

## Review

# *Cephalanthera longifolia* and *Cephalanthera rubra* (Orchidaceae) in Lithuania. Analysis of distribution, population dynamics and conservation issues

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### Abstract

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Accurate assessment of conservation strategy and management actions for threatened plant species requires comprehensive quantitative information on population status and trends. This study aimed to analyse, evaluate and summarise all available information on *Cephalanthera longifolia* and *Cephalanthera rubra* in Lithuania. All known literature sources, published from the end of the 18th century to the present, mentioning species of the genus *Cephalanthera* in the present and historical territory of Lithuania were analysed, and herbarium specimens were examined. Data on the area occupied by populations of *Cephalanthera longifolia* and *Cephalanthera rubra* were collected during field surveys in 2021–2024. The number of localities of *Cephalanthera longifolia* in Lithuania has increased during the last two decades, and it was estimated that they occupy a total of 22.98 ha. Currently, there are four localities of *Cephalanthera rubra* in Lithuania, whose status and size are regularly assessed, occupying a total of 2.10 ha. Most localities of *Cephalanthera rubra* occur in protected areas, while almost half of the localities of *Cephalanthera longifolia* occur outside protected areas. Two case studies showed that *Cephalanthera longifolia* can colonise abandoned arable land and thrive in early successional tree stands and tree plantations. Objective knowledge of rare species populations is necessary for decision-makers to design an effective conservation system and implement the measures required for their protection.

**Keywords:** conservation, distribution, herbarium, management, population dynamics, population size, protected species.

## INTRODUCTION

The loss of biodiversity due to human activities and climate change is a global concern to scientists and society (Bálint et al., 2011; Dobson et al., 2021; Antonelli et al., 2024). Although evidence of species extinction and extensive habitat loss is well documented, these processes continue at an alarming

rate, and efforts to halt them have not yielded satisfactory results (Nielsen et al., 2021). It is estimated that nearly 600 plants have already become extinct globally (Humphreys et al., 2019), and numerous scientific studies suggest that between 20% and 39% of plant diversity is currently threatened with extinction (Brummitt et al., 2015; Bachman et al., 2018; Lughadha et al., 2020). The situation in Europe is

even more complicated. Its flora contains about 5.7% of the world's plant species, of which an estimated 44.9% are threatened with extinction in Europe (Bilz et al., 2011).

Anthropogenic factors leading to habitat destruction and degradation, biological invasions and land-use change are among the leading causes of species decline and extinction (Newbold et al., 2015; Downey & Richardson, 2016). The decline of species of least concern usually starts locally and then becomes a global phenomenon as populations dramatically decrease in size and density (Wiens, 2016). Although humans have impacted forest habitats for millennia, and these ecosystems are usually considered resilient to rapid environmental change, forests are now at their smallest extent since the last glacial maximum (Grove, 2002; Whitehouse, 2006). Modern forest management practices, which include large-scale logging, artificial drainage, replacement of native species with fast-growing introduced trees, ever-expanding forest plantations and limited populations of large herbivores, are leading to significant changes in forest plant communities and population declines of herbaceous forest species (Fritzboeger, 2001; Levin & Normander, 2008; Gossner et al., 2013; Pringle et al., 2023). Therefore, planning long-term conservation actions and management approaches for threatened species populations requires an understanding of the factors that cause species distribution patterns, processes in the demographic structure of populations, the persistence of a species in a given environment, its fecundity and adaptability (Álvarez-Yépez et al., 2019).

In Lithuania, the list of threatened plant species is dominated by grassland and wetland species, but some typical forest and woodland species are also at risk (Rašomavičius, 2007, 2021; Gudžinskas et al., 2016). The loss of characteristic forest species has several causes, including the decline of old and biologically mature forests due to logging, the expansion of forest plantations, the loss of forest glades and habitat ecotones between forests and grasslands due to succession, and intensive economic activity (Mills, 2008; Bobbink et al., 2010; Barlow et al., 2016). This group includes species such as *Hordelymus europaeus* (L.) Jess. ex Harz, *Festuca altissima* All., *Isopyrum thalictroides* L., *Cardamine bulbifera* (L.) Crantz, *Cypripedium calceolus* L., *Cephalanthera*

*longifolia* (L.) Fritsch, *Cephalanthera rubra* (L.) Rich. (Hédli, 2004; Gudžinskas et al., 2016; Neblea et al., 2020; Rašomavičius, 2021).

*Cephalanthera longifolia* and *Cephalanthera rubra* are recognised as species of least concern (LC) in Europe because they are widespread and abundant in some regions. However, *Cephalanthera longifolia* is reported to be declining in many locations, while *Cephalanthera rubra* is becoming very rare and threatened at the edge of its range (Harrap & Harrap, 2005; Randou, 2011a, b). In Lithuania, both species have been protected since 1962 and considered endangered because only a few localities with small populations were recorded (Lekavičius, 1992; Gudžinskas, 2001; Gudžinskas & Ryla, 2006; Ryla, 2007; Patalauskaitė, 2021; Žalneravičius, 2021). However, despite their rarity and recognised need for protection, these species have been studied inconsistently in Lithuania. Most available data have been collected through local flora and vegetation surveys, resulting in scattered and incomplete information. To date, only six populations of *Cephalanthera longifolia* have been comprehensively studied, focusing on habitat conditions, population size, demographic structure and a few morphological traits (Ryla & Čiuplys, 2005). Since 2021, more systematic studies have been initiated, investigating reproductive traits and the natural fruit set of *Cephalanthera longifolia* and *Cephalanthera rubra* (Taura & Gudžinskas, 2024).

Accurate assessment of conservation strategy and management actions for threatened plant species requires comprehensive quantitative information on population status and trends. Unfortunately, detailed data are often lacking for many species, as much of the information on rare and threatened species, especially their distribution, is gathered through casual observation or by amateurs rather than through targeted studies. Nevertheless, even fragmented or incomplete information is essential. It cannot be ignored, but must be analysed, systematised, correctly interpreted and used to assess the status of threatened species (Maes et al., 2015; Feldman et al., 2021). Much of the information on protected plant species in Lithuania, including *Cephalanthera longifolia* and *Cephalanthera rubra*, is also highly fragmented. Therefore, the aim of this study was to analyse, evaluate and summarise all information on species of the genus *Cephalanthera* in Lithuania. The follow-

ing questions were posed and investigated during the study: (a) How has the knowledge about the distribution of *Cephalanthera* species in the country accumulated during different historical periods? (b) What is known about the size and changes in the populations of *Cephalanthera* species? (c) What is the current conservation status of *Cephalanthera* species, and what is the need for protection? (d) What factors contributed to the formation of the two recently discovered populations of *Cephalanthera longifolia*?

## MATERIALS AND METHODS

All known literature sources, published from the end of the 18th century to the present, mentioning species of the genus *Cephalanthera* in the present and historical territory of Lithuania were analysed to provide a comprehensive overview of the distribution of the species, revealing the history of their study and assessing their population dynamics. All references to *Cephalanthera longifolia* and *Cephalanthera rubra* records published in the literature were compared with the information in the original sources. By cross-checking information, we were able to identify and correct inaccuracies and errors in the interpretation of data provided by later authors.

*Cephalanthera* specimens in the collections of the Herbarium of Vilnius University (WI) and the Herbarium of the Institute of Botany of the Nature Research Centre (BILAS) were analysed. More than 40 herbarium specimens were examined, 30 of which were *Cephalanthera longifolia* and *Cephalanthera rubra* specimens collected in the present territory of Lithuania. The complete list of examined herbarium specimens is in the appendix (Appendix I). The information on the herbarium labels in Lithuanian and Polish was translated into English. In some cases, their modern versions are also given in addition to the historical geographical names. Spelling errors in the text of the labels have been corrected without additional remarks.

Revised distribution maps of *Cephalanthera longifolia* and *Cephalanthera rubra* were created using a geographic grid system. Each grid cell covers 6' latitude and 10' longitude. All records of a species within the same grid cell were marked with a single symbol. We divided all localities into five groups: (1) localities that we have verified and eval-

uated (indicated by a black dot), (2) localities that have been reported in the literature or herbaria but not recorded by us (indicated by a black circle with a white fill), (3) records that were marked inaccurately on maps published in the literature due to errors in interpretation of the information (indicated by a red circle), (4) localities that are extinct (indicated by a red cross), and (5) doubtful records (indicated by a red question mark). Doubtful localities were those where we checked the information in the reference sources, but no *Cephalanthera* species were found or those where no suitable habitats for their growth were found. In grid cells with records of two or more localities belonging to different groups, the locality with the highest confidence level among the records was mapped.

Data on the area occupied by populations of *Cephalanthera longifolia* and *Cephalanthera rubra* and the abundance of individuals within them, unless otherwise stated in the text, were collected during field surveys carried out between 2021 and 2024. The area covered by each population was determined by defining the range of individuals based on geographical coordinates. Polygons were then drawn based on the collected data, and the area of the polygons was calculated using the tools of the Spatial Information Portal of Lithuania (geoportal.lt). The development history of the newly established populations of *Cephalanthera longifolia* was analysed based on orthophotos provided on the same portal (geoportal.lt). Information on the location of some *Cephalanthera longifolia* populations was obtained from the Protected Species Information System of Lithuania (sris.biip.lt). The conservation regime of localities was determined according to the information provided by the State Cadastre of Protected Areas of Lithuania (stvk.lt).

