebryakov system (Serebryakov 1962) was used to characterize life forms. Current invasion status is established or inferred according to Pyšek et al. (2004). Since the territories of the Murmansk region and adjacent Finnish Lapland are geographically and floristically similar (Uotila 2013), the author reported here aliens known from polar Finland. The information about plant records in northern Finland was derived from the Finnish Biodiversity Information Facility [5].

Fig. 2. The location of the city of Murmansk (Murmansk Region, Northwest Russia) – ✢.

Reported plant specimens were collected at anthropogenic habitats in localities such as:

Site 1. 68° 57.569′ N, 33° 6.277′ E, 55 m a. s. l., Rogozerskaya St., gas station in the central part of Murmansk;

Site 2. 68° 58.305′ N, 33° 6.673′ E, 135 m a. s. l., Kapitan Maklakov St. 47, the area adjacent to a block of flats;

Site 3. 68° 58.495′ N, 33° 6.885′ E, 143 m a. s. l., Skalnaya St. 25, the facade of the building, the area adjacent to a block of flats;

Site 4. 68° 57.298′ N, 33° 3.244′ E, 31 m a. s. l., Polevaya St., fruit and vegetable market.

Results

For each species, data on the scientific family, location number (*see* above), a detailed description of the habitat, quantitative characteristic, and vegetative stage are listed.

Bromus japonicus Houtt. (*Poaceae*) – Site 1: a single plant (with immature seeds) growing on a gravel-sandy substrate on a sown roadside lawn with a scarce grassy vegetation cover (Fig. 3).

Onobrychis viciifolia Scop. (*Fabaceae*) – Site 1: two vegetative individuals growing on a gravel-sandy substrate on a sown roadside lawn with a scarce grassy vegetation cover (Fig. 4).

Hylotelephium telephium s. l. (*Crassulaceae*) – Site 2: a concrete ring about 40 cm high, in the gap between the concrete part and the hatch., 3 individuals with fruits containing seeds (Fig. 5).

Cichorium intybus L. (*Compositae*) – Site 1: a single 2-year plant growing on a gravel-sandy substrate on a sown roadside lawn with a scarce grassy vegetation cover (Fig. 6).

Iva xanthiifolia Nutt. (*Compositae*) – Site 4: one vegetative individual, growing on a thin layer of soil, accumulated on a protruding horizontal surface approximately 15 cm wide (0.5 m above the ground) of the wall of a warehouse building (Fig. 7).

Discussion

The annual-biannual grass, *B. japonicus* (japanese brome), is native in Northern Africa (Egypt), the Caucasus, Asia (eastern, middle and western parts), the Indian Subcontinent, and in most of Europe, with the exception of the northern part (Tzvelev and Probatova 2019, [14]). In Siberia, it grows wild in the Middle and Southern Urals (Tzvelev and Probatova 2019). It was introduced in Australia, New Zealand, South Africa and North and South America [14]. This grass is considered invasive species in some parts of USA and Canada [3].

The recent find of *B. japonicus* is the second in the Murmansk region. It happened 88 years after the first one (67° 33.851′ N, 33°22.174′ E) by Ganeshin (Gusev 1975) and is considered the second in the Russian Arctic. Some individuals of the species have been found by Ganeshin near Apatity railway station in the Khibiny Mountains in 1930. Only two records of this species are known in northern Finland.

A single possible route of invasion of the species is proposed. This species could have been introduced with contaminated seed mixtures. *Lolium perenne* L., used as seed grass, has been observed on this and other lawns in the gas station area. This means that all the lawns in the territory had been sown. The invasion status of *B. japonicus* is to be considered a casual alien plant.


Bromus japonicus
31 V
2019 A.V.Kravchenko, Petrozavodsk (PTZ)
Herbarium of the Forest Research Institute, Karelian Research Centre, Russian Academy of Sciences, Petrozavodsk (PTZ)
Bromus squarrosus L.
Region: Russia, Murmansk region, 68.959489 N, 33.104618 E
Place: Murmansk, Rogozerskaya St., Gas station
Habitat: gravel-sandy substrate on a sown roadside lawn with a scarce grassy vegetation cover, 1 ind.
Col., Det. O.A. Rudkovskaya № 4014
23 August 2018

Fig. 4. Herbarium specimen of *Onobrychis viciifolia* collected in the city of Murmansk (scanned by F. Gerasimov).

