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Contribution to the native flora of Lithuania. First report

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Abstract

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Comprehensive and accurate information on the diversity and distribution of native plant species in an area is essential for understanding its biodiversity, assessing ongoing changes in the flora and providing timely protection for threatened species. Some important information cannot be used effectively because it remains unpublished in the notebooks of researchers or is published in social networks, ever-changing websites, or other ephemeral publications. With this article, we initiate the regular publication of the most important information on the diversity of native plant species in Lithuania, especially on the recorded new native taxa, the status of rare species and their populations. *Orobanche bartlingii*, which parasitises *Libanotis pyrenaica*, was recorded for the first time in eastern Lithuania (Utena distr.) in 2017. Although *Orobanche bartlingii* flowered every year, there was considerable variation in the number of flowering individuals between years. A large population of *Polystichum aculeatum*, consisting of more than 500 individuals, was found near Ignalina (Ignalina distr., eastern Lithuania). *Crambe maritima* in Lithuania was first reported in the literature in the 19th century. Still, it was not observed until 2022, when solitary individuals of this species were again found at two sites on the Baltic Sea coast (near Karklė, Klaipėda distr., and Juodkrantė, Neringa). Seeds of this species, which originate from other coastal regions of the Baltic Sea, have probably been washed ashore during storms. *Solidago virgaurea* subsp. *pineticola*, previously recorded at only one site in Lithuania, was found to be much more widespread in the southern and eastern parts of the country. This subspecies differs from *Solidago virgaurea* subsp. *virgaurea* not only in morphology but also in phenology. *Solidago virgaurea* subsp. *pineticola* starts flowering about one month earlier than *Solidago virgaurea* subsp. *virgaurea*. Conservation issues of *Polystichum aculeatum* and *Crambe maritima* were analysed and discussed.

Keywords: conservation, *Crambe maritima*, distribution, habitats, *Orobanche bartlingii*, *Polystichum aculeatum*, population, *Solidago virgaurea* subsp. *pineticola*.

INTRODUCTION

The most apparent and significant contemporary changes in the composition of the flora of any region are caused by the invasion and spread of alien species (Pejchar & Mooney, 2009; Davies, 2011; Pyšek et al., 2012, 2020). However, the diversity and distribution of native plants in a given area is also constantly changing as a result of various natural environmental changes and anthropogenic pressure on ecosystems

(Stohlgren et al., 2000; Keith et al., 2009; Nobis et al., 2016; Olden et al., 2018).

In addition to the objective reasons for changes in the diversity and composition of the flora, significant changes are caused by subjective reasons. Knowledge of the diversity of plant species depends to a large extent on the intensity of field research and the gathering of herbarium specimens (Kress & Funk, 2005; Funk, 2006; Taylor, 2007; Simpson, 2010; D'Antraccoli et al., 2022). Detailed surveys in specific natural habitats or in areas that have been little explored in the past can lead to the discovery of new native plant species (or subspecies) and the detection of new populations of very rare or endangered species (Funk et al., 2005; Rouhan & Gaudeul, 2014; Mayo, 2022). Detailed examination of newly collected herbarium specimens or critical revision of herbarium specimens collected in earlier periods may also reveal new species previously not recorded in a given area. The plant species lists of certain areas are also subject to considerable modification due to changes in the taxonomic treatment of species (Mace, 2004; Taylor, 2007; Chiarucci et al., 2011; Christenhusz & Byng, 2016).

Despite the long history and tradition of flora research in Lithuania (Jundziłł, 1791, 1811, 1830; Gorski, 1830; Zelencov, 1890; Hryniewiecki, 1933; Kuprevičius, 1934; Snarskis, 1954, 1968; Natkevičaitė-Ivanauskienė, 1959, 1961, 1963; 1971, 1976, Natkevičaitė-Ivanauskienė et al., 1980; Lekavičius, 1989; Gudžinskas, 1999; Laasimer et al., 1993; Kuusk et al., 1996, 2003), the current state of knowledge about plant diversity is deficient. As in many countries in Europe and other regions, Lithuania has a severe shortage of specialists with expertise in plant taxonomy. Even though the Baltic region is not a biodiversity hotspot, there is only preliminary information on the diversity of some plant genera in the country. Among the poorly studied genera are *Chenopodium* L., *Festuca* L., *Galium* L., *Ranunculus* L., and there is particularly little knowledge of taxonomically complex and globally understudied genera such as *Alchemilla* L., *Hieracium* L., *Pilosella* Hill, *Taraxacum* F.H. Wigg. Detailed studies of the diversity of these and many other genera and their critical revision in the light of the latest taxonomic results could reveal dozens of new native plant species not yet recorded in Lithuania.