*Cephalanthera longifolia* and *Cephalanthera rubra* have branched underground rhizomes, making it difficult to determine the exact boundaries of an individual (Harrap & Harrap, 2005; Gudžinskas & Ryla, 2006). These plants are reported to produce usually one, less often two or more shoots (Püttsepp & Kull, 1997). Since the exact boundaries of an individual can only be determined by destroying the plant (by digging it up) or damaging it (by exposing the entire rhizome), we considered a single above-ground shoot to be an individual (the counting unit) for the

survey. Shoots with a developed inflorescence containing at least one flower were counted as flowering (generative) shoots.

## HISTORICAL DISTRIBUTION OVERVIEW

In the late 1700s, Jundziłł (1791) was the first to mention species of the genus *Cephalanthera* in Lithuania, describing *Cephalanthera rubra* (as *Serapias rubra* L.) and *Cephalanthera damasonium* (Mill.) Druce (as *Serapias lancifolia* Murray). He indicated that *Cephalanthera rubra* occurs in Polesie, but did not provide details on *Cephalanthera damasonium* distribution. The first substantial information on plants of this genus in the present territory of Lithuania was published in the first half of the 19th century (Jundziłł, 1811; Gorski, 1830), and some records were confirmed by herbarium specimens (WI; Appendix I). It should be added that Jundziłł (1830) listed three species of the genus *Cephalanthera*, but did not mention specific localities for any of them, giving only general information on habitats.

### *Cephalanthera longifolia*

Jundziłł (1811) reported that *Cephalanthera longifolia* (*Serapias longifolia* (L.) Huds.) was recorded near the village of Boltup (now about 5 km southeast of Ashmyany, Grodno region, Belarus), but this reference was misinterpreted by later authors and considered to be in the vicinity of Kalvarijos (Baltupis stream) near Vilnius (Snarskis, 1954, 1963). Gorski (1830) stated that *Cephalanthera longifolia* (as *Cephalanthera ensifolia* (Ehrh.) Rich.) was rare near Vilnius [selten um Wilna]. Probably, his report was based on a herbarium specimen collected in Ribišškės in the former surroundings of Vilnius in 1824 ([In pratis fruticoso loco dicta Hrybiszki prope Vilnam, rarissima]; Appendix I). Zelencov (1890), in his inventory of the flora of the Vilnius governorate, referred to the above-mentioned localities of *Cephalanthera longifolia* (Jundziłł, 1811; Gorski, 1830) and explicitly stated that he had seen a herbarium specimen from Ribškės. Thus, in the 19th century only one locality of *Cephalanthera longifolia* was found in present-day Lithuania near Vilnius.

For more than 100 years, there has been no information about *Cephalanthera longifolia* populations in the present territory of Lithuania. This species was re-discovered by Szakien near Paneriai (Vilnius) in 1930

(Appendix I), and this area still supports one of the largest populations of the species in Lithuania. Later, several more herbarium specimens of *Cephalanthera longifolia* were collected in the forests of Paneriai by Mowszowicz (Mowszowicz, 1938; Appendix I).

Snarskis (1954, 1963) referred to the localities of *Cephalanthera longifolia* already published in the literature (Gorski, 1830; Zelencov, 1890; Mowszowicz, 1938), but added the locality of Kalvarijos (Vilnius). We assume that this locality is based on a misinterpretation of the record in Boltupe (today Belarus) and not on the Baltupis creek (also known as Cedronas, a stream flowing through Kalvarijos and the present Baltupiai district of Vilnius). In addition, the information on the locality of *Cephalanthera longifolia*, discovered in 1959 in the Vanaginė Forest (now the northern part of the city of Vilnius), was not included in the publication because, at that time, the specimen confirming the record was deposited in the herbarium of the Forestry College and only later transferred to BILAS.

For a long time, there was no new information on the distribution and population status of *Cephalanthera longifolia* in Lithuania, and only in 1984 a new locality of this species was recorded near Aukštadvaris (Trakai distr.), near the village of Tabaliukai (Lazdauskaitė et al., 1986; Lazdauskaitė & Rašomavičius, 1994). In the same year, a small population of this species was discovered 6 km south of Sudervė, near the village of Vaivadiškės (Vilnius distr.). Still, the status of this population is unknown, as the search for this species has been unsuccessful.

In 1986, *Cephalanthera longifolia* was again found in the vicinity of Paneriai in Vilnius (Rinkevičius, 1995). Later, since the 1990s, at least seven localities of various sizes of *Cephalanthera longifolia* have been registered in Paneriai and adjacent forests (Balevičius, 1993; Rinkevičius, 1995; Gudžinskas & Ryla, 2006). All localities of *Cephalanthera longifolia* in Paneriai and adjacent forests, which are somewhat separated from each other, can be considered as parts of a large population discovered in 1930, which increased over time and occupied new areas.

The second largest part of the *Cephalanthera longifolia* population in the country is recorded in the south-eastern part of Lithuania, in Dieveniškės Regional Park and its surroundings (Šalčininkai distr.), bordering Belarus (Fig. 1). The species was first re-

corded in this part of Lithuania in 1989, in the Šilinė Botanical Reserve. Later, in the 2000s–2010s, four localities of *Cephalanthera longifolia* were discovered in Klevyčia, Stakai and Šilinė Forests and near the village of Vėjeliai, as well as four more localities in Dieveniškės Regional Park, around the village of Stakai: near the settlements of Stakų Ūta, Mikališkės, Katkuškės and Stalgionys.

Since 2010, information on two new localities of *Cephalanthera longifolia* in Šalčininkai district has become available. A small population of the species was found in the Dimitrai Forest near Eišiškės. In contrast, only five individuals of the species were found in the Kamičiai Forest near the village of Dainava. A relatively large population of *Cephalanthera longifolia* was recorded in the Kamorūnai For-

est, between the villages of Kamorūnai and Vydeniai (Varėna distr.). A new locality has recently been reported in Žemasis Pavilnys (Vilnius). Still, we could not study this population as the exact location of the record was not specified, and we could not find it during our search. Interestingly, this locality is relatively close to Ribiškės (Vilnius), where *Cephalanthera longifolia* was found in 1824.

Four other localities of *Cephalanthera longifolia*, mentioned in various sources, i.e. 1.5 km east of Aleksandriškės (Trakai distr.), 2 km northeast of Paberžė, near the settlement of Kudarai (Vilnius distr.), 2 km north of Bartkuškis, near the settlement of Skėteriai (Širvintos distr.), and north of Veisiejai (Lazdijai distr.) are considered doubtful and require further field surveys. None of these localities has been

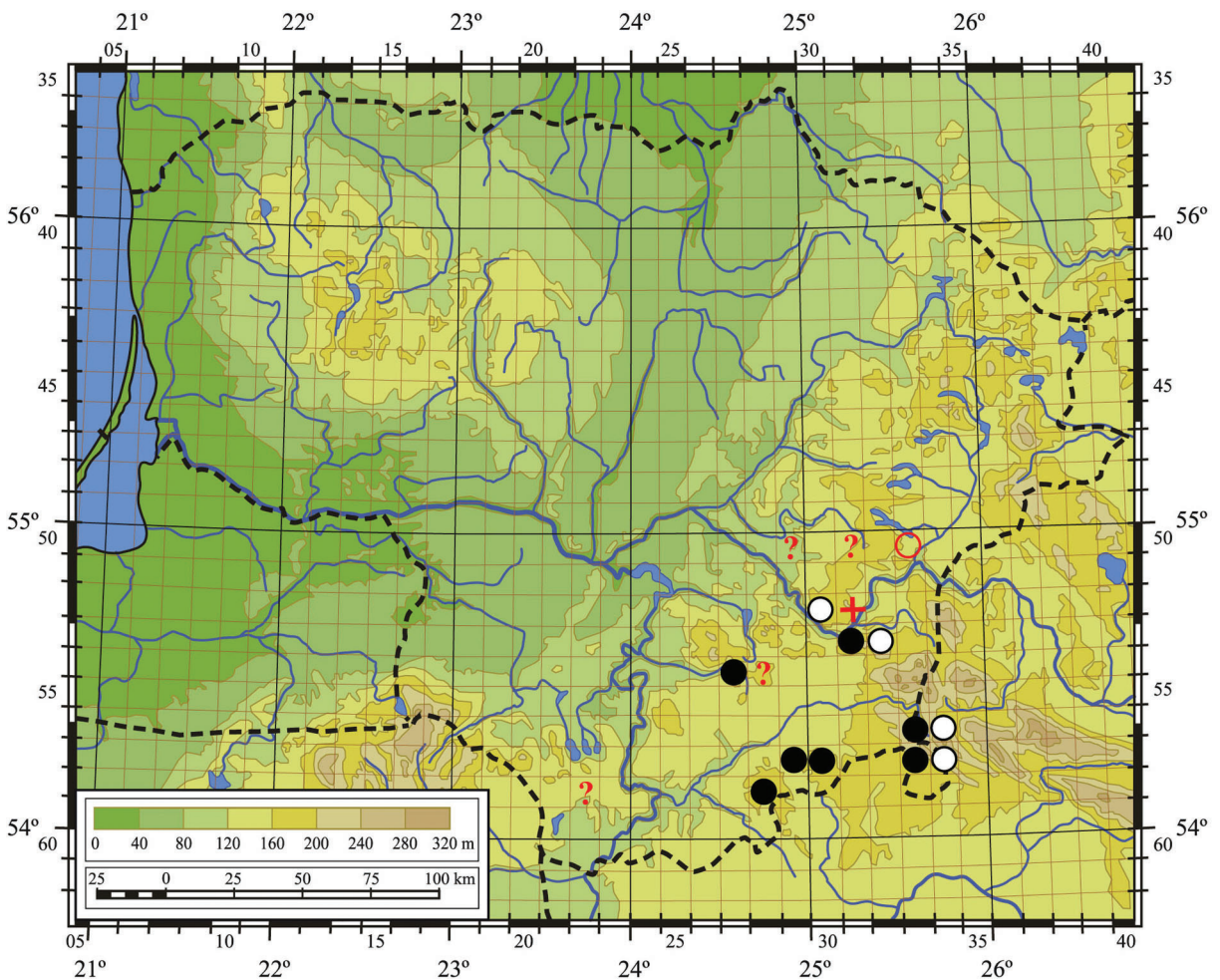


Fig. 1. Revised distribution of *Cephalanthera longifolia* in Lithuania. Black dots indicate populations that are currently confirmed and whose status is continuously monitored and assessed, white dots indicate populations where the current status of the species is unknown, red circles indicate areas where the species has been mapped due to misinterpretation of information, red question marks indicate doubtful localities, and a red cross indicates an extinct population.

confirmed by herbarium specimens or other reliable documentation. It is likely that some of these populations are very small and have not yet been rediscovered. However, some of the references are erroneous, as in the Information System of Protected Species (SRIS database), localities of *Cephalanthera longifolia* have been marked on roads or in gardens, and the records do not contain any additional information.

