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DISTRIBUTION, STATE AND CONSERVATION OF *EQUISETUM TELMATEIA* IN LITHUANIA

Zigmantas Gudžinskas[1*], Mindaugas Rasimavičius[2]

[1] Nature Research Centre, Institute of Botany, Žaliųjų Ežerų Str. 49, Vilnius LT-08406, Lithuania
[2] Vilnius University, Life Science Centre, Institute of Biosciences, Herbarium, Saulėtekio Av. 7, Vilnius LT-10257, Lithuania
* Corresponding author: zigmantas.gudzinskas@botanika.lt

Abstract

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Conservation of endangered plant species requires a thorough knowledge about the present state of their populations and habitats as well as identification of current and potential threats. The aim of this research was to evaluate current distribution, state of habitats and the size of populations of *Equisetum telmateia* (Equisetaceae) in Lithuania as well as to reveal the main threats and requirement for the conservation of this species. Analysis of all available information revealed that *E. telmateia* currently occurs in seven localities in Lithuania, mainly in the southern part of the country. One formerly recorded population in the south-western part of Lithuania has become extinct. Two reported localities in the environs of Druskininkai (southern Lithuania) are doubtful, because the reports have been based on misidentified specimens. Locality of *E. telmateia* in the western part of the country probably has been provided erroneously and one locality in the south-eastern region of Lithuania should be verified and the identity of the species requires confirmation. Total area occupied by the stands of *E. telmateia* in Lithuania is 2.41 ha. Most frequently this species grows in river valleys or close to rivers and occupies alluvial forest habitats, which frequently creates complexes with habitats of mineral-rich springs or springs with tufa formations. Occasionally it grows in the habitats of forests of slopes, tall herb fringe communities and hay meadows. Sporulation of *E. telmateia* in Lithuania is poor: no fertile shoots were registered in two studied populations, whereas in other localities few fertile shoots were recorded. Evaluation of the status of *E. telmateia* in Lithuania applying the IUCN criteria resulted in its categorization as a vulnerable species. The main threats for *E. telmateia* are forest logging and changes in habitat hydrological regime, though wild animals, human activities and invasive plant species also have certain negative impact on the populations of this species.

Keywords: habitats, IUCN criteria, protected species, sporulation, threats, variation, vulnerable species.

INTRODUCTION

Conservation of endangered species requires a thorough knowledge about their biological and ecological features, the state of their habitats and the identification of current and potential threats. This knowledge is necessary to define an appropriate conservation strategy of a species as well as to make reasonable decisions for habitat protection, management and restoration, if required (Fasciani & Pace, 2015; Maes et al., 2016).

Protection of rare and endangered plant species in Lithuania has a long tradition (Jankevičienė, 1978; Lazdauskaitė et al., 1986; etc.), but a large part of the environmental actions was and still is based on the insufficiently deep knowledge about the ecological needs of plant species and the state of their populations. Furthermore, much attention is paid to

the conservation of species of European Community interest, while conservation of nationally endangered and rare plant species receives much less attention and efforts. In fact, plant species as well as species of other organisms, which are included into the *List of Protected Animal*, *Fungi and Plant species of the Republic of Lithuania* (Aplinkos ministerija, 2003), should receive much more attention.

A large number of endangered fern species and their allies have been seriously impacted by climate change and are in danger of extinction (Wang et al., 2016). Species of the genus *Equisetum* L. (*Equisetaceae*) is a surprisingly ancient and morphologically conservative group of plants, with many unusual characteristics and adaptations that have persevered across geological time as well as geographical and ecological space. Therefore, the genus *Equisetum* is considered as the most successful living genus of ancient vascular plants (Stanich et al., 2009; Husby, 2013; Vannestea et al., 2015). The genus *Equisetum* worldwide includes 15 species (Hauke, 1993; Guillon, 2004, 2007) and over a dozen of hybrids (Dostál, 1984; Wróbel, 2013).

Equisetum telmateia Ehrh. is distributed in West, Central and South Europe, North Africa, Turkey, the Caucasus, North Iran and the western part of North America (Jalas & Suominen, 1972; Dostál, 1984; Hauke, 1993; Olgaard, 2000). North American plants of this species are considered as *E. telmateia* subsp. *braunii* (Milde) Hauke. This subspecies is characterized by green vegetative stems, whereas *E. telmateia* subsp. *telmateia* differs primarily in having main aerial stem with white or greenish internodes (Hauke, 1993).