Over the last two decades, botanists, environmentalists and amateur botanists have discovered several native plant species in Lithuania through various biodiversity surveys, some of which have already been published in scientific publications (Sinkevičienė, 2016; Gudžinskas & Taura, 2021a, b; Ryla et al., 2022; Taura et al., 2022). Many rare species have been found in new habitats, and the distribution and status of some species in Lithuania have been clarified (Gudžinskas & Taura, 2022; Kazlauskas et al., 2022; Taura et al., 2022; Sinkevičienė et al., 2023). Some important information cannot be used effectively because it remains unpublished in the notebooks of researchers or is published in social networks, ever-changing websites, or other ephemeral publications. As a result, valuable data on the population size, abundance of individuals or habitat quality of rare and endangered species is lost over time and cannot be recovered. This led to the initiation of regular publication of information on the most significant discoveries of native plant species or infraspecific taxa in Lithuania, as well as on the status and dynamics of populations of rare and endangered species. This publication is the first in a planned series of articles that we hope will encourage professional botanists, conservationists, ecologists, as well as amateur plant enthusiasts to engage in more in-depth and responsible research on the flora of Lithuania and contribute to the study of national biodiversity.

MATERIALS AND METHODS

The surveys of the described plant species and subspecies were carried out in different areas of Lithuania from 2017 to 2024. Part of the information was collected during targeted surveys and assessment of previously discovered plant populations. The dates and locations of the surveys for each species or subspecies are given in the text. However, the exact geographical coordinates of the sites are not provided due to the sensitivity of the information on protected species. Full details of the localities, including geographical coordinates, are given on the labels of the herbarium specimens that support the records and may be available to specialists. The herbarium specimens of the analysed taxa have been deposited at the Herbarium of the Institute of Botany of the Nature Research Centre (BILAS).

Primary sources (data published in the literature, specimens stored in herbaria) were used to analyse the distribution and history of the studied plants in Lithuania. In some cases, information published in social networks, mainly on the *iNaturalist* platform, was used. Label information of specimens stored in the Herbaria of BILAS, KRAM, WI and LE was used (acronyms of herbaria are given according to the *Index Herbariorum* database). The distribution map of *Solidago virgaurea* subsp. *pineticola* is based on the geographical grid system, with each grid cell being 6' latitude and 10' longitude. All localities within the same grid cell were marked with a single symbol.

For the morphological comparison of flowers between subspecies of *Solidago virgaurea*, the material was collected in two populations of each subspecies. In each population, ten synflorescences were randomly collected. In the laboratory, three capitula per synflorescence (from the bottom, middle and top) were taken from each synflorescence, dissected, and the florets counted and measured using a stereomicroscope (*Leica EZ4*). After the dissection of the capitula, the ligules and disc florets were counted separately, and the length of a randomly selected ligule and disc floret was measured. The length of the ligules and disc florets was measured from the junction with the ovary to the apex. The total number of florets was determined by adding the number of ligules and disc florets. The normality of the data sets was estimated using the Shapiro-Wilk test. The data sets of some of the individual populations were not normally distributed, whereas the pooled data for both subspecies were normally distributed. Results of descriptive statistics were expressed as mean and standard deviation (mean ± SD). Differences between populations were assessed using the non-parametric Mann-Whitney pairwise test, and pooled subspecies data were compared using a two-sample *t*-test. All calculations were performed using the PAST 4.16c software package (Hammer et al., 2001).

RESULTS AND DISCUSSION

Polystichum aculeatum

Polystichum aculeatum (L.) Roth (*Aspidium aculeatum* (L.) Sw.; *Dryopteris aculeata* (L.) Kuntze; *Polypodium aculeatum* L.; Polypodiaceae) is distributed over a large part of Europe except for the northern and eastern regions, occurs in south-western Asia, in some parts of Central Asia and North Africa (Hultén & Fries, 1986). In the Baltic region, the species is rare and considered close to the northeastern limit of its range (Lazdauskaitė, 1996). In Lithuania, *Polystichum aculeatum* is exceedingly rare and has been included in the list of protected species and classified as critically endangered (CR; D1) (Rasimavičius, 2021).

Throughout the history of floristic studies in Lithuania, only four localities of *Polystichum aculeatum* have been registered. Two historical localities of this species were recorded in the early 19th century, and two localities were discovered in the late 20th and early 21st centuries (Jundziłł, 1822a; Lazdauskaitė, 1996; Tupčiauskaitė, 2007; Rasimavičius, 2021). *Polystichum aculeatum* was found in 1821 in the then Vilnius region (now Vilnius city), on the slope of the Sudervė stream, near the village of Pilaitė (Jundziłł, 1822a). The species has not been found in this locality or the surrounding area since, despite searches. Another locality was probably found in 1821 during Jundziłł's journey through Lithuania (Köhler, 1995). The date and exact location of the find were not written on the label of the herbarium, which is now kept in Krakow (KRAM), but only the western region of Lithuania, Žemaitija [Żmuydź], was mentioned (Köhler, 1995). More recently, in 1996, *Polystichum aculeatum* was discovered near Druskininkai (southern Lithuania), in the Raigardas valley, but only one individual was found (Lazdauskaitė, 1996; Rasimavičius, 2021). The species has not been found in this locality since, but there is a possibility that it may be rediscovered. Unfortunately, the locality was not accurately recorded at the time of discovery, and the potential area of occurrence is quite large. Another population of *Polystichum aculeatum* was discovered in Jurbarkas district (southwest Lithuania) in 2013. The population has been reported to consist of about ten individuals at the time of discovery, but no further information is available (Rasimavičius, 2021).