◄ **Fig. 3.** Herbarium specimen of *Bromus japonicus* collected in the city of Murmansk (scanned by F. Gerasimov).

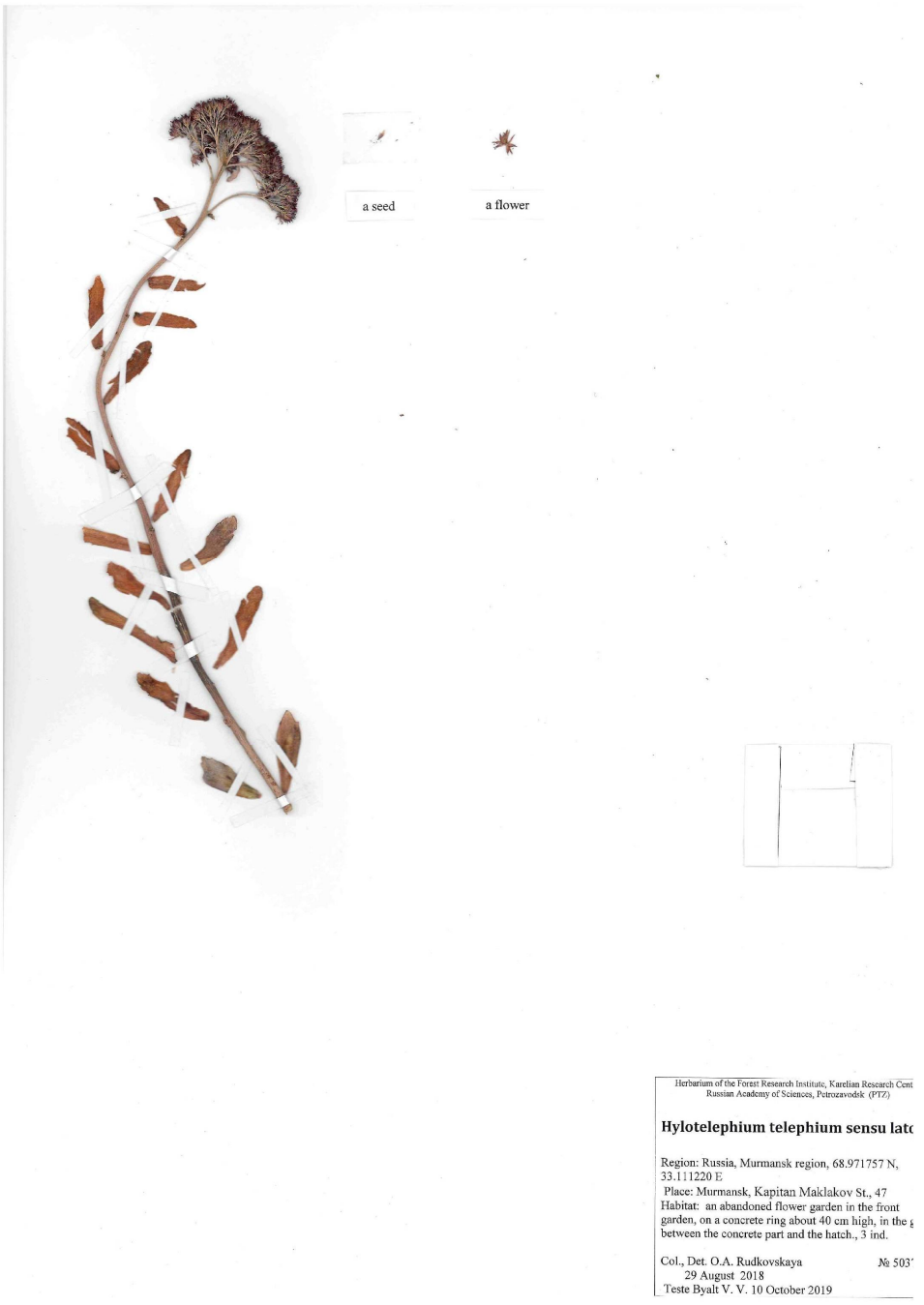

Fig. 5. Herbarium specimen of *Hylotelephium telephium* s.l. collected in the city of Murmansk (scanned by F. Gerasimov).