Although the habitat degradation across the range of *E. telmateia* has been reported, it is not currently affecting the status of this species or threatening its survival globally and, therefore, it is considered as species of least concern (Akhani et al., 2014). However, in certain regions, mainly in those which are close to the limits of the distribution range of *E. telmateia*, it is considered as threatened species (Eglīte, 2003; Naujalis, 2007; Stępień, 2009; Gubareva, 2010; Skuratovich, 2015; etc.).

E. telmateia has been registered in all regions neighbouring to Lithuania. In Latvia, a single locality of *E. telmateia* was recorded in the valley of the River Venta in 1895 (Lehmann, 1896), and this population has survived in the Piešdanga Nature Reserve until now (Eglīte & Šulcs, 2000; Eglīte, 2003; Priedītis, 2014). Rather large population is located on springy slope of the river and along the river banks (Priedītis, 2014).

One locality of *E. telmateia* has also been recorded in the Kaliningrad region of Russia. Quite small population of this species is situated in the valley of the River Kornevka in Bagrationovsk district and occurs in mixed broad-leaved forest and alluvial alder forest habitats (Gubareva, 2010). Two localities of *E. telmateia* have been recorded in Belarus in Gomel region (Skuratovich, 2009). Quite small population of sparsely growing individuals occupying about 100 m^2 has been reported in Gomel region, on the main slope of the River Pripyat in the vicinities of Pietrykau settlement (Parfenov et al., 1987). Another population has been recorded on the banks of the River Dnepr in the vicinities of Byvalki village (Skuratovich, 2009), however, the current stage of this population is not known.

In Poland, *E. telmateia* is quite frequent in the region of the Sudety and Carpathian Mountains, however, in lowland regions it is rare and endangered (Zając & Zając, 2001; Piękoś-Mirkowa & Mirek, 2003; Stępień, 2009). In the north-eastern part of Poland, this species is very rare (Zając & Zając, 2001). It is clear that the frequency of *E. telmateia* from South Poland northwards and eastwards decreases drastically and the north-eastern boundary of the range of the species stretches through Latvia and Lithuania.

The aim of this research was to evaluate the current distribution, the state of habitats and the size of populations of *E. telmateia* in Lithuania as well as to reveal the main threats and requirement for the conservation of this species.

MATERIALS AND METHODS

The studied species

Equisetum telmateia is a herbaceous perennial plant, with separate sterile green photosynthetic stems, and pale brown or yellowish fertile non-photosynthetic spore-bearing stems. The sterile stems are 0.30–1.50 m, occasionally to 2.00 m tall and about 1 cm in diameter. They grow in late spring and die down in late autumn. The stem is branched,

with whorls of 14–40 branches, these up to 20–30 cm long, 1–2 mm diameter. The fertile stems are produced in early spring (at the end of April or in early May) before the sterile shoots. The fertile stems are to 10–25 cm tall with an apical spore-bearing strobilus 4–10 cm long and 1–2 cm broad. The fertile stems die out immediately after spore release, usually in mid-May. It spreads by spores. Rhizomes penetrate up to 4 m into wet soil and they usually are spreading laterally in multiple layers (Dostál, 1984; Hauke, 1993; Husby, 2013).

Methods

Herbarium specimens deposited at the Herbarium of the Institute of Botany of the Nature Research Centre (BILAS) and at the Herbarium of Vilnius University (WI) were studied (Appendix 1). Herbarium specimens collected during this investigation by the authors of this paper are deposited at the above-mentioned herbaria (Appendix 1). The data on the records of *E. telmateia* obtained from the *Information System on Protected Species* (SRIS) of the Ministry of Environment of Lithuania were also used.

Field studies and estimation of the state of *E. telmateia* populations were performed from April to September in 2015 and 2016. Each habitat was visited at least twice. The evaluation of sporulation was performed in spring, whereas the size of populations, the structure of habitats and plant communities were studied in summer or at the beginning of autumn. Generative stems were counted thoroughly and consistently surveying the whole area of the habitat. The mean number of generative stems in 100 m^2 was calculated dividing the number of stems by the whole area occupied by *E. telmateia* stand and multiplied by 100.