A new population of *Polystichum aculeatum* was discovered in the western part of Ignalina (eastern Lithuania), near Lake Šiekštys (Žaliasiai) in 2020 (found by B. Šablevičius). The status of the population was monitored annually from 2020 to 2024 and appeared to have remained unchanged. It consisted of

Fig. 1. Group of *Polystichum aculeatum* individuals on a slope. Photograph by B. Šablevičius.

more than 500 individuals. Individuals of *Polystichum aculeatum* were in good condition, with the leaves of the largest plants reaching a height of about 1 m (Fig. 1). The total area occupied by the *Polystichum aculeatum* population was about 1.5 ha, but the site had no clear boundaries. From the central part, where the density of individuals was highest (in an area of about 0.2 ha), the density gradually decreased towards the periphery. Several small groups of plants were separated from the main group by gaps of about 70–100 m. Judging by the area covered by the population and the abundance of individuals, it might have been established long ago, probably shortly after the forest was established, but remained undiscovered for a long time due to the extremely rugged terrain.

The green leaves of *Polystichum aculeatum* overwinter under the snow, but when the snow melts in spring, the leaves usually break off at ground level and begin to wither. New leaves emerge from the centre of the clump in spring, and by the end of May, they are usually fully expanded and have reached their maximum height. In all years of observation, individuals of *Polystichum aculeatum* have sporulated abundantly (Fig. 2), but no precise recruitment assessment has been made. Judging by the number of young (3–6 cm tall) and immature (about 20 cm tall) individuals (Fig. 3) that can be easily identified as *Polystichum aculeatum*, it can be concluded that reproduction by spores is relatively slow. Such individuals are scattered throughout the habitat and constitute less than 1% of the population.

The population of *Polystichum aculeatum* occurs on steep southeast, south and southwest-facing slopes with an inclination of 30–45°, occasionally up to 50°. The stand in which *Polystichum aculeatum* occurs consists of 90–100-year-old trees. *Picea abies* was the dominant tree species (about 70% of the stand), *Populus tremula* L. (20%) was much less abundant, and *Acer platanoides* L., *Quercus robur* L., *Betula pendula* Roth, *Fraxinus excelsior* L. and *Alnus incana* (L.) Moench grew as isolated trees. The sparse shrub layer consisted of scattered *Lonicera xylos-*

teum L., *Prunus padus* L., *Corylus avellana* L. and *Viburnum opulus* L. The herb layer was relatively sparse due to the lack of sunlight, with a total plant cover of about 40%. About 50% of the ground surface was covered by plant debris, and about 10% was bare soil. In the stand where *Polystichum aculeatum* occurred, the most abundant were *Lamium galeobdolon* (L.) L., *Brachypodium sylvaticum* (Huds.) P. Beauv., *Dryopteris filix-mas* (L.) Schott, *Actaea spicata* L., *Fallopia dumetorum* (L.) Holub, *Stachys sylvatica* L., *Lactuca muralis* (L.) Gaertn., while *Scrophularia nodosa* L. and *Lathraea squamaria* L. were sparse.

Fig. 2. Adaxial surface of *Polystichum aculeatum* frond with abundant sori. Photograph by B. Šablevičius.

Despite the steep slopes in the *Polystichum aculeatum* habitat, there are no signs of current erosion. Trees and shrubs naturally reinforce the slopes of the old ravine. The border of the Ažušilė Landscape Reserve is close (about 300 m) to the *Polystichum aculeatum* habitat. The *Polystichum aculeatum* locality had not been discovered when the landscape reserve was established (in 1988) and was, therefore, not included in the reserve. In the future, when the protected area's boundaries are adjusted, the forest area with the *Polystichum aculeatum* population should be included in the landscape reserve. The species is threatened, though indirectly for the time being, by human activities in a particularly active recreational area near Lake Šiekštys (Žaliasiai).

Fig. 3. Immature individual of *Polystichum aculeatum* at the base of a tree trunk. Photograph by Z. Gudžinskas.

Crambe maritima

The native range of *Crambe maritima* L. (Brassicaceae) is disjunct. It includes coastal areas of the Northern and the Baltic Sea, from France to Finland, and coastal areas of the Black Sea in Europe and the Caucasus (Prina, 2009).

The first mention of *Crambe maritima* in Lithuania was published by Jundziłł (1830). He stated that the species occurred in the coastal sands of the Baltic Sea near Palanga. Interestingly, in his earlier publications, *Crambe maritima* was not mentioned in Palanga or any other Baltic coastal area where he reported the plant species found during his travels in Lithuania in 1821 (Jundziłł, 1822a, b). Gorski (1830) did not include *Crambe maritima* in the compendium of plants of Lithuania, while Hryniewiecki (1933) referred to the species following Jundziłł's (1830) report. Later reports (Snarskis, 1954; Jankevičienė, 1961) are based only on the same literature source. The herbarium of Jundziłł (KRAM; Köhler, 1995) does not contain any specimens of *Crambe maritima*. Thus, it remains unclear whether this species has ever been found in Lithuania, and if so, by whom and when. It cannot be excluded that the first reference may have been erroneous.