Fig. 6. Herbarium specimen of *Cichorium intybus* L. collected in the city of Murmansk (scanned by F. Gerasimov).

Fig. 7. Herbarium specimen of *Iva xanthiifolia* collected in the city of Murmansk (scanned by F. Gerasimov).

The perennial polycarpic herb, *O. viciifolia* (common sainfoin), is native to Central Europe (Hämet-Ahti et al. 1998, Mossberg and Stenberg 2003). Currently it is widely cultivated as a fodder plant, and naturalized in some areas in Europe (Ball 1968), in Asia (Langran and Choi 2010), in Africa (Zarrabian 2015), in Australia and in parts of western and central North America (Bisby 1992).

In Russia, *O. viciifolia* is cultivated in steppe and forest-steppe zones as a fodder plant and an excellent source of nectar and pollen for honey bees [2]. It is planted in Crimea (mainly steppe zone), where escaped plants are might be considered as agriophytes occurring in habitats that are close to being natural (Brynza and Korzhenevskiy 2015). In the northeastern part of Ukraine, *O. viciifolia* occurs as an ephemerophyte (Dvirna 2017). A review of the available world literature, publicly available digitized herbarium data, and databases showed that the find (67° 44.25′ N, 32° 17.967′ E) discovered by N. Berlina in 2013 in the Murmansk region (Kozhin et al. 2014), has been likely the only find in the Russian Arctic so far. In neighboring Finland, common sainfoin has not yet been found in high latitudes.

Common sainfoin is a thermophilic plant (Filz et al. 2013), whose growth depends on environmental conditions, especially during seed germination and the initial development of seedlings. It has been established that its seeds can germinate at a temperature ranging 15-20°C, but early seedling growth is possible only at 20-30°C (Carleton et al. 1968). The necessary thermal conditions for germination and growth of sainfoin plants in Murmansk were observed from July 9 to August 2 in 2018 [9]. During this period, the daily temperature was kept within 21-32°C, which played a key role for seed germination, and most importantly, initial growth. Thus, the new find of the thermophilic sainfoin plant at such high latitudes may be related to a global warming trend. Consideration should be given to the Urban Heat Island Effect (UHI), which is also known to promote the naturalization of alien plants (Rysiak and Czarnecka 2018).

The emergence of common sainfoin on the same gas station lawn on which *B. japonicus* has been collected is also associated with a contaminant seed mixture. The invasion status of *O. viciifolia* is to be considered a casual alien plant.

Hylotelephium telephium (orpine) is a widespread perennial polycarpic herb in Eurasia: in Europe, this plant extends northeast to the Arctic Circle and approximately 41 latitudes in the south (Jalas et al. 1999); it is also distributed in the taiga, forest, forest-steppe zones of Siberia, the Far East, Mongolia, China, Japan (Martynenko 1976). The vicinity of Kuttura (68° 24.412' N, 26° 26.89' E), the vicinity of Sirkka (67° 53.489' N, 24° 50.516' E), and the vicinity of Rovaniemi (66° 35.438' N, 23° 37.917' E) are the only known records of this species growing wild in polar Finland.

The only reliably known occurrence of the species in the Murmansk region, located in the Lapland State Nature Biosphere Reserve (between 67°39'–68°15' N and 31° 10'–32°45' E), is considered native (Berlina 1997). On the contrary, the find referred to in the article was found in a man-made habitat. A boreonemoral species, *H. telephium* is considered to be a rare plant in the tundra zone north of the Arctic Circle (Jalas et al. 1999, Sekretareva 2004, [4, 5]). In addition to the indicated localities, other localities of the species are also known in Russian Polar Europe: the vicinity of Vorkuta (67° 29.61′ N, 64° 3.007′ E) and Naryan-Mar (67° 38.283′ N, 53° 0.416′ E) (Byalt 2001). In the last two localities, the species was recorded in the field.