Habitat types were indicated after the *Manual for Inventory of EU Natural Habitats* (Rašomavičius, 2012). The nomenclature of the habitat types follows the *Interpretation Manual of European Union Habitats* (European Commission, 2013). Full names of habitat types and their codes as well as short versions of habitat type names used in the paper are provided on Table 1.

The size of stands of *Equisetum telmateia* was measured using the measurement type (for small populations) and GPS device (for large populations). Using GPS device, marginal points of *E. telmateia* stands were fixed and the area occupied by this species was calculated using GIS software.

Table 1. Standard names of European Union habitats and their short versions used in the text

Code and standard name of the habitat type	Short version of the habitat name used in the text
6510 Lowland hay meadows (*Alopecurus pratensis*, *Sanguisorba officinalis*)	Hay meadows
6430 Hydrophilous tall herb fringe communities of plains and of montane to alpine levels	Tall herb fringe communities
7160 Fennoscandian mineral-rich springs and springfens	Mineral-rich springs
7220 * Petrifying springs with tufa formation (*Cratoneurion*)	Springs with tufa formation
9180 * *Tilio-Acerion* forests of slopes, screes and ravines	Forests of slopes
91E0 * Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior*	Alluvial forests

RESULTS AND DISCUSSION

Overview of distribution

At the end of the 19th century, Lehmann (1896) supposed that *E. telmateia* should occur in Lithuania, because it had been recorded in Latvia, in the valley of the lower reaches of the River Venta, which flows from the territory of Lithuania. Later, this species was included in the manuals for identification of plants of Lithuania as expected species (Dagys et al., 1934; Snarskis, 1954). *E. telmateia* was found for the first time in Lithuania in 1957 by L. Šidla in Vilkaviškis district, in the environs of Gražiškiai, between Gražupiai and Duonelaičiai villages, in a black alder logging area, on springy slope of a ravine (Minkevičius, 1959; Šidla, 1960). Later, *E. telmateia* was not recorded in that locality and became extinct probably because of significant changes in the habitat after wood-logging or later performed land reclamation in the area, and, therefore, changed water regime.

Large population of *E. telmateia* was discovered in 1959 by R. Murkaitė in Varėna district, between Puvočiai and Kasčiūnai villages, on the right bank of the River Merkys (Natkevičaitė-Ivanauskienė, 1961, 1994). Now several groups of plants are distributed along the bank of the river in wooded areas and in meadows as well as in anthropogenic habitats.

Another population of *E. telmateia* was recorded in Alytus district, during the investigations on flora of the Punia Forest Botanical-Zoological Reserve. It was situated on the left bank of the River Nemunas, on a steep springy south-western slope, in a deep ravine. When recorded, this population was quite small, though exact number of individuals was not indicated (Jankevičienė & Lazdauskaitė, 1976).

Locality of *E. telmateia* near Rokai, in Vingytė village, Kaunas district (currently Kaunas city) was recorded during the studies on flora of the Jiesia Landscape Reserve in 1970 by E. Purvinas and G. Turkevičius. *E. telmateia* occurred on a slope with springs, in grey alder stand and covered about 25% of the total habitat area (Balvočiūtė et al., 1992).

In the valley of the River Lapainia, about 4 km south-west of Kruonis, in the environs of Kleboniškis village (Kaišiadorys district), *E. telmateia* was first found in 1982. This population consisted of two subpopulations separated by approximately 0.5 km (Gudžinskas, 1983). Large group of *E. telmateia* occupied the valley and springy slopes of the River Lapainia and much smaller subpopulation was recorded at the foot of the slope close to the confluence of the Rivers Kruonė and Lapainia. In 1982, this group of individuals occupied about 4 m^2. Last time this subpopulation was recorded in 2012, whereas in 2013 all area of the habitat was flooded, as beavers built a dam on small spring rivulet and in 2014 no individuals of *E. telmateia* were recorded.

Two localities of *E. telmateia* were reported in the environs of Druskininkai (Lazdauskaitė et al., 1986; Parfenov et al., 1987). First locality was recorded by A. Lekavičius in 1974, in Druskininkai Forest Park, on the slope of the River Nemunas, close to the islet of the river. However, all collected specimens in fact belong to *E. arvense* and were misidentified as *E. telmateia*. Recent searches for *E. telmateia* in Druskininkai have not been successful.