The first reliable data on the growth of *Crambe maritima* in Lithuania appeared almost 200 years after the first reference in the literature (Jundziłł, 1830). On 3 July 2022, a photo of *Crambe maritima* taken on the Baltic Sea coast, in Pajūris Regional Park, near the Holland Cap escarpment (Klaipėda distr.), was published on the citizen science platform *iNaturalist*. An individual of this species was found about 29 metres offshore on a pebble beach.

The second locality of *Crambe maritima* in Lithuania was discovered on 13 September 2022 during the triennial inventory of the *Eryngium maritimum* population in Curonian Spit National Park, on the Baltic Sea coast west of Juodkrantė (Neringa municipality). One individual of this species was found on the western slope of the foredune, 32 m from the seacoast (Fig. 4). *Crambe maritima* occurred in the habitat of white dunes (also called shifting dunes along the shoreline with *Ammophila arenaria*), where about 40% of the surface was covered by the herb layer and 60% of the surface consisted of open aeolian sand (Fig. 5). The herb layer in the *Crambe maritima* site was mainly composed of species characteristic of white dunes (*Ammophila arenaria* (L.) Link, *Leymus arenarius* (L.) Hochst., *Lathyrus japonicus* Willd. *maritimus* (L.) J.T. Kartesz & Gandhi), with isolated individuals of *Cakile maritima* Scop. subsp. *baltica* (Jord.) Hyl. ex P.W. Ball. However, *Carex arenaria* L., characteristic of grey dune habitats, was abundant in some areas of the site. It should be noted that the invasive species *Rosa rugosa* Thunb. occurred in the habitat, although its abundance was low (less than 5%). Therefore, the state of the *Crambe maritima* habitat can be considered satisfactory.

The Pajūris Regional Park Administration staff announced on social media that a single individual of *Crambe maritima* flowered, matured and released seeds in 2023 and 2024. However, on 11 June 2023, it was observed that the plant was massively attacked by *Pieris brassicae* larvae (Fig. 6). Therefore, the larvae may have destroyed at least some of the seeds, and the actual seed production is unknown.

Fig. 4. Individual of *Crambe maritima* near Juodkrantė, Curonian Spit National Park. Photograph by Ž. Valiuška.

Fig. 5. The white dune habitat with *Crambe maritima* near Juodkrantė, Curonian Spit National Park. Photograph by Ž. Valiuška.

Fig. 6. *Pieris brassicae* larvae on *Crambe maritima* inflorescence in Pajūris Regional Park, 11 June 2023. Photograph by Ž. Valiuška.

The individual of *Crambe maritima* in Curonian Spit National Park, unlike the individual in Pajūris Regional Park, did not produce an inflorescence for three consecutive years (from 2022 to 2024). The individual is still relatively small, and in 2024, it produced four leaves (the lowest leaf was 20.5 cm long and 10.7 cm wide, the second – 13.9 cm × 8.4 cm, the third – 7.5 cm × 7.7 cm and the fourth – 20.0 cm × 11.7 cm).

Currently, two known localities of *Crambe maritima* are in Lithuania, separated by about 30 km. The population of the species in the country is extremely small, with only two individuals, of which only one has flowered and produced seeds during the observation period since 2022. No new seedlings of *Crambe maritima* have been observed. As *Crambe maritima* grows on the shores of the Baltic Sea in other countries, we assume that its seeds have been brought to the Lithuanian shores by water, probably during intense storms. Its seeds survive long in seawater and are adapted to hydrochory (Scott & Randall, 1976). Therefore, a species introduced into the country from its natural range by natural factors should be considered native and protected. However, according to IUCN (2012) guidelines, the species cannot yet be assessed according to these criteria because it has not yet formed a stable, continuously recruiting population.

The two currently recorded habitats of *Crambe maritima* in Lithuania are mainly threatened by recreational activities. Both plants grow in recreational areas where people frequently visit, so individuals may be accidentally damaged or destroyed by visitors. Natural abiotic factors, powerful storms, can increase populations or localities by bringing seeds from other Baltic Sea areas and destroying existing habitats and *Crambe maritima* plants. The site near Juodkrantė (Curonian Spit National Park) is threatened by habitat succession and the possible invasion of *Rosa rugosa*. With *Rosa rugosa* patches found only 1.4–1.7 m from *Crambe maritima* in 2024, there is a serious risk that this invasive shrub will soon invade the site and significantly change the growth conditions (Gudžinskas & Rasimavičius, 2021).

It is often assumed that the destruction of coastal habitats by erosion and anthropogenic activities mainly threatens populations of coastal plant species. Still, some studies (Ievinsh et al., 2020) have shown that suitable habitats for *Eryngium maritimum* and *Crambe maritima* in the Baltic Sea region cover large areas, but populations of these species are declining. Therefore, there are likely other causes for the decline of coastal species, and further in-depth studies are needed. Anthropogenic factors undoubtedly have an impact on the stability of coastal species populations. Studies on the Baltic coast of Germany have shown that *Crambe maritima* responds to trampling by reducing individuals' growth rate and longevity (Seer et al., 2015).