Summarising all available distribution data, we can state that the number of localities of *Cephalanthera longifolia* in Lithuania is increasing. This species is present in at least seven grid cells (Fig. 1), and some populations are quite large. However, one historical and five recently discovered localities are considered doubtful. In one locality, *Cephalanthera longifolia* is probably extinct, as it has not been found there for more than 60 years.

### ***Cephalanthera rubra***

In the description of the flora of the Grand Duchy of Lithuania, published by Jundziłł (1791), *Cephalanthera rubra* (as *Serapias rubra*) was mentioned only from Polesie. Still, later, he (Jundziłł, 1811) indicated that this species had been recorded in the surroundings of Vilnius, near Ribiškės. Gorski (1830) did not mention the locality of *Cephalanthera rubra* near Vilnius and referred only to the other localities, which are now in the territory of Belarus. It remains unclear on what basis Gorski (1830) rejected Jundziłł's (1811) reference. No herbarium specimens are now available on which Jundziłł (1811) could have relied. There is one herbarium specimen (Prope Vilnam; Appendix I), which was collected much later, in 1828, and misidentified as *Serapias rubra* (in fact, *Epipactis palustris* (L.) Crantz). Zelencov (1890), in his inventory of the flora of the Vilnius governorate, mentioned records of *Cephalanthera rubra* in Antakalnis and Ribiškės (both in the former surroundings of Vilnius) and explicitly referred to Jundziłł (1811) when listing the Ribiškės locality. Thus, in the 19th century, only one confirmed locality of *Cephalanthera rubra* was found on the territory of present-day Lithuania in 1838, around Antakalnis (now in Vilnius; Appendix I), and the second reported locality of this species in Ribiškės is doubtful.

For more than 130 years (from 1828 to 1962), there was no new data on the distribution of *Cephalanthera rubra* in Lithuania. Snarskis (1954), re-

ferring to earlier publications (Jundziłł, 1811; Zelencov, 1890), mentioned a locality near Antakalnis and a doubtful locality in Ribiškės (Vilnius). Later, in the Flora of Lithuania, he (Snarskis, 1963) described a locality of *Cephalanthera rubra* discovered in 1962 at Lake Spindžius (Trakai distr.). This population still exists, although it is relatively small.

Several new populations of *Cephalanthera rubra* were recorded during floristic surveys of protected areas in the 1970s and 1980s. It was found in the former Punia Forest Botanical-Zoological Reserve (Alytus distr.), the Balsys Landscape Reserve (Lazdijai distr.) and the Čepkeliai Strict Nature Reserve (Varėna distr.) (Jankevičienė & Lazdauskaitė, 1976; Jankevičienė, 1980; Lekavičius & Lapelė, 1984). It should be noted that the record of *Cephalanthera rubra* in the Čepkeliai Strict Nature Reserve was interpreted differently in some references (Lekavičius, 1992; Gudžinskas & Ryla, 2006; Ryla, 2007) and was mapped as two or even three localities (Fig. 2).

Two different records of *Cephalanthera rubra* have been reported in the former Lazdijai district (now Druskininkai distr.) near the villages of Raudonikiai (Lazdauskaitė et al., 1986) and Zasciūniškė (Lekavičius, 1992), but these records have not been confirmed by herbarium specimens. However, a herbarium specimen of *Cephalanthera rubra* was collected in 1980 near the village of Stračiūnai (Appendix I), which is halfway between the two villages listed above. Therefore, we assume that the localities near the villages of Raudonikiai and Zasciūniškė mentioned in the references (Lazdauskaitė et al., 1986; Lekavičius, 1992) are based on the same herbarium specimen from the surroundings of Stračiūnai, but different villages were indicated for the generalisation of the data. The species has not been subsequently recorded in this area, and no data on the population's status is available.

The first localities of *Cephalanthera rubra* on the slopes of the Skroblus River valley were recorded in 1979 and 1980. Later, several more groups of individuals were found between the villages of Kapiniškiai, Rudnia and Aukštagiris in Dzūkija National Park (Varėna distr.) (Jankevičienė, 1980; Gudavičius, 1994; Gudžinskas & Ryla, 2006). All these localities can be considered fragments of a single population, as they are separated by 1–3 km (Appendix I). A very large population of *Cephalanthera rubra* was

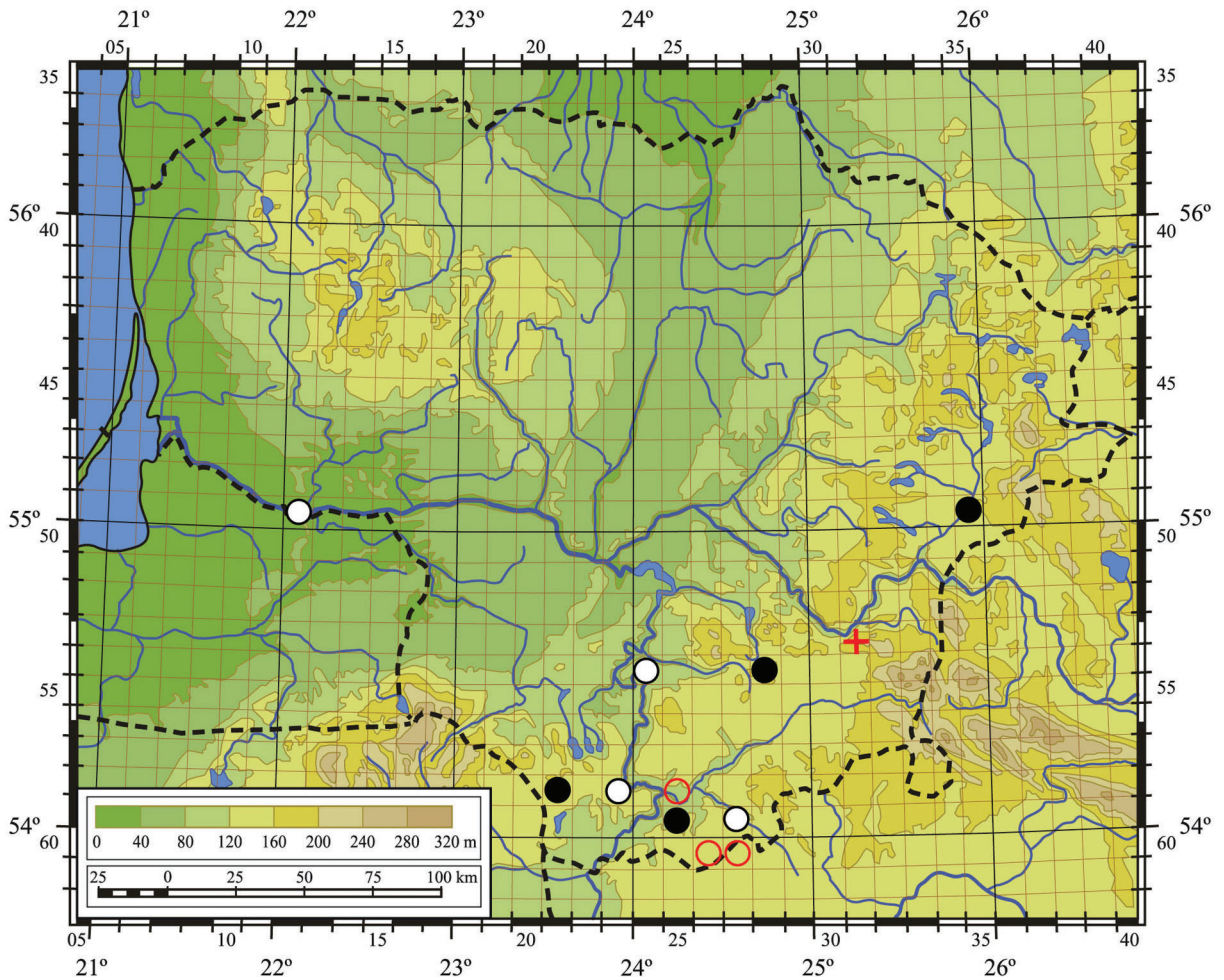


Fig. 2. Revised distribution of *Cephalanthera rubra* in Lithuania. Black dots indicate populations that are currently confirmed and whose status is continuously monitored and assessed, white dots indicate populations where the current status of the species is unknown, red circles indicate areas where the species has been mapped due to misinterpretation of information, and a red cross indicates an extinct population.

found in 1993 north of Pabradė (Švenčionys distr.), near Lake Molinė (Lazdauskaitė & Patalauskaitė, 1994). In the 21st century, only one new locality of *Cephalanthera rubra* was reported from Rambynas Regional Park (Pagėgiai distr.) in the western part of Lithuania (Smaliukas et al., 2008), but it has not been rediscovered subsequently.