The second locality of *E. telmateia* in the environs of Druskininkai was registered in 1975, about 6 km south of Druskininkai, in the Raigardas Landscape Reserve, at the foot of the slope by a drained rivulet. Herbarium specimens collected by A. Lekavičius and later by M. Lapelė in 1991 in fact belong to *E. arvense* and *E. fluviatile*. Therefore, the occurrence of *E. telmateia* in that area was not confirmed.

Population of *E. telmateia* was discovered on the right bank of the River Neris, about 3.5 km north-west of Čiobiškis (Širvintos district), in the environs of Rusių Ragas village in late 1970s by S. Janonienė. First herbarium specimens of *E. telmateia* from this locality were collected in 1986 by M. Lapelė and only brief information about this population was published (Lazdauskaitė et al., 1986; Parfenov et al., 1987).

In Neris Regional Park (Vilnius district), on the slopes of Naujoji Rėva mound, which is situated in a deep valley of the River Neris, *E. telmateia* was found in 2007 by G. Švitra. According to the data provided in the Information System on Protected Species of the Ministry of Environment of Lithuania (hereafter, SRIS), this species occupied the area of about 300 m^2.

During the implementation of the project *Inventory and Mapping of EU Habitats all over Lithuania* in 2013, formerly unknown population of *E. telmateia* was registered by V. Kreile and B. Kalva in Utena district, about 2 km north of Utena, between Karveliškės and Šaltupys villages in the habitat of mineral-rich springs and spring-fens. No information about the density of population or occupied area was provided in the SRIS database.

Locality of *E. telmateia* in the former Rambynas Landscape Reserve (presently Pagėgiai district, Rambynas Regional Park, environs of Bitėnai village) was first mentioned by Jankevičienė (1978) and subsequently it was frequently repeated in different references (Lazdauskaitė et al., 1986; Parfenov et al., 1987; Naujalis, 2007). However, the specimens of *E. telmateia* from this region are not deposited at the Herbaria of Lithuania and exact location of the population has never been indicated. Furthermore, this species was not included in either the analysis of rare and endangered species or the list of flora of the former Rambynas Landscape Reserve (Jankevičienė et al., 1987). Thus, this locality was rejected by the authors in their later publication due to unknown reasons. Besides, the locality in the environs of Rambynas was not mentioned in the *Red Data Book of Lithuania* (Lapelė, 1992), either. Because the record of *E. telmateia* in the environs of Rambynas was not confirmed by herbarium specimens collected by the authors of the publication or by later investigators, and there is no detailed information about the species, we consider this record as doubtful.

The most recent new record of *E. temlateia* was made by R. Draugelytė in 2014, about 2 km south of the village Kalesninkai (Šalčininkai district), in the environs of Dabrai village, in the Razumnos forest. Based on the information provided by the SRIS database, the population of this species occupies the area of 1294 m^2 in the wet forest. Unfortunately, this record was not confirmed by herbarium specimens or other evidences and we had no possibility to verify the accuracy of identification and the state of population. Therefore, this locality was excluded from further analysis and evaluation.

The analysis of all available information revealed that currently *E. telmateia* occurs in seven localities in Lithuania (Fig. 1): Šaltupys (Utena district), Rusių Ragas (Širvintos district), Lapainia (Kaišiadorys district), Rokai (Kaunas city), Naujoji Rėva (Vilnius district), Panemuninkai (Alytus district) and Kasčiūnai (Varėna district). One population formerly recorded in the environs of Gražiškiai (Vilkaviškis district) currently is extinct. We suppose that the locality of *E. telmateia* in the environs of Bitėnai village (now Pagėgiai district, Rambynas Regional Park) was provided erroneously. Two localities of this species in Druskininkai and its environs were reported based on misidentified specimens. Population in the environs of Dabrai village (Šalčininkai district) should be verified and the identity of the species requires confirmation.

Almost all populations of *E. telmateia* in Lithuania are located along the River Nemunas and its tributaries (Rivers Jiesia, Lapainia and Merkys) and along the River Neris. A single population of *E. telmateia* recorded in Utena district is in a significant distance from the rivers. The River Šventoji flows 8 km to the north and the River Vyžuona is ca. 1 km south of the locality of this species. In Lithuania, *E. telmateia* is at the north-eastern limit of the species range. Further to the north from Lithuania, a single locality of this species has been registered in the valley of the River Venta in Latvia (Eglīte & Šulcs, 2000; Eglīte, 2003; Priedītis, 2014).