It is difficult to predict the future of *Crambe maritima* in Lithuania. A rapid spread of *Crambe maritima* in Lithuania, as happened in the Netherlands in the 1970s and 1980s (Rappé, 1984), is unlikely because the coastal habitats in Lithuania are much less favourable for the species than in other countries around the Baltic and North Seas. In Lithuania, almost all coastal areas are covered by sand, whereas in other countries, there are areas with permanently wet, muddy habitats and sections with abundant boulders and pebbles. It is therefore necessary to continuously monitor the development of *Crambe maritima* populations in the coastal areas of the Baltic Sea in Lithuania.

Orobanche bartlingii

The genus *Orobanche* L. (Orobanchaceae) comprises about 200 species, often highly specialised plant holoparasites. The parasitic lifestyle and specialisation have resulted in a large but taxonomically complex group of species (Pusch & Günther, 2009; Schneeweiss, 2013; Schneider et al., 2016). Depending on the taxonomic concept, the genus *Orobanche* is sometimes divided into five genera, sometimes as many as 14 (Kojić & Vrbničanin, 2000; Kojić et al., 2001; Pusch & Günther, 2009; Schneeweiss, 2013; Schneider et al., 2016). Species of the genus *Orobanche* s.l. are distributed almost worldwide, but the greatest diversity is concentrated in the Mediterranean region, western and central Asia, northern Africa and North America (Pusch & Günther, 2009; Schneider et al., 2016).

In the Baltic States, the genus *Orobanche* is represented by ten species, most of which (six species) are alien (Viljasoo et al., 1996). In addition, all native species of the genus are rare or extremely rare (Viljasoo et al., 1996; Kukk, 1999; Patalauskaitė, 2021; Stalažs, 2024). In Lithuania, two native species of the genus *Orobanche* (*Orobanche elatior* Sutton and *Orobanche reticulata* Wallr.) and two alien species (*Orobanche lucorum* A. Braun ex F.W. Schultz and *Orobanche ramosa* L.) have been recorded so far (Jankevičienė, 1976; Viljasoo et al., 1996; Gudžinskas, 1999). The occurrence of four other species in Lithuania has not been confirmed but is expected (Jankevičienė, 1976; Gudžinskas, 1999). The record of the third presumably native species in Lithuania, *Orobanche bartlingii* Griseb., is reported here.

Orobanche bartlingii Griseb. (*Orobanche libanotidis* Rupr.) has long been considered a variety (*Orobanche alsatica* var. *libanotidis* (Rupr.) Beck) or a subspecies (*Orobanche alsatica* subsp. libanotidis (Rupr.) Pusch). *Orobanche bartlingii* is now generally accepted as a separate species, close to *Orobanche alsatica* Kirschl. and forming a distinct group with two other European species (*Orobanche mayeri* (Suess. & Ronniger) Bertsch & F. Bertsch and *Orobanche montserratii* A. Pujadas & D. Gómez) (Viljasoo et al., 1996; Pujadas Salvà & Gómez García, 2000; Szeląg, 2001; Piwowarczyk et al., 2009; 2014; POWO, 2024).

The native range of *Orobanche bartlingii* is not completely clear. Still, it occurs in much of Western and Central Europe, the Baltic region and some parts of western and central Russia, while its occurrence in Asia still needs to be verified (Pujadas

Salvà & Gómez García, 2000; Piwowarczyk et al., 2014; POWO, 2024). The species has been recorded in southern and central Poland (Szeląg, 2001; Piwowarczyk et al., 2014) and Estonia (Viljasoo et al., 1996; Kukk, 1999), but there is no information on its occurrence in Latvia (Stalažs, 2024).

Orobanche bartlingii (Fig. 7) was first found in Lithuania (by B. Šablevičius) on 13 August 2017, east of the village of Tauragnai, in Aukštaitija National Park, Utena district (eastern Lithuania), but at that time, the above-ground part of the plants was dried, and their precise identification was not possible. The following year, on 21 June 2018, the site was revisited, and the flowering plants could be identified. *Orobanche bartlingii* was associated with the host plant *Libanotis pyrenaica* (L.) Bourg. (*Libanotis montana* Crantz), and grew only where these plants were present.

The population of *Orobanche bartlingii* consists of two parts separated by a paved road. The two parts of the population cover an area of about 500 m^2 each (the first part 20 m × 25 m and the second part 10 m × 50 m), but the abundance and density of *Orobanche bartlingii* differ. In the first part of the population, plants grow solitarily or in small groups, and no more than two dozen flowering individuals are found annually in the whole area. The plants grow quite densely in the second part of the population and form distinct, sometimes quite dense groups. The density of individuals in a site dependends on the host plant's abundance, but varies from year to year. In 2017, a total of 19 stems of *Orobanche bartlingii* were found, but in 2018, around 120 flowering stems were counted. As the first half of the summer of 2024 was exceptionally dry and hot, the number of flowering plants was approximately halved, and the plants were smaller than in previous years. In previous years, the most robust individuals were 40–45 cm tall, whereas in 2024, they were only 7–10 cm tall, with a few individuals up to 20 cm tall.