Generalising all available information on *Cephalanthera rubra* in Lithuania, it can be concluded that this species is probably extinct in one locality (Antakalnis, Vilnius), as it has not been recorded there for almost 200 years. The record of this species in Ribiškės (Vilnius) is doubtful. Three localities on the maps published in the literature are inaccurately marked due to different interpretations of the avail-

able information (Fig. 2). There is no current information on the status of the populations in the Punia Forest (Alytus distr.), the Čepkeliai Strict Nature Reserve (Varėna distr.), Rambynas Regional Park (Pagėgiai distr.) and in the surroundings of Stračiūnai (Druskininkai distr.). Currently, there are four populations of *Cephalanthera rubra* in Lithuania, whose status and size are regularly assessed (Fig. 2).

#### POPULATION SIZE AND DYNAMICS

Information on the size and abundance of *Cephalanthera longifolia* and *Cephalanthera rubra* individuals was not available on the labels of herbarium specimens collected in the 19th and first half

of the 20th century. This information was also missing in literature reports from that period. Population information was also incomplete and inconsistent on the labels of herbarium specimens of both species collected between the 1960s and 1980s and in the literature. Later, in the 1990s, researchers began to assess plant populations in a more systematic and detailed way. As a result, herbarium labels (Appendix I) and publications provide more data on habitats, abundance of individuals and sometimes the area covered by populations.

### *Cephalanthera longifolia*

The label of the first herbarium specimen of *Cephalanthera longifolia*, collected in 1824 on the territory of present-day Lithuania, stated that it was very rare near Ribiškės (Vilnius), but did not indicate the exact abundance. The species has not subsequently been found in the area. Although the area has undergone significant changes due to urban development, suitable habitats for *Cephalanthera longifolia* still exist in this area of highly complex relief.

The oldest surviving population, discovered in 1930, is located in a hilly area around Paneriai (Vilnius). The number of individuals was not reported at the time of discovery (Mowszowicz, 1938; Appendix I), and no information was available for a long time. In 1992, the site was rediscovered, but the population size or number of individuals was not indicated on the labels of the herbarium specimens (Appendix I). In 2000, when a group of *Cephalanthera longifolia* was found in the forest near Zuikiai Street, 13 flowering individuals were counted (Appendix I). In 2024, we revisited this site and recorded more than 60 flowering individuals growing in approximately 0.05 ha.

Ryla & Čiuplys (2005) studied three subpopulations of *Cephalanthera longifolia* with significantly different densities of individuals in Paneriai in 2004. However, the authors did not provide precise data on plant density. In the smallest subpopulation, 11 individuals were counted, distributed over an area of about 0.02 ha. In the other two subpopulations, they estimated that there could have been between 30,000 and 60,000 *Cephalanthera longifolia* individuals. As the counts were made on two small (50 m<sup>2</sup> and 100 m<sup>2</sup>) sampling plots and the results were then extrapolated to the whole area, it can be assumed that the number

of individuals was overestimated. Nevertheless, it cannot be denied that the population covered a large area (6.5 ha) at the time of the survey and that the density of individuals was high. As the coordinates of both subpopulations were given with typographical errors in the publication (Ryla & Čiuplys, 2005), it was impossible to accurately assess the changes that had occurred over almost two decades. This was probably why Patalauskaite (2021), who estimated the population using the coordinates given by Ryla & Čiuplys (2005), indicated that only a few individuals of the formerly extremely abundant population remained. We estimated that *Cephalanthera longifolia* now occurs on 3.21 ha in the Paneriai Forest, 6.60 ha in the Raisteliai Forest and 7.55 ha in Aukštieji Paneriai (the Baltoji Vokė Forest; Table 1). However, the density of individuals in the Aukštieji Paneriai Forest was low: 136 individuals were counted in the whole area in 2023, of which only slightly more than 50 were flowering. According to our most recent expert assessment (made in 2023), the Paneriai Forest may contain up to 5,000 individuals, while the Raisteliai Forest may contain around 15,000 individuals. *Cephalanthera longifolia* usually grows solitarily in the surveyed localities of this area, but sometimes forms clusters of several shoots (Fig. 3).

Two small localities of *Cephalanthera longifolia* have been found near the Raisteliai Forest: at the edge of the forest near Eišiškės Str. and in a deciduous stand near Salininkai Str. (Vilnius). In 1994, about 200 individuals were recorded at Salininkai Str. (Appendix I). In 2024, about 120 flowering and at least 60 non-flowering individuals were counted in 0.20 ha plot. Thus, the number of individuals remained almost unchanged after 30 years. At Eišiškės Str., only five flowering individuals were found in an area of 0.01 ha in 2024.

When a population of *Cephalanthera longifolia* was found near the village of Tabaliukai (Trakai distr.) in 1984, a total of 106 flowering individuals were found (Lekavičius, 1992; Appendix I). The number of individuals recorded in this population varied considerably during subsequent surveys. Lazdauskaitė & Rašomavičius (1994) reported that only over a dozen individuals were found in this area during the 1990–1992 surveys, and only a few were flowering. In 1994 and 2005, despite targeted searches, no plant was found in the area, and the population was con-



Table 1. List of confirmed *Cephalanthera longifolia* populations in Lithuania with their location, area and conservation regime. The grid cell number corresponds to the symbol on the map (Fig. 1). An asterisk (\*) next to the area indicates data from the 2004–2005 survey (Ryla & Čiuplys, 2005)

| Locality           | Administrative unit | Grid cell | Area (ha)    | Conservation regime  |
|--------------------|---------------------|-----------|--------------|--|
| Paneriai           | Vilnius city        | 5132      | 3.21         | Vokė Geomorphological Reserve                                  |
| Zuikiai Str.       | Vilnius city        | 5132      | 0.05         | Paneriai Erosive Ridge Landscape Reserve                       |
| Raisteliai         | Vilnius city        | 5132      | 6.60         | Unprotected  |
| Aukštieji Paneriai | Vilnius city        | 5132      | 7.55         | Vokė Geomorphological Reserve                                  |
| Salininkai Str.    | Vilnius city        | 5132      | 0.20         | Unprotected  |
| Eišiškės Str.      | Vilnius city        | 5132      | 0.01         | Unprotected  |
| Vaivadiškės        | Vilnius distr.      | 5230      | Unknown      | Medžiakalnis Geomorphological Reserve                          |
| Žemasis Pavilnys   | Vilnius city        | 5332      | Unknown      | Pavilniai Regional Park, Tuputiškiai Geomorphological Reserve  |
| Tabaliukai         | Trakai distr.       | 5427      | 0.56         | Aukštadvaris Regional Park, Tabaliukai Hydrographical Reserve  |
| Stakų Ūta          | Šalčininkai distr.  | 5633      | 1.79         | Dieveniškės Historical Regional Park, Stakai Landscape Reserve |
| Klevyčia           | Šalčininkai distr.  | 5634      | 0.33*        | Unprotected  |
| Kamičiai           | Šalčininkai distr.  | 5729      | 0.01         | Unprotected  |
| Dimitrai           | Šalčininkai distr.  | 5730      | 0.03         | Unprotected  |
| Mikaliskės         | Šalčininkai distr.  | 5733      | 0.77         | Dieveniškės Historical Regional Park, Stakai Landscape Reserve |
| Katkuškės          | Šalčininkai distr.  | 5733      | 0.85         | Dieveniškės Historical Regional Park, Stakai Landscape Reserve |
| Stalgonys          | Šalčininkai distr.  | 5733      | Unknown      | Dieveniškės Historical Regional Park                           |
| Šilinė             | Šalčininkai distr.  | 5734      | 0.18*        | Šilinė Botanical Reserve                                       |
| Vėjeliai           | Šalčininkai distr.  | 5734      | Unknown      | Unprotected  |
| Kamorūnai          | Varėna distr.       | 5828      | 0.84         | Unprotected  |
| <b>Total</b>       |                     |           | <b>22.98</b> |  |

sidered extinct (Ryla & Čiuplys, 2005; Gudžinskas & Ryla, 2006; Ryla, 2007; Patalauskaitė, 2021). In 2022, we re-surveyed the area and found three groups of *Cephalanthera longifolia*, with distances between the groups ranging from 300 m to 800 m. The plants were scattered or grew in small groups and did not form distinct clusters. In all three parts of the population, about 100 individuals flowered that year, with the smallest group near the shore of Lake Tabaliukai containing 12 flowering individuals. This suggests that the absence of individuals for several years does not mean the plants are extinct. Even if some of the population has disappeared, there is still a chance that plants will survive elsewhere or recover from seed under favourable conditions.

At least seven localities of *Cephalanthera longifolia* are now known from the south-eastern edge of Lithuania, in the vicinity of Dieveniškės (Šalčininkai distr.). All these localities, scattered over an area of about 72 km<sup>2</sup>, can be considered subpopulations of a single large population. When this species was

first recorded in the Šilinė Forest in 1989, the exact number of individuals and area were not specified. A detailed assessment of *Cephalanthera longifolia* in the Šilinė and Klevyčia Forests was made in 2004 (Ryla & Čiuplys, 2005). At that time, 93 individuals were found in the Šilinė Forest, distributed over an area of 0.18 ha, and 169 individuals were recorded in the Klevyčia Forest, distributed over an area of 0.33 ha. Later, small groups of *Cephalanthera longifolia* were found in the Vėjeliai Forest and the part of the Šilinė Forest outside the Šilinė Botanical Reserve. The current status of *Cephalanthera longifolia* in these localities is unknown. As the above-mentioned localities are in the protection zone of the state border between Lithuania and Belarus, it was impossible to enter this zone during the survey period due to the tightened security regime caused by the ongoing geopolitical processes.