In the North-East of Siberia, few records of *H. telephium* is reported for natural environments on the high-mountainous right bank of the Kolyma River (Yurtsev et al. 2010) and in the Yana River basin. Among them, the northernmost record was

noted (69° 42' N, 135° 12' E) on the southern slope near the mouth of the Dzhangka River, the right tributary of the Yana River (Petrovsky 1992).

As for the Murmansk find, the nature of the habitat, the location of the collection site (concrete ring) next to the flower bed, and the presence of fruits with seeds in the collected specimen indicate that it has escaped from the flower bed and apparently grew from a seed. According to the classification scheme for alien plants (suggested by Holub and Jirásek 1967), such plants are considered ergaziophygophytes. The invasion status of *H. telephium* is to be considered a casual alien plant (or intentionally introduced casual alien).

The natural range of the perennial polycarpic herb, *Cichorium intybus* (common chicory), includes almost all of Europe (except for areas north of the 61st latitude), the Caucasus, the Mediterranean, Southwestern, and Southeastern Siberia, Asia Minor, Central Asia, and Mongolia (Tzvelev 1989, [2]). As an alien plant, it occurs in Northern Europe, South Africa, South and North America, Australia, and the western provinces of China [2]. The vicinity of Karigasniemi is the only known record (69° 25.376' N, 26° 6.234' E) of this species as alien in Finnish Lapland.

Throughout the Russian Arctic, *C. intybus* is known only from the Murmansk region, where it was recorded as an occasional ephemeral species at 4 points in the city of Kandalaksha (Mäkinen 2002, [11]) and its environs [6, 12], in the town of Polyarnye Zori [8], in the Lapland State Natural Biosphere Reserve (Berlina 1997), and in Murmansk (Menshakova et al. 2009, [1]).

C. intybus was found on the same sown lawn as *B. japonicus* and *O. viciifolia*, indicating that it also was introduced with contaminated seeds. The invasion status of common chicory is to be considered a casual alien plant.

The annual herb, *Iva xanthiifolia* (ragsumpweed), is native to the North American prairies [13]. As an alien species, it occurs in Europe, in the Caucasus, in Asia (Kazakhstan, China, Japan), in the forest and forest-steppe zones of Siberia, in the Far East, in South America, in Australia, and in New Zealand (Lomonosova and Zykova 2003, Omelianenko 2021, [2, 3]). Over the past decades, *I. xanthiifolia* has increased drastically in population in Central and Eastern Europe, including Central Russia, where it has become an invasive species (Vinogradova et al. 2009, Follak et al. 2013). In addition to environmental damage, it causes economic damage (noxious weed of row crops) and may be harmful to human health (allergenic) (Follak et al. 2013).

Previously, rag-sumpweed was known only from three localities in the Murmansk region. At first, as a casual, it was collected by Sokolov D. D. on the railway track near Kovda station in 1993 [10]. Later, *I. xanthiifolia* was registered by Kostina V. A. at the railway station in Apatity town in 1999 (Kostina 2001). The last known find was registered in Murmansk in 2001 on a wasteland in a residential area (Menshakova et al. 2009). In Finland, beyond the Arctic Circle, rag-sumpweed has not yet been found.

The new specimen from Murmansk was found at a fruit and vegetable market at the point of sale, indicating that it arrived with contaminated packaging material such as boxes, bags, or straw. The invasion status of *I. xanthiifolia* is to be considered a casual alien plant.

Thus, the pathways of the introduction of five new neophytes reported here are different but its invasive status is the same. All five alien species reported here are considered casual. Three of them, *B. japonicus*, *C. intybus*, and *O. viciifolia* have been introduced as contaminants in seed mixtures. Contrastingly, *H. telephium* escaped from cultivation. *I. xanthiifolia*, which is invasive in Central and Eastern Europe and also in Central Russia, was introduced into the city of Murmansk with contami-

nated fruit and vegetable packaging material.

In this study, the list of the alien flora of Murmansk has been replenished with new finds of *B. japonicus*, *H. telephium*, and *O. viciifolia*. In addition, the discovery of a thermophilic alien species (*O. viciifolia*) in the north, which is the most remote from its original and secondary ranges, promotes the interest in further research of alien plant species invading Arctic regions under global/regional/local warming scenarios.

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