In Lithuania, the flowering of *Orobanche bartlingii* lasts about one month, from the second half of June to the second half of July (Fig. 7). In 2020 and 2021, the first flowering plants were found on 17 June and the last flowering plants on 15 and 20 July, respectively. Individuals of medium height have 12–15 flowers per inflorescence, with only the tallest plants having an inflorescence of 60–70. After flowering and seed dispersal, the stems remain erect until the following spring or even midsummer.

Orobanche bartlingii is closely related to *Orobanche alsatica*, from which the smaller corolla, and several features of flower morphology can distinguish it. The corolla of *Orobanche bartlingii* is less than 20 mm long (usually 12–17 mm long), and the style is glabrous or with solitary glands, whereas the corolla of *Orobanche alsatica* is 20 mm or longer (usually 20–25 mm) and the style is distinctly glandular-pubescent. The stamens of *Orobanche bartlingii* are inserted 1–3 mm above the base of the ovary, whereas those of *Orobanche alsatica* are inserted 4–7 mm above the base of the ovary (Pujadas Salvà & Gómez García, 2000; Szeląg, 2001; Piwowarczyk et al., 2009). The plants found in Lithuania have the characteristic differentiating features of *Orobanche bartlingii*: the stamens are attached to the lower part of the corolla about 2.5 mm from the base of the ovary, the style is almost glabrous, with few glands (in some flowers, the glands are present only in the upper part of the style, below the stigma). The upper part of the plant is often purplish or pinkish, and the stem, bracts and corolla are moderately glandular-hairy.

These two species have different host preferences. *Orobanche alsatic*a usually parasitises roots of *Peucedanum cervaria* (L.) Lapeyr. whereas the main host of *Orobanche bartlingii* is *Libanotis pyrenaica* (L.) Bourg. (*Libanotis montana* Crantz) and only occasionally species of the genus *Peucedanum* L. (Szeląg, 2001; Piwowarczyk et al., 2009). *Orobanche bartlingii* may be more widespread in Lithuania, especially in the southern and eastern parts. Still, suitable habitats with abundant host species, *Libanotis pyrenaica*, populations in dry grasslands are rare.

Based on references, Snarski (1968) has stated that *Orobanche alsatica* Kirschl. is found in the eastern part of Lithuania, but he has not indicated the source of the information, and there are no herbarium specimens to support the record. Therefore, this record of *Orobanche alsatica* in Lithuania must be considered doubtful.

Solidago virgaurea* subsp. *pineticola

The genus *Solidago* L. is represented in Lithuania by one native species (*Solidago virgaurea* L.), two alien species (*Solidago canadensis* L. and *Solidago gigantea* Aiton) and hybrids of the two alien species

Fig. 7. *Orobanche bartlingii* at different stages of anthesis, 21 June 2018. Photographs by B. Šablevičius.

with the native species (*Solidago ×niederederi* Khek and *Solidago ×snarskisii* Gudž. & Žaln.) (Gudžinskas et al., 2003; Karpavičienė & Radušienė, 2016; Gudžinskas & Žalneravičius, 2016).

Solidago virgaurea, distributed throughout Europe, much of Asia and northwest Africa, is now divided into 14 recognised subspecies. In the Baltic States, in addition to the widespread subspecies *Solidago virgaurea* subsp. *virgaurea*, *Solidago virgaurea* subsp. *taurica* (Juz.) Tzvelev (on the islands of Estonia) and *Solidago virgaurea* subsp. *stenophylla* (G.E. Schultz) Tzvelev (in Estonia) have been reported (Gudžinskas et al., 2003). Later, narrow-leaved plants from northwest Russia were described as a new subspecies, *Solidago virgaurea* subsp. *pineticola* Sennikov (Sennikov, 2006). Three specimens (all in LE) collected in the Baltic States and previously identified as *Solidago virgaurea* subsp. *stenophylla*, were recognised as belonging to *Solidago virgaurea* subsp. *pineticola* (Sennikov, 2006). The report by Sennikov (2006) on the occurrence of *Solidago virgaurea* subsp. *pineticola* in Lithuania was based on the herbarium specimen collected in 1985 in Šalčininkai district, near the village of Jašiūnai (26th km of the Vilnius–Lida road, in a dry pine forest, 3 July 1985, leg. D. Geltman, V. Dorofeev, O. Semenova, A. Haare; LE).

The analysis of the herbarium specimens in BILAS showed that the first specimen of *Solidago virgaurea* subsp. *pineticola* was collected in southern Lithuania in 1960 (in the pine forest by the River Merkys, near the Vilnius–Druskininkai road, 3 July 1960, leg. S. Bieliukienė; BILAS). Unfortunately, the exact location of this record cannot be determined, as the sites corresponding to the characteristics indicated on the herbarium label are found along a 20 km section of the road, somewhere between the villages of Paakmenė and Perloja (Varėna distr.). *Solidago virgaurea* subsp. *pineticola* was recorded in 2017 in sandy grassland near the Pažeimenė railway station (Švenčionys distr.) and 4 km north of Marcinkonys, on the slope of an inland dune in a pine forest (Varėna distr.). Three more localities of *Solidago virgaurea* subsp. *pineticola* were found in southern Lithuania in 2024: near Barteliai village (Varėna distr.), 3 km east of Varėna, in Užupis forest (Varėna distr.), and in Žygmantiškės village, 3 km north of Tetėnai (Šalčininkai distr.) (Fig. 8). At all sites surveyed between 2017 and 2024, except near Žygmantiškės village (Šalčininkai distr.), populations of *Solidago virgaurea* subsp. *pineticola* were abundant and occupied extensive areas of sand, sandy grassland and pine forest edge habitats.