In Dieveniškės Historical Regional Park (Šalčininkai distr.), four populations of *Cephalanthera longifolia* have now been identified, three of



Fig. 3. Cluster of flowering *Cephalanthera longifolia* in sparse stand, the Paneriai Forest (Vilnius), 3 June 2021. Photograph by Z. Gudžinskas.

which cover a relatively large area (Table 1) and are abundant. A detailed analysis of the density of individuals and the composition of the populations at Stakų Ūta and Katkuškės will be reported separately. More than 300 individuals were recorded at each site in 2023, distributed relatively evenly across the habitat. At Mikališkės, 45 flowering individuals were found in 2021, while in 2022, there were about 140 such individuals. Unfortunately, during a storm that year, many trees were felled, covering a large part of the densest part of *Cephalanthera longifolia* stand,

and the number of flowering individuals dropped to about 60 in 2023. It is possible that the fallen trees affected the flowering of *Cephalanthera longifolia*, but natural fluctuation cannot be excluded. Therefore, long-term monitoring in permanent study plots is needed to determine the exact causes of the dynamics of the number of flowering individuals in different years.

Three small populations of *Cephalanthera longifolia* have been found in the southern part of Lithuania, Varėna and Šalčininkai districts during the last

decade (Table 1). The populations near the villages of Dimitrai and Kamičiai (Šalčininkai distr.) cover only 100–300 m<sup>2</sup> and contain 5 to 20 individuals. A much larger population was found near the village of Kamorūnai (Varėna district). In 2024, about 180 individuals were counted, distributed almost evenly over an area of 0.84 ha.

The data analysis showed that the number of *Cephalanthera longifolia* localities in Lithuania is increasing, and now all assessed populations cover 22.98 ha. According to expert estimates, the country's total population of *Cephalanthera longifolia* may be up to 30,000 individuals. The increase in the number of localities cannot only be explained by the lack of research in the past, but we believe that some of the localities recorded are newly established. The reasons for the presumed spread of *Cephalanthera longifolia* need to be clarified by specific studies in the future.

### ***Cephalanthera rubra***

When *Cephalanthera rubra* was first found in 1962 in the forest near Lake Spindžius (Trakai distr.), no data were published on its abundance and the area occupied by the population (Snarskis, 1963). The label of the herbarium specimen collected in 1978 indicated that *Cephalanthera rubra* was quite common at the site. Still, surveys from 1990 to 1992 showed that the population consisted of only a dozen individuals and that only the plants at the forest's edge were flowering (Lazdauskaitė & Rašomavičius, 1994). Almost a decade later, in 2000, the survey results showed no flowering plants in the population, and only 20 non-flowering individuals were recorded (Gudžinskas & Ryla, 2006). According to the survey results in 2021, the population of *Cephalanthera rubra* occupied an area of 0.22 ha. In that year, 38 flowering and 21 non-flowering individuals were found. The following year, 2022, seven flowering and 28 non-flowering individuals were found, while in 2023, only four flowering and 25 non-flowering individuals were registered (Taura & Gudžinskas, 2024). Changing habitat conditions significantly reduced sunlight due to increased shrub cover may have a negative impact on the abundance of individuals. High visitor numbers may also have an effect, as the habitat is adjacent to a nature trail.

A few individuals of *Cephalanthera rubra* were

found in 1970 in the then Punios Šilas Botanical-Zoological Reserve (Alytus distr.), but neither the exact number nor the area of the population was given. It was mentioned that the plants grew on a dry, flat slope (Jankevičienė & Lazdauskaitė, 1976). *Cephalanthera rubra* has not been found in this area since, and its population status is unknown. It may be already extinct, but it cannot be excluded that there are still solitary non-flowering plants, which are very difficult to find even with targeted searches. However, this area is difficult to reach and is rarely visited by researchers. There is also no information on the size of the population found in the Čepkeliai Strict Nature Reserve (Lekavičius & Lapelė, 1984), and its status is unknown. The population of *Cephalanthera rubra* near the village of Stračiūnai (Druskininkai distr.) has not been rediscovered, and there is no information on its size in the literature (Lazdauskaitė et al., 1986; Lekavičius, 1992) or on the label of the herbarium specimen (Appendix I).

In the former Balsys Landscape Reserve, now part of Veisiejai Regional Park (Lazdijai distr.), the abundance of the population between Liūnelis and Šlavantėlis Lakes also varied considerably during the surveying period. When the species was first recorded in this area in 1975, the abundance was not indicated on the herbarium label or in the information published in the literature about the find (Jankevičienė, 1980). In 1993, 65 plants were counted in the whole area (Balevičienė et al., 1996), but it seems that only flowering individuals were counted. More than two decades later, in 2015, a total of 46 individuals were recorded in a part of the study population (10 m<sup>2</sup>), with an average density of  $4.60 \pm 2.91$  individuals/m<sup>2</sup> (Gudžinskas et al., 2016). The habitat of the population of *Cephalanthera rubra* in the Liūnelis Strict Nature Reserve covers 1.25 ha (Table 2). Still, individuals are unevenly distributed throughout the area, forming three dense patches, with only isolated individuals occurring between them. In 2016 and 2017, management measures (removal of shrubs and some trees) were implemented in this reserve to improve the habitat for *Cypripedium calceolus* and other protected species, resulting in a significant increase in the population of *Cephalanthera rubra*. During the natural fruit set study of *Cephalanthera rubra*, more than 60 flowering individuals were found in 2021. Unfortunately, six years after implementing habitat

Table 2. List of confirmed *Cephalanthera rubra* populations in Lithuania with their location, area and conservation regime. The grid cell number corresponds to the symbol on the map (Fig. 2)

| Locality         | Administrative unit | Grid cell | Area (ha)   | Conservation regime                                     |
|------------------|---------------------|-----------|-------------|---|
| Rambynas         | Pagėgiai distr.     | 4912      | Unknown     | Rambynas Regional Park                                  |
| Molinė           | Švenčionys distr.   | 4935      | 0.39        | Unprotected   |
| Punia Forest     | Alytus distr.       | 5424      | Unknown     | Nemuno Kilpos Regional Park                             |
| Spindžius        | Trakai distr.       | 5428      | 0.22        | Aukštadvaris Regional Park, Spindžius Landscape Reserve |
| Liūnelis         | Lazdijai distr.     | 5821      | 1.25        | Veisiejai Regional Park, Liūnelis Strict Nature Reserve |
| Stračiūnai       | Druskininkai distr. | 5823      | Unknown     | Unprotected   |
| Kapiniškiai      | Varėna distr.       | 5925      | 0.15        | Dzūkija National Park, Kapiniškiai Landscape Reserve    |
| Rudnia           | Varėna distr.       | 5925      | 0.03        | Dzūkija National Park, Skroblus Strict Nature Reserve   |
| Aukštagiris      | Varėna distr.       | 5925      | 0.05        | Dzūkija National Park, Skroblus Strict Nature Reserve   |
| Darželiai forest | Varėna distr.       | 5925      | 0.01        | Dzūkija National Park, Skroblus Strict Nature Reserve   |
| Čepkeliai        | Varėna distr.       | 5927      | Unknown     | Čepkeliai Strict Nature Reserve                         |
| <b>Total</b>     |                     |           | <b>2.10</b> |   |

management measures, shrub cover had increased significantly, and the number of flowering plants began to decline sharply. In the same study area, only 28 flowering plants were recorded in 2022, which decreased to 17 in 2023 (Taura & Gudžinskas, 2024). The number of non-flowering individuals in the whole population area was not assessed.

The population of *Cephalanthera rubra* at Lake Molinė (Švenčionys distr.) consisted of more than 1000 flowering individuals when it was discovered in 1993, and it was the largest population of this species in Lithuania at that time (Lazdauskaitė & Patalauskaitė, 1994). Unfortunately, almost three decades later, in 2021, repeated surveys of the entire area revealed only three small flowering plants with a mere 3–4 flowers each and 36 non-flowering individuals. The habitat has undergone significant changes in the last three decades: the once sparse birch stand has been overgrown with a dense shrub understory dominated by low spruce. This change has resulted in a significant reduction in the amount of sunlight reaching the herb layer. Isolated individuals are thought to survive in other parts of the habitat (0.39 ha), but they are challenging to detect. In the event of a change in environmental conditions (e.g. after thinning the shrub layer), the population has the potential to recover or at least increase in numbers.

In Rambynas Regional Park (Pagėgiai distr.), only five flowering individuals were found (Smaliukas et al., 2008). As the exact location of the population was not determined at the time of the first discovery, it was not rediscovered later, and its current status is unknown.

The largest known population of *Cephalanthera rubra* is in Dzūkija National Park, between the villages of Kapiniškiai and Rudnia (Varėna distr.). The entire population, consisting of at least four groups with higher densities and scattered isolated individuals, extends along the slopes of the Skroblus stream valley in a narrow strip at least 5 km long covering about 6 ha. However, the total area occupied by patches of *Cephalanthera rubra* in this large area is only about 0.24 ha (Table 2). Most groups of *Cephalanthera rubra* individuals were small, with 8–11 flowering plants recorded in different survey years, sometimes up to 60 plants (Gudavičius, 1994; Appendix I). The largest and most viable part of the population is in the village of Kapiniškiai (Gudžinskas & Ryla, 2006; Ryla, 2007). *Cephalanthera rubra* grows on dry slopes, dry grasslands and the edge of the forest (Fig. 4). In 2000, about 100 flowering individuals were found throughout the site (Gudžinskas & Ryla, 2006). During the natural fruit set studies from 2021 to 2023, significant fluctuations in the number of flowering individuals were observed in the village of Kapiniškiai (Taura & Gudžinskas, 2024). In 2021, about 130 flowering plants were counted; in 2022, about 60 flowering individuals were present, and in 2023, the number decreased further and only 46 flowering plants were recorded. However, in 2023, some individuals that had produced inflorescences wilted before flowering due to a particularly severe drought in spring and the first half of summer.