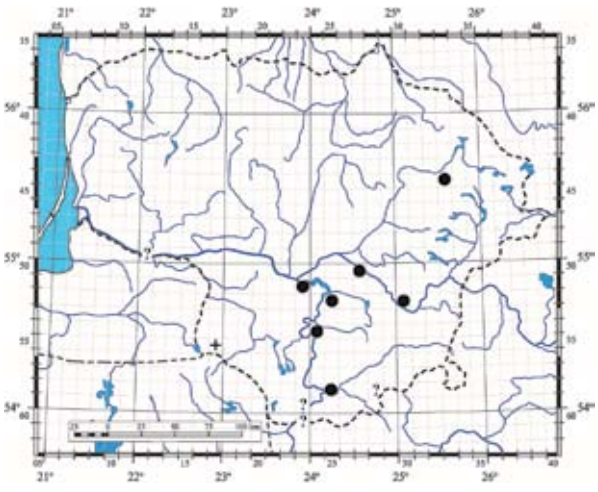

Fig. 1. Distribution of *Equisetum telmateia* in Lithuania: ● – evaluated existing population; + – extinct population; **?** – doubtful report

The state of populations

During the study, seven populations of *E. telmateia* were evaluated and factors, which influence or may influence the state of population, were analysed. The summarized results of the study of seven populations of *E. telmateia* indicating the occupied habitats and the size of stands are provided on Table 2.

Šaltupys. The population of *E. telmateia* in Šaltupys consisted of two parts separated by about 70 m wide and 5–7 m high ridge. One part of the population was situated in a depression with mineral-rich spring and their stream habitat intermingled with the alluvial forest habitat. This subpopulation occupied about 1800 m^2 (60 m long and 30 m wide). The dominant tree was *Alnus glutinosa* of about 60 years old. Coverage of the tree layer was 50%. Coverage of the shrub layer was 30%, and the most abundant species in this layer was *Prunus padus*. The herb layer was moderately dense; its coverage was 60%. The most abundant species in the herb layer were *Cirsium oleraceum*, *Geum rivale*, *Solanum dulcamara*, *Urtica dioica* and *Chrysosplenium alternifolium*. The highest density of *Equisetum telmateia* was around springs and in the area irrigated by streams, whereas in the habitat of alluvial forest, its density was significantly lower, only small groups or solitary shoots occurred. A part of habitat was polluted by rubbish (glass, brick and metal debris), which was dumped about ten years ago.

The second subpopulation was located on a flat slope of the southern exposition and occupied about 200 m long and 40 m wide belt. *E. telmateia* grew in several isolated groups of various sizes, which in total occupied about 4650 m^2. The densest stands were around mineral-rich springs and along their streams, whereas in the alluvial forest habitat, the density of *E. telmateia* was significantly lower. *Alnus glutinosa* was dominant in the tree layer; coverage of the layer

Table 2. Location, occupied habitats and the size stands of *Equisetum telmateia* in the studied populations

Name of population	Locality	Habitats	Area of the stand (m^2)
Šaltupys	Utena distr., between villages Šaltupys and Karveliškės	Alluvial forests Mineral-rich springs	6450
Rusių Ragas	Širvintos distr., 3.5 km north-west of Čiobiškis, environs of village Rusių Ragas	Alluvial forests Tall herb fringe communities	1170
Naujoji Rėva	Vilnius distr., environs of Šilėnai village, Neris Regional Park, Naujoji Rėva mound	Alluvial forests Springs with tufa formation Forests of slopes	2400
Rokai	Kaunas city, environs of Rokai, Vingytė village	Alluvial forests Springs with tufa formation Forests of slopes	480
Lapainia	Kaišiadorys district, 4 km south-west of Kruonis, Lapainia Botanical Reserve	Alluvial forests Mineral-rich springs Springs with tufa formation	8800
Panemuninkai	Alytus distr., environs of Panemuninkai village, Nemuno Kilpos Regional Park	Forests of slopes Mineral-rich springs	240
Kasčiūnai	Varėna distr., between Puvočiai and Kasčiūnai, Dzūkija National Park	Alluvial forests Tall herb fringe communities Forests of slopes Mineral-rich springs Hay meadows Anthropogenic habitat	4580

was 70%. *Prunus padus* and *Alnus glutinosa* were most abundant in the shrub layer; coverage of the layer was 30%. The herb layer was quite dense, its coverage was 70% and the most abundant species were *Carex acutiformis*, *Cirsium oleraceum*, *Urtica dioica*, *Solanum dulcamara* and *Mercurialis perennis*.