Solidago virgaurea subsp. *pineticola* is best distinguished morphologically from *Solidago virgaurea* subsp. *virgaurea* by its leaves. In *Solidago virgaurea* subsp. *pineticola*, the basal and lower cauline leaves are lanceolate. In contrast, the middle and upper cauline leaves are narrowly lanceolate or linear (Fig. 9), and the broadest point of the leaf blade is not distinct. *Solidago virgaurea* subsp. *virgaurea* basal and lower stem leaves are ovate or elliptic, middle and upper stem leaves are broadly lanceolate or lanceolate, and have a distinct widest point at the middle of the leaf-blade.

Complete information on the differences in most morphological characters between *Solidago virgaurea* subsp. *pineticola* and *Solidago virgaurea* subsp. *virgaurea*, as well as other subspecies of this species, is not yet available. A small-scale flower number and size study

Table 1. Comparison of the number and size of florets of *Solidago virgaurea* subsp. *pineticola* and *Solidago virgaurea* subsp. *virgaurea*. Different lowercase letters in the same column indicate significant differences between populations according to the Mann-Whitney pairwise test. Differences between the pooled data of the subspecies were estimated by the two-sample *t*-test (* – $p < 0.05$; ** – $p < 0.01$; *** – $p < 0.001$)

Subspecies and populations	n	Number of ligules	Length of ligule (mm)	Number of disc florets	Length of disc floret (mm)
Solidago virgaurea* subsp. *pineticola					
Pažeimenė	30	9.1 ± 1.7^{a}	9.98 ± 0.78^{ab}	17.7 ± 2.6a	5.90 ± 0.49^{a}
Marcinkonys	30	7.4 ± 1.2^{b}	9.56 ± 1.03^{a}	12.5 ± 1.7^{b}	5.80 ± 0.58^{a}
Pooled	**60**	**8.3 ± 1.7****	**9.77 ± 0.93***	**15.1 ± 3.4*****	**5.84 ± 0.54*****
Solidago virgaurea* subsp. *virgaurea					
Pagiriai	30	8.3 ± 1.1^{c}	10.13 ± 0.34b	17.6 ± 2.6^{a}	6.68 ± 0.63^{b}
Zabarauskai	30	10.2 ± 1.6^{d}	10.03 ± 0.41b	18.1 ± 4.7^{a}	6.74 ± 0.28^{b}
Pooled	**60**	**9.3 ± 1.7****	**10.08 ± 0.38***	**17.8 ± 3.8*****	**6.70 ± 0.32*****

showed significant differences between the subspecies (Table 1). The analysis showed that the total number of florets (ligules and disc florets combined) in a capitulum of *Solidago virgaurea* subsp. *virgaurea* (27.1 ± 4.7) was significantly ($t = 4.46$; $p < 0.001$) higher than that of *Solidago virgaurea* subsp. *pineticola* (23.3 ± 4.5). *Solidago virgaurea* subsp. *pineticola* has significantly fewer ligules and disc florets in a capitulum and they are significantly shorter than those in the *Solidago virgaurea* subsp. *virgaurea* (Table 1). However, these characters are quite variable between populations and a much larger study involving more populations is needed to assess the significance of these and other characters for subspecies identification.

The phenology of the two subspecies is quite different: *Solidago virgaurea* subsp. *pineticola* starts flowering in mid-June and by mid-July, when *Solidago virgaurea* subsp. *virgaurea* usually starts blooming, it is already releasing ripe fruits. In addition, secondary flowering is rarely observed in *Solidago virgaurea* subsp. *pineticola*, whereas the type subspecies often produces lateral branches or stems and continues to flower until late autumn. Differences in flowering phenology are a major obstacle to cross-pollination between subspecies, even when both occupy the same habitat or occur in neighbouring habitats.

Although all recorded localities of *Solidago virgaurea* subsp. *pineticola* are concentrated in the southern and eastern parts of Lithuania (Fig. 9), the distribution of this subspecies could be much wider in the country. It is expected to occur in suitable habitats throughout the Baltic elevation in eastern and southern Lithuania, but further studies on its distribution and ecological preferences are required.