Considering all available information on *Cephalanthera rubra* populations in Lithuania, the cur-



Fig. 4. Dense group of flowering *Cephalanthera rubra* at the edge of the forest in Kapiniškiai village (Varėna distr.), 26 June 2021. Photograph by Z. Gudžinskas.

rently assessed and at least occasionally observed habitats cover an area of 2.10 ha (Table 2). However, the number of flowering individuals in these habitats is variable. In favourable years up to 500 flowering plants were counted, whereas in unfavourable years up to 150 flowering plants were observed. Obviously, the status of the *Cephalanthera rubra* population needs to be continuously monitored, and, where possible, active conservation measures should be implemented.

## CONSERVATION

*Cephalanthera longifolia* and *Cephalanthera rubra* were included in the List of Protected Plant Species of Lithuania in 1962, and since then, both species have been protected in the country. In the first edition of the Lithuanian Red Data Book, both species were classified as very rare (Balevičienė & Balevičius, 1981). In two subsequent editions of the Red Data Book (Lekavičius, 1992; Ryla, 2007), both

species were listed as endangered, requiring special conservation measures. To further enhance protection, *Cephalanthera longifolia* was added to the List of Strictly Protected Species of Lithuania in 2010 (Patalauskaitė, 2015). Recently, the protected species have been assessed according to the IUCN (2012a, b) criteria, and both considered species classified as endangered: EN B1ab(ii,iv,v)+2ab(ii,iv,v)c(iv) for *Cephalanthera longifolia* and EN B2ab(ii,iv,v); C2b for *Cephalanthera rubra* (Patalauskaite, 2021; Žalneravičius, 2021). Based on the currently available information, the assessment of *Cephalanthera rubra* is entirely consistent with the current status of the population. In contrast, the assessment of *Cephalanthera longifolia* should be refined. Due to the discovery of several new localities in recent years, the increase in the area of occurrence and the area of occupancy, and the latest estimates of abundance for some populations, *Cephalanthera longifolia* meets the criteria for vulnerable (VU) species, but is not endangered.

The analysis of all currently known *Cephalanthera longifolia* localities showed that most are in non-protected areas (Table 2). Most of the localities around Paneriai (Vilnius) are in two protected areas: the Paneriai Erosive Ridge Landscape Reserve and the Vokė Geomorphological Reserve. In Aukštadvaris Regional Park, the locality near the village of Tabaliukai is in the Tabaliukai Hydrographic Reserve. In Dieveniškės Regional Park, most localities are in the Stakai Landscape Reserve, except for the Stalgony's locality, which is in the Ecological Protection Zone of the Regional Park. One part of the population that could not be assessed in the Šilinė Forest is protected in the Šilinė Botanical Reserve (Šalčininkai distr.), while the other sites (Klevyčia and Vėjeliai Forests, and a part of the Šilinė Forest) are in non-protected areas.

Most of the localities of *Cephalanthera rubra*, in contrast to *Cephalanthera longifolia*, are in protected areas. Only one existing population at Lake Molinė (Švenčionys distr.) is outside protected areas (Table 2). All localities in Dzūkija National Park are part of the Skroblus Strict Nature Reserve; only the locality in Kapiniškiai village is part of the Kapiniškiai Landscape Reserve. The locality in Veisiejai Regional Park is within the Liūnelis Strict Nature Reserve. The population in Aukštadvaris Regional Park is included in the Spindžius Landscape Reserve. In addition, three other populations, previously recorded but now of unknown state, are in protected areas (the Čepkeliai Strict Nature Reserve, Nemuno Kilpos Regional Park, Rambynas Regional Park). Therefore, if populations of *Cephalanthera rubra* were to be re-discovered in these areas, habitat management and protection could be organised immediately.

Judging by the formal protection regime of protected areas, *Cephalanthera rubra* populations, most of which are found in landscape reserves and strict nature reserves, are better protected in Lithuania than *Cephalanthera longifolia* populations. Most of these populations are in areas without formal protection status or in geomorphological and hydrographical reserves, where the conservation regime is focused on non-living natural objects.

Different researchers have suggested various reasons for the decline of *Cephalanthera longifolia* and *Cephalanthera rubra* in Lithuania. Balevičienė & Balevičius (1981) have pointed out that the causes

of the decline of these plants are unstudied and unknown. Later it was stated that habitat changes, especially the increase in density of trees and shrubs, and recreational activities were the main threats to the species (Lekavičius, 1992). Other researchers who have analysed the causes of the decline of both species have also highlighted the reduction of light availability in the habitat as one of the most important causes of population decline (Ryla & Čiuplys, 2005; Gudžinskas & Ryla, 2006; Ryla, 2007; Patalauskaitė, 2015, 2021; Žalneravičius, 2021). Damage to the aerial part of *Cephalanthera longifolia* and *Cephalanthera rubra* is also mentioned as a cause of their decline (Gudžinskas & Ryla, 2006; Ryla, 2007; Žalneravičius, 2021). Poor fruit set and consequent low seed production have only recently been considered a threat and possible cause of population decline, especially under unfavourable habitat conditions (Taura & Gudžinskas, 2024).

Analysis of changes in population abundance shows that the two species have slightly different ecological preferences and respond slightly differently to changes in habitat conditions. Observations of *Cephalanthera rubra* in the Liūnelis Strict Nature Reserve and the Spindžius Landscape Reserve have shown a significant decrease in the number of flowering individuals in a short period with a rapid increase in shrub cover and density (Taura & Gudžinskas, 2024). In *Cephalanthera longifolia* populations, a negative correlation was found between woody species cover, the proportion of young individuals in the population and the mean density of individuals (Ryla & Čiuplys, 2005). However, the response of *Cephalanthera longifolia* to light reduction is somewhat controversial. They can grow, flower and produce fruit, albeit much less, even in relatively shady spruce forest habitats. However, they also grow well in completely open areas at forest edges and grasslands. Furthermore, the formation of populations in abandoned cultivated fields, as observed in Raisteliai and Mikališkės, suggests that *Cephalanthera longifolia* spreads faster and occupies new habitats more easily than *Cephalanthera rubra*. This indicates that *Cephalanthera longifolia* has greater ecological plasticity than *Cephalanthera rubra*.

Observations showed that habitat management measures implemented to improve the status of populations of other Orchidaceae species in two Lithua-

nian protected areas also positively effected the status and abundance of *Cephalanthera rubra* individuals. Habitats of *Cypripedium calceolus* in the Spindžius Landscape Reserve and the Liūnelis Strict Nature Reserve were managed to restore their favourable conservation status. However, single habitat management does not ensure long-term improvement of habitat conditions and stability of populations of protected species. Appropriately selected management measures need to be implemented periodically, following an assessment of the status of the habitat and the rate and direction of changes that are detrimental to the species. The example of the Liūnelis Strict Nature Reserve shows that only six years after the implementation of management measures, the habitat had become unfavourable not only for the target species *Cypripedium calceolus*, but also for *Cephalanthera rubra* and other species found in the area.

We believe that artificial pollination of the flowers in small populations of *Cephalanthera longifolia* and *Cephalanthera rubra* can be used to increase the abundance of plants by increasing the number of fruits and seeds produced. In order to improve the chances of germination of the naturally produced seeds, it may be recommended to prepare patches of bare soil around the fruiting plants (mainly by removing plant debris). Careful inspection of the growing sites has shown that most new individuals appear in areas where the soil surface has recently been disturbed, such as along forest tracks and near technological clearings.

## TWO CASE STUDIES OF THE SPREAD OF *CEPHALANTHERA LONGIFOLIA*

When reviewing the information on *Cephalanthera longifolia* populations published in the literature and assessing them in the field, we found significant discrepancies between previously published and actual distribution areas and the size of localities. In the surroundings of Paneriai (Vilnius city), two large and dense groups of *Cephalanthera longifolia* have been reported in 80- and 60-year-old stands (Ryla & Čiuplys, 2005), while we found a large and dense population in a 30-year-old birch stand and an even younger pine plantation. Thus, we realised that this site was not recorded and studied in 2004 because this habitat might not have existed then. We exam-

ined the cartographic material (orthophotos) and found that a large part of the current *Cephalanthera longifolia* population in the surroundings of Paneriai is of recent origin. The area near the settlement of Raisteliai (Vilnius city) was still cultivated and used as a forest nursery in 1999 (Fig. 5). Soon after, between 2000 and 2004, according to orthophotos, a pine plantation was established on part of the previously cultivated land, while other plots spontaneously overgrew with trees and shrubs. Later, a population of *Cephalanthera longifolia* was established in the area, which could not be assessed during the previous extensive study in 2004 (Ryla & Čiuplys, 2005). Recently established habitats in a young tree stand in the Raisteliai Forest, formed on former arable land, now support a large population of *Cephalanthera longifolia*. Isolated individuals of *Cephalanthera longifolia* also occur on the edges of plantations, in naturally established tree stands and in the remaining open grassland patches (Fig. 5).

Analysis of another recently discovered population of *Cephalanthera longifolia* near the village of Mikališkės (Šalčininkai distr.) has shown that the whole or at least a large part of the population is also of recent origin. According to orthophoto information, a large part of the habitat of the current population was arable land until 1999. We assume that the initial part of the population (occupying 0.11 ha) may have existed earlier, as it is located in a stand of about 60 years old. The other part of the population probably established in the early 2000s, when the previously cultivated fields were planted with pines or spontaneously overgrew with deciduous trees (Fig. 6). The densest concentration of individuals during the study years was in the stand dominated by *Populus tremula* L. and *Salix caprea* L. (0.17 ha). In contrast, in the pine plantation, the density is much lower, and individuals are sparsely distributed over an area of 0.49 ha (Fig. 6).