Rusių Ragas. The population of Rusių Ragas was situated along the bank of the River Neris on the lower part of the slope and at its foot. The stand of *E. telmateia* was about 200 m long and its width varied from 2 m to 20 m (the mean width was 6 m). Total area occupied by this species was about 1170 m^2. On the lower part of the slope, *E. telmateia* grew in alluvial forest habitat in which *Alnus incana* and *A. glutinosa* were the dominant trees. Coverage of the tree layer was 50%. Coverage of the shrub layer was 40%. Dominant species in the shrub layer were *Corylus avellana*, *Alnus incana* and invasive *Acer negundo*. The herb layer was quite dense; its coverage was 70%. The most abundant species in the herb layer were *Cirsium oleraceum*, *Eupatorium cannabinum*, *Stellaria nemorum*, *Aegopodium podagraria*, *Cardamine amara* and invasive species *Impatiens parviflora*. At the foot of the slope, *Equisetum telmateia* occupied the tall herb fringe habitat. This habitat was heavily invaded by alien plant species: *Bidens frondosa*, *Impatiens glandulifera*, *I. parviflora*, *Acer negundo*, *Echinocystis lobata*, *Solidago gigantea* and *Symphyotrichum lanceolatum*. In several sections, the stand of *Equisetum telmateia* was trampled by anglers.

Naujoji Rėva. The population of *E. telmateia* in Naujoji Rėva was composed of three subpopulations, which were situated on different slopes and foots of the mound. All three subpopulations were separated by 30–60 m wide ridges. The total area occupied by *E. telmateia* in this locality was 2400 m^2. Subpopulation on the eastern side of the mound was 30 m long and about 20 m wide and occupied the habitat of springs with tufa formation and edges of the surrounding alluvial forest. The tree layer was sparse; its coverage was 30%. Coverage of the shrub layer was 60%, and the most abundant species were *Salix cinerea* and *Prunus padus*. Coverage of herb layer was 70% and *Equisetum telmateia* was the only dominant species.

The second subpopulation was in the middle of the steep south-western slope of the mound. It was about 40 m long and 30 m wide with two narrow branches, 2–4 m wide and 20–30 m long, stretching to the western and north-western slopes of the mound. This subpopulation occupied the habitats of springs with tufa formation, alluvial forest and for-

ests of slopes. The tree layer was sparse (coverage was 20%), composed of solitary individuals of *Fraxinus excelsior*. Coverage of the shrub layer was 30% and it was dominated by *Corylus avellana*, *Cornus sanguinea* and *Fraxinus excelsior*. Coverage of the herb layer was 60%. The most abundant species, except *Equisetum telmateia*, were *Filipendula ulmaria*, *Cirsium oleraceum*, *Scrophularia umbrosa* and *Aegopodium podagraria*.

The third subpopulation was situated on the lower part of south-eastern slope. It was about 40 m long and 20 m wide and occupied the habitats of springs with tufa formation and alluvial forests. The tree layer was mainly composed of 40–60 year-old *Alnus incana* trees, the coverage of which was 50%. Coverage of the shrub layer was 30% and the dominant shrubs were *Corylus avellana* and *Alnus incana*. The herb layer covered 70% and the most abundant species were *Carex acutiformis*, *Eupatorium cannabinum*, *Glechoma hederacea*, *Humulus lupulus* and *Filipendula ulmaria*. Invasive species *Impatiens parviflora* was also abundant in the habitat of alluvial forests.

Though the locality of *Equisetum telmateia* in Naujoji Rėva is in the area which is intensively visited by tourists, no evident damage to plants made by visitors was noted. However, since 2014, the mound slope management measures have been implemented, which in certain degree contradicts with the requirements for conservation of *E. telmateia*. Removing of shrubs affects the state of this species positively; however, all biomass should be removed from the site. Dumping of shrubs in the vicinity of springs or on the habitat of springs with tufa formation triggers the degradation of both, the habitat and population of *E. telmateia*. In September 2016, herbs were mown on the slopes of the mound and a part of *E. telmateia* stand (about 25% of the total area) was cut down. In the third subpopulation, about 40 m^2 of the stand of this species and the spring habitat were heavily damaged by wild boars.