Considering the currently known distribution of *Solidago virgaurea* subsp. *pineticola* in Lithuania,

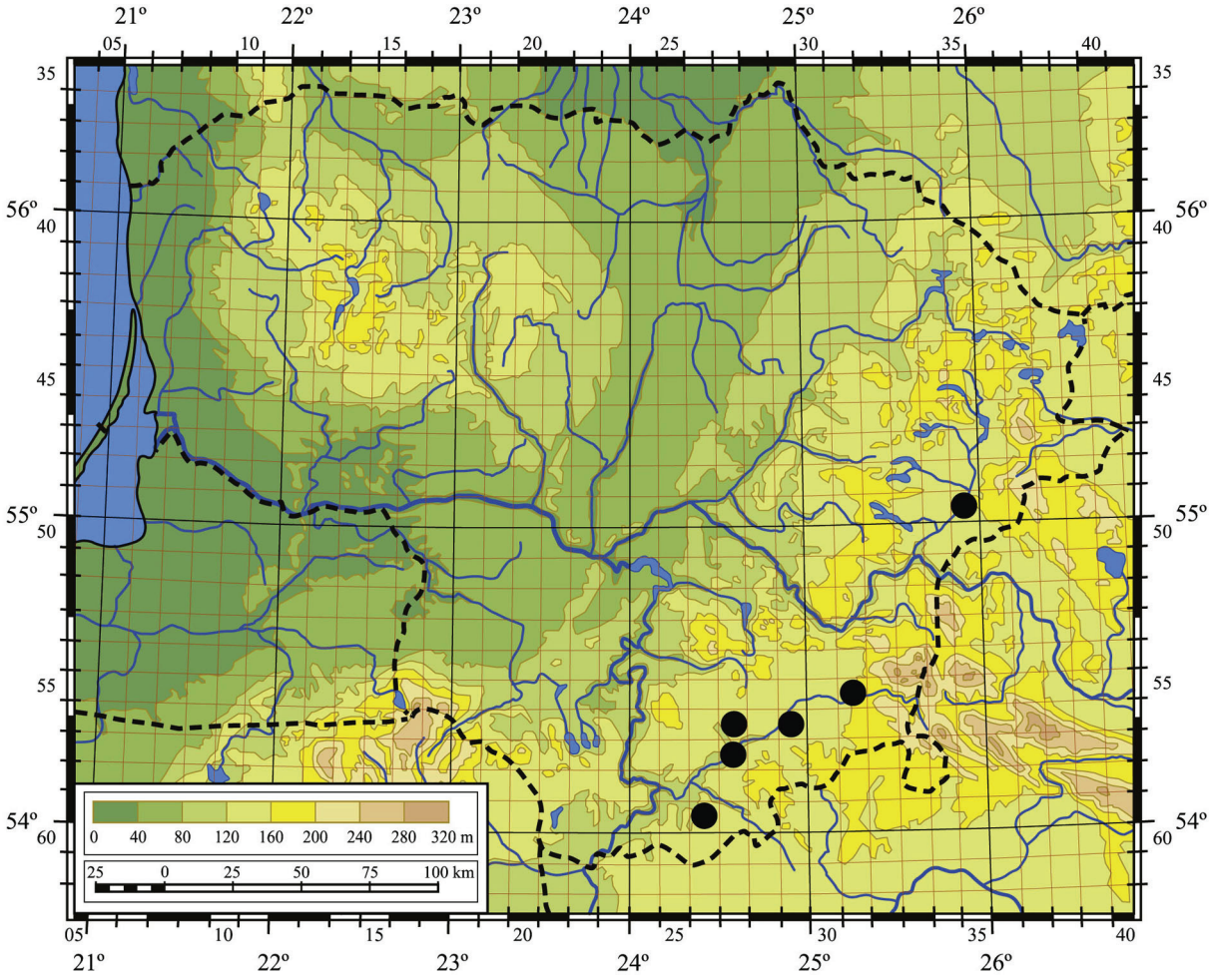

Fig. 8. Distribution of *Solidago virgaurea* subsp. *pineticola* in Lithuania.

Fig. 9. *Solidago virgaurea* subsp. *pineticola* near Barteliai village (Varėna distr., southern Lithuania, 5 July 2024). Photgraphs by Z. Gudžinskas.

it can be assumed that there is a high probability of its occurrence in some regions of Belarus (northwest and north), especially in districts bordering Lithuania. The subspecies may also occur in Poland, most probably in the Lakeland area of the Baltic uplands. The distribution of *Solidago virgaurea* subsp. *pineticola* in Latvia should be further investigated, as only one occurrence is currently reported (Sennikov, 2006), and this subspecies is not included in the latest plant checklist of Latvia (Stalažs, 2024).

Plant surveys in different parts of Lithuania have led to the discovery of a new species in the country, *Orobanche bartlingi*. Further studies of this and other species of the genus *Orobanche* will help to determine whether their spread is linked to climate change or whether they are truly rare due to their particular biological characteristics. The population of *Crambe maritima*, which occurs on the Baltic Sea coast, is extremely small in Lithuania. It is, therefore, necessary to continuously monitor the status of the plants already recorded and to search for new locations in suitable habitats. If a stable population of *Crambe maritima* is established in Lithuania, legal protection for this species would be worth considering. The discovery of a large population of *Polystichum aculeatum* in the eastern part of Lithuania suggests that this species could be found in other parts of the country. Therefore, surveys of suitable habitats, especially forests on the slopes of ravines, in early spring, when the plants are most visible, are necessary. It was confirmed that *Solidago virgaurea* is represented in Lithuania by two subspecies: the widespread and common *Solidago virgaurea* subsp. *virgaurea* and *Solidago virgaurea* subsp. *pineticola*. Further studies are needed to determine the distribution of *Solidago virgaurea* subsp. *pineticola* in the country.

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