Furthermore, the analysis of the available historical orthophotos showed that a large part of the area around Paneriai (including Raisteliai) was dominated by cultivated fields with small forest patches in 1944. This suggests that the population of *Cephalanthera longifolia*, first recorded in this area in 1930, is in a permanent dynamic state and that the plants readily colonise new habitats suitable for them at that time. It can be assumed that in the absence of drastic changes

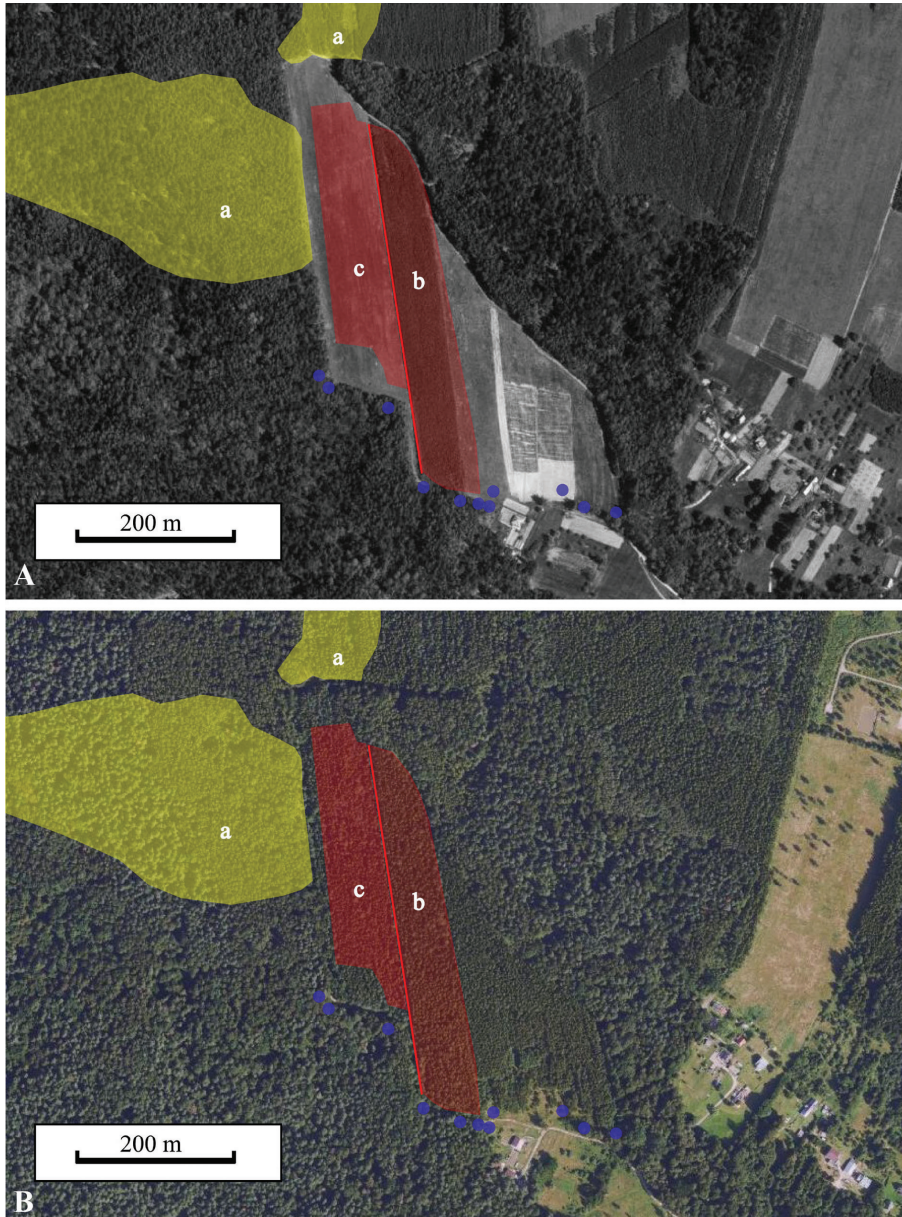


Fig. 5. The spread of *Cephalanthera longifolia* in formerly cultivated fields in the surroundings of Raisteliai (Vilnius city) during about two decades. The orthophoto maps of 1999 (A) and 2023 (B) show the distribution area of *Cephalanthera longifolia* as determined in 2023. Two yellow shaded areas (a) indicate the forest areas that supported individuals of this species before 1999, the red (b) indicates part of the birch stand developed for a tree nursery, and the area of *Pinus sylvestris* plantation on former arable land (c) and blue dots mark solitary individuals. The maps are based on orthophotos provided by the Spatial Information Portal of Lithuania (geoportal.lt).

in land use, *Cephalanthera longifolia* has the potential to persist indefinitely in the surroundings of Paneriai (Vilnius city). In Poland, *Cephalanthera longifolia* has also been observed to occupy tree plantations in some areas (Jakubská et al., 2006), where it has been abundant for some time.

These two case studies show that *Cephalanthera longifolia* can colonise abandoned arable land and thrive in early successional tree stands and tree plantations if a seed source is available to ensure successful dispersal. Further long-term studies may reveal the directions and patterns of how these recently established populations evolve and survive.



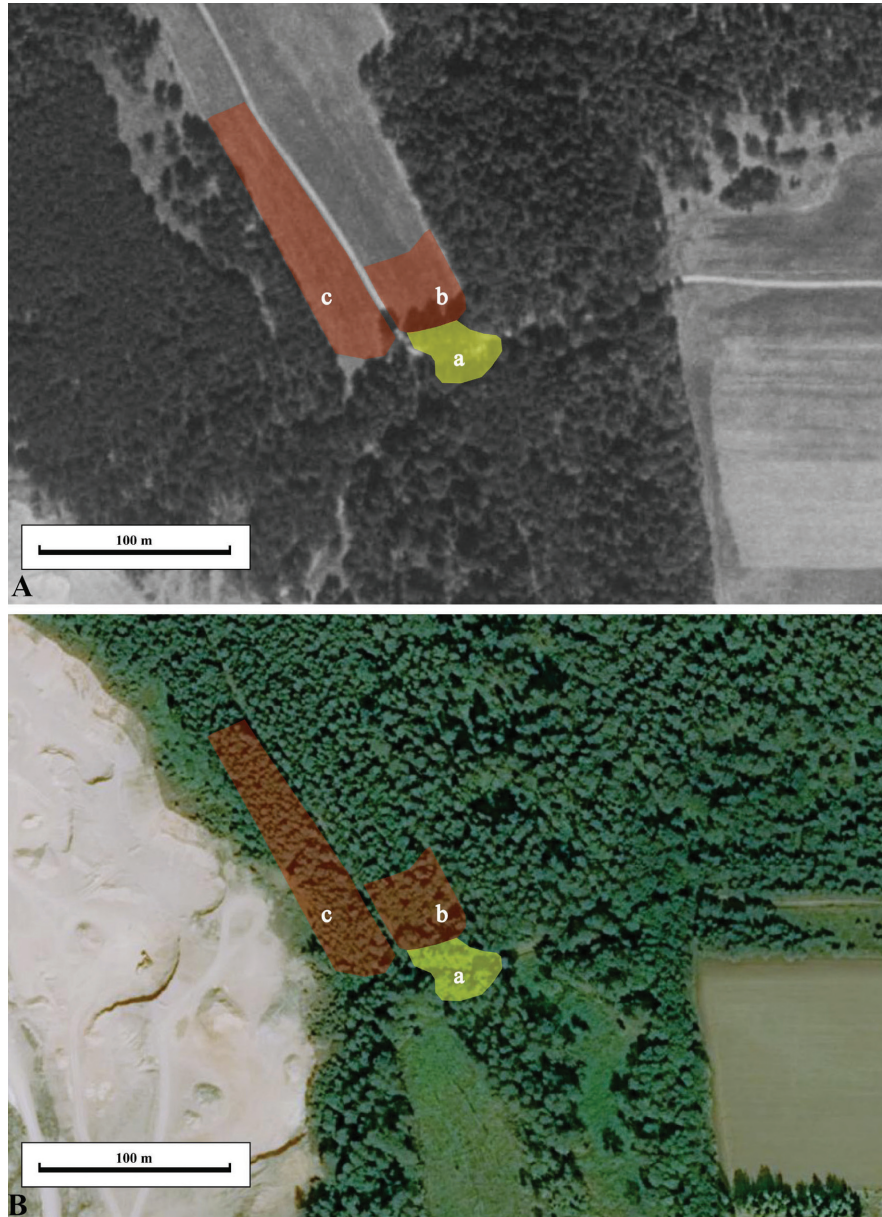


Fig. 6. The spread of *Cephalanthera longifolia* in formerly cultivated fields around the village of Mikališkės (Šalčininkai district) during about two decades. The orthophoto maps of 1999 (A) and 2023 (B) show the distribution area of *Cephalanthera longifolia* as determined in 2023. Yellow (a) indicates the forest that may have supported individuals of this species before 1999, red (b) indicates a portion of the population with the highest density and the area covered by the sparsely distributed individuals (c). The maps are based on orthophotos provided by the Spatial Information Portal of Lithuania (geoportal.lt).