Rokai. This population of *E. telmateia* was situated on the middle and lower part as well as the foot of a quite steep (about 30°) south-eastern slope. The stand of this species was about 60 m long and from 2 m to 15 m wide (total area was 480 m^2). It occupied the habitats of alluvial forests, springs with tufa formation and a forest of slopes. The habitat of springs occupied quite small area and created a complex with the habitat of alluvial forests. In the habitat of forests of slopes, the density of *E. telmateia* was quite low. Coverage of the tree layer, which was composed mainly of *Tilia cordata*, was 30%, however, the layer of shrubs was quite dense, it covered 60%. Dominant species in the shrub layer were *Corylus avellana*, *Tilia cordata* and *Cornus sanguinea*. The most abundant species in the herb layer, coverage 60%, were *Aegopodium podagraria* and *Urtica dioica*. The tree layer in the habitat complex of alluvial forests and springs with tufa formation covered 30%. The layer of shrubs was less dense compared to the habitat of forests of slopes (40%) and the most abundant species were *Alnus incana*, *Prunus padus* and *Cornus sanguinea*. Coverage of the herb layer was 70%. Dominant herb species in this habitat were *Cirsium oleraceum*, *Urtica dioica*, *Humulus lupulus*, *Phragmites australis* and *Eupatorium cannabinum*. No signs of recent human activity were noted in the locality of *Equisetum telmateia*, however, heaps of rubbish dumped several decades ago were still visible. Expansion of *Phragmites australis* from the banks of nearby pond is the most significant threat to the viability of *Equisetum telmateia* population.

Lapainia. This population of *E. telmateia* was situated in a deep valley of the River Lapainia, at the foot of the steep slope and in a floodplain. The stand of *E. telmateia* was 240 m long and from 10 m to 50 m wide. The total area occupied by the stand of this species was 8800 m^2. The largest part of this population (75%) occupied the habitat of alluvial forests, much smaller part was in the habitat of mineral-rich springs (20%) and the remaining part (5%) occupied the habitat of springs with tufa formation. Coverage of the tree layer in the habitat of alluvial forests was 50%. Dominant species in the tree layer were *Alnus glutinosa* and *A. incana*. The mean age of dominant trees was 80 years. Coverage of the shrub layer was 30% and the layer was dominated by *Alnus incana*, *A. glutinosa*, *Prunus padus* and *Ribes nigrum*. The herb layer was dense; its coverage was 70%. Among the most abundant herb species, except *Equisetum telmateia*, were *Phragmites australis*, *Eupatorium cannabinum*, *Cardamine amara*, *Solanum dulcamara*, *Cirsium oleraceum*, *Scrophularia umbrosa*. *Phragmites australis* was the dominant species in the habitat of mineral-rich springs and its mean coverage

was 40%. Though no signs of human activities were recorded in the area occupied by *Equisetum telmateia* stand, significant part of mineral-rich spring habitat and about 10% of alluvial forest habitat in 2015 and 2016 were damaged by wild boars.

Panemuninkai. This population of *E. telmateia* was situated on a steep (about 40°) southern slope of the River Nemunas. The stand of *E. telmateia* was 40 m long and from 2 m to 5 m wide. The total area occupied by the stand of this species was 240 m^2. The population was very small and shoots of *E. telmateia* in 2016 were lower than usually. In the whole area, 104 vegetative shoots were counted. The population of *E. telmateia* occupied the habitats of forests of slopes and mineral-rich springs. Coverage of the tree layer in the habitat of forests of slopes was 50%. The most abundant species were *Quercus robur*, *Picea abies* and *Tilia cordata*. Coverage of the shrub layer was 30%. *Corylus avellana*, *Picea abies* and *Prunus padus* prevailed in this layer. The herb layer was sparse; its coverage was 40%. Invasive *Impatiens parviflora* was quite abundant species in the herb layer. In mineral-rich spring habitat, coverage of the herb layer was 70%. The most abundant species in this habitat were *Ranunculus repens*, *Veronica beccabunga*, *Carex remota*, *Chrysosplenium alternifolium*, *Geranium robertianum*, *Cardamine amara* and *Crepis paludosa*. No signs of human activity were noted in the locality of *Equisetum telmateia* population, however, almost half of the spring habitat in 2016 was damaged by wild boars. The state of this population of *E. telmateia* is unsatisfactory.