## CONCLUDING REMARKS

Information on *Cephalanthera longifolia* and *Cephalanthera rubra*, accumulated over more than 200 years, has shown different trends in their population development. The number of populations and the number of localities in populations of *Cephalan-*

*thera longifolia* are increasing, and the number of individuals in populations is considerably high. If the currently doubtful localities of this species are confirmed, then the trend of *Cephalanthera longifolia* spreading will be undeniable. The opposite is true for *Cephalanthera rubra*. The number of its populations is stable, while the number of individuals in them

fluctuates considerably or remains consistently low.

The spread of *Cephalanthera longifolia*, probably by seed dispersal, is expected to be positively influenced by climate change. Both local and long-distance seed dispersal by air masses cannot be excluded. Long-distance seed dispersal of Orchidaceae species has been documented in some regions of Europe (Vanden Broeck et al., 2014; Brzosko et al., 2017). It is probably responsible for introducing *Epipactis albensis* Nováková & Rydlo in Lithuania (Ryla et al., 2022). It remains unclear which barriers hinder the spread of *Cephalanthera rubra*: the low number of propagules or the lack of suitable habitats for establishment.

The analysis of historical and contemporary information on the distribution of *Cephalanthera longifolia* and *Cephalanthera rubra* showed that some of the data, especially those collected before 1990, were somewhat limited in detail and accuracy. This has led to different interpretations, errors and inaccuracies in the various literature sources, especially in mapping the distribution of the species. Some records have sometimes been identified as two or even three different localities. This situation can significantly distort species assessment according to the IUCN (2012b) criteria, as the area of occurrence and area of occupancy become inaccurate. Data analysis has shown that it is essential to always rely on primary sources of information and to assess critically all data provided in references.

The results of this study suggest a lack of systematic data on long-term changes in the status of *Cephalanthera longifolia* and *Cephalanthera rubra* populations in Lithuania. Fragmented data collected during occasional surveys prevail. Even when habitat management measures for protected species are implemented, comprehensive monitoring or assessment of populations of protected species, including target species (e.g. *Cypripedium calceolus*), is generally not undertaken, or if some surveys are performed, relevant information is unavailable.

Accurately documented information on the distribution and abundance of protected species in the wild is of great importance at the time of its collection. It will not lose its relevance in the future. Objective knowledge of rare species populations is needed not only for theoretical purposes, for modelling future scenarios of species fate, but also for the routine

work of decision-makers in designing and implementing an effective conservation system and adopting the necessary measures for their protection.

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## Appendix I

A chronological list of herbarium specimens of *Cephalanthera longifolia* and *Cephalanthera rubra* collected in Lithuania. The contents of the herbarium specimen labels were translated from Lithuanian and Polish into English. Notes and corrections are enclosed in square brackets. The four-digit number preceding the herbarium acronym refers to the number of the map grid cell, and the herbarium acronym is followed by the herbarium specimen number. Acronyms of the herbaria: BILAS – Herbarium of the Institute of Botany of the Nature Research Centre; WI – Herbarium of Vilnius University.

### *Cephalanthera longifolia*

1. In pratis fruticosis loco dicto Hrybiszki [Ribiškės] prope Vilnam, rarissima! 1824, [unsigned], sub. *Serapias ensifolia* Richard. 5331. WI.
2. Ponary [Paneriai, environs of Vilnius], 6 June 1930, leg. B. Szakien. 5331. WI P06560.
3. Ponary [Paneriai, environs of Vilnius], in the forest, 2 July 1933, leg. et det. J. Mowszowicz. 5331. WI P06561.
4. Ponary [Paneriai, environs of Vilnius], in the oak forests, 2 July 1933, leg. et det. J. Mowszowicz. 5331. WI P19773.
5. Vilnius district, Riešė forestry, the Vanaginė Forest, forest block No. 50, spruce forest with pine trees, 10 June 1959, leg. A. Galentas, det. J. Gelaževičius. 5231. BILAS 61077.
6. Vilnius district, Vaivadiškės village, at the edge of the grassland with *Salix* trees, 26 May 1984, leg. et det. V. Rinkevičius. 5033. BILAS 64796.
7. Trakai district, 3 km east of Aukštadvaris, in a mixed forest habitat, relatively abundant (106 flowering individuals). 7 June 1984, leg. et det. A. Lekavičius. 5427. BILAS 43624.
8. Šalčininkai district, the Šilinė Forest, forest block no. 137, the Šilinė Botanical Reserve, in the spruce stand, relatively few, 6 June 1989, leg. et det. V. Rašomavičius. 5734. BILAS 61078.
9. Vilnius Forest Enterprise, Paneriai Forestry, forest block No. 22, plot No. 9, 9 June 1992, leg. et det. K. Balevičius. 5331. BILAS 51235.
10. Vilnius, the Paneriai Forest, forest block No. 35, plot No. 9, 8 June 1993, leg. et det. K. Balevičius. 5331. BILAS 51236.
11. Šalčininkai district, the Poškonys Forest, forest block No. 41, plot No. 2, in a spruce stand; relatively abundant, 25 June 2002, 54°18'52.0'' N, 25°38'08.3'' E, leg. et det. R. Čiuplys. 5733. BILAS 65748.
12. Šalčininkai district, Dieveniškės forestry, the Šilinė Forest, forest block No. 28, plot No. 7, the Šilinė Botanical Reserve, in a spruce-birch-aspens stand, sparse (about 90 individuals), 11 June 2004, 54.2621°N, 25.2051°E. leg. et det. R. Čiuplys. 5734. BILAS 73017.
13. Šalčininkai district, the Poškonys Forestry, the Klevyčia Forest, forest block No. 41, plot No. 2, in mixed stand, relatively abundant, 18 June 2004, leg. et det. R. Čiuplys. 5733. BILAS 73125.
14. Vilnius, the Paneriai Forest, 1 km east of the Paneriai Railway Station, in birch and pine forest, near the asphalted road (continuation of Zuikiai street), 13 individuals, 3 June 2000, leg. et det. V. Rinkevičius. 5331. BILAS 74199.
15. Vilnius, Paneriai Street, forest block No. 29, plot No. 2, in a relatively sparse birch stand, very abundant, 22 June 2004, 54.6222°N, 25.2051°E, leg. et det. M. Ryla. 5331. BILAS 73121.

### *Cephalanthera rubra*

1. Specimen hoc [...] extra Antokol [Antakalnis, Vilnius] in pinetis caedmis sepertus. 1837 versus finum Junii, [unsigned]; 5331. WI.
2. On the edge of a mixed forest, at the outlet of the Strėva River from Lake Spindžius, Trakai distr., 25 June

- 1962, leg. et det. R. Kazlauskas. 5428. WI P06563.
3. Pine stand on a slope, at the outlet of the River Strėva from Lake Spindžius, Trakai distr., 28 June 1962, M. Natkevičaitė-Ivanauskienė. 5428. WI P06562.
  4. Alytus distr., the Punios Šilas Forest, forest block No. 44, in the spruce stand near the ravine of Nemunas slope, 30 June 1970, leg. et det. R. Jankevičienė. 5424. BILAS 26797.
  5. Lazdijai distr., the Balsys Landscape Reserve, in the bushes between Šlavantėlis and Liūnelis Lakes, in calcareous soil, 25 June 1975, leg. J. Jaskonis, det. R. Jankevičienė. 5821. BILAS 26799.
  6. Trakai distr., at the outlet of the Strėva River from Lake Spindžius, Aukštadvaris Regional Park, in the dry mixed forest; quite common, 25 June 1978, leg. et det. V. Rašomavičius. 5428. BILAS 55840.
  7. At the edge of the forest, on the right bank of the Skroblus stream, Varėna distr., between the villages of Rudnia and Kapiniškės, 10 July 1979, leg. et det. R. Prapiestienė. 5925. WI P06564.
  8. On the right bank of the Skroblus stream, on a slope, Varėna distr., Rudnia village, 30 June 1980, leg. et det. A. Daumėnaitė. 5925. WI P06565.
  9. Lazdijai distr., Stračiūnai village, in a pine forest with *Vaccinium myrtillus*, 13 July 1980, leg. et det. M. Lapelė. 5823. BILAS 66157.
  10. Trakai distr., environs of Aukštadvaris, 24 June 1967, leg. P. Snarskis, det. J. Balevičienė. 5428. BILAS 26798.
  11. Švenčionys distr., Pabradė Military Forestry, forest block No. 88, in a birch stand, very abundant, 8 July 1993, leg. et det. D. Patalauskaitė. 4935. BILAS 50003.
  12. Lazdijai distr., between Liūnelis and Šlavantėlis Lakes, Veisiejai Regional Park, grassland with *Juniperus communis* surrounded by forest; relatively abundant, 28 June 1997, leg. et det. Z. Gudžinskas. 5821. BILAS 67143.
  13. Varėna distr., about 3 km south of Rudnia, the Margionys Forestry, forest block No. 168, plot No. 5, on the upper terrace of the right bank of the Skroblus River valley, Dzūkija National Park, in a pine forest on a west-facing 20° slope, in a sunny position; 8 flowering individuals (rhizome 20 cm deep), 29 June 1999, leg. et det. R. Čiuplys. 5925. BILAS 58104.
  14. Varėna distr., about 4 km south of Rudnia, the Margionys Forest, forest block No. 168, plot No. 28, left slope of the Skroblus valley, Dzūkija National Park, on the upper terrace of the valley, between the grassland and the forest, on the slope, 11 flowering individuals, 29 June 1999, leg. et det. R. Čiuplys. 5925. BILAS 58100.
  15. Lazdijai distr., the Veisiejai Forestry, forest block No. 34, plot No. 2, between Šlavantėlis and Liūnelis Lakes, Veisiejai Regional Park, in birch forest with rich herb cover, several dozen individuals, 54.1279 °N; 23.6604 °E, 17 June 2005, leg. et det. R. Čiuplys. 5821. BILAS 73099.

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