Kasčiūnai. This population of *E. telmateia* was composed of three subpopulations of different size, located in 1.5 km long section of the right bank of the River Merkys and separated from each other by 500–700 m. The total area occupied by stands of *E. telmateia* was 4580 m^2. The first subpopulation, which was located close to Puvočiai village, at the edge of alluvial forest was the smallest (380 m^2) and occupied mainly the habitat of tall herb fringe communities. Only few shoots of *E. telmateia* were recorded in alluvial forest of *Alnus glutinosa*.

The second subpopulation of *Equisetum telmateia* was in wooded area, on the southern slope and at its foot, in the habitat of alluvial forests and its junction with the habitats of forests of slopes and mineral-rich springs. The stand of *E. telmateia* in this subpopulation was 240 m long and 2–10 m wide. Total area occupied by this subpopulation was 1600 m^2. Coverage of the tree layer in alluvial forest was 60% and the tree stand was dominated by *Alnus glutinosa*. The layer of shrubs was quite sparse, composed by *Alnus glutinosa* and *Prunus padus*, and its coverage was 20%. Coverage of the herb layer was 70%. Dominant species of the herb layer were *Cirsium oleraceum*, *Angelica sylvestris*, *Urtica dioica*, *Aegopodium podagraria*, *Glechoma hederacea* and *Stellaria nemorum*. Invasive *Impatiens parviflora* was also abundant in the herb layer. Solitary shoots or small groups of shoots of *Equisetum telmateia* occurred in the habitat of forests of slopes. Both habitats of this subpopulation were partly damaged in 2015 during tree logging.

The third subpopulation of *E. telmateia* occupied the largest area (2600 m^2) and occurred in the habitats of alluvial forests, tall herb fringe communities, and hay meadows as well as in anthropogenic habitat. In the habitat of hay meadows, *E. telmateia* grew sparsely and usually only low solitary shoots occurred, whereas in the habitat of tall herb fringe communities, the stand of this species was quite dense and shoots were of characteristic height. Coverage of the herb layer in the habitat of tall herb fringe communities was 90%. The most abundant species, except *E. telmateia*, were *Anthriscus sylvestris*, *Rubus caesius*, *Aegopodium podagraria*, *Chaerophyllum aromaticum*, *Glechoma hederacea*, *Urtica dioica* and *Eupatorium cannabinum*. This habitat was also invaded by *Impatiens parviflora*.

Part of this subpopulation occurred in the anthropogenic habitat on the slopes of a pond. This pond was renovated in 2012 or 2013 and steep slope was created. On the gravelly slopes of the pond, *Equisetum telmateia* formed a narrow, curved belt, 2–3 m wide and 32 m long. Upper part of the slope was dry and covered with sparse plants, characteristic of dry habitats (*Echium vulgare*, *Medicago lupulina*, *Artemisia campestris*, *Pimpinella saxifraga*, *Sedum acre*, *Arenaria serpyllifolia*), whereas the lower part of the slope was wet, irrigated by seeping ground water and covered by *Agrostis stolonifera*. *Equisetum telmateia* was unusually branched and low in this habitat, its height was about 30 cm, and, however, the stand was extremely dense.

Sporulation

The number of generative shoots in the studied populations of *E. telmateia* differed significantly. No generative shoots were recorded in two studied populations located in Panemuninkai and Rusių Ragas (Table 3). In spring of 2016, in the entire population of Šaltupys only one generative shoot growing on the edge of forest and meadow was recorded. The number of generative shoots in the other studied populations tended to be higher (Table 3).

Table 3. Number and density of recorded generative shoots in the studied populations of *Equisetum telmateia* in 2015–2016.

Locality	Year of study	Generative shoots	
		recorded number	mean density in 100 m^2
Šaltupys	2016	1	0.01
Rusių Ragas	2016	0	0
Naujoji Rėva	2016	44	1.83
Rokai	2015	32	6.67
Lapainia	2015	33	0.38
Panemuninkai	2016	0	0
Kasčiūnai	2015	191	4.17

The largest number of generative shoots was recorded in Kasčiūnai population. A total of 191 generative shoots in all three subpopulations were counted in 2015. In Rokai and Lapainia, the number of recorded generative shoots was almost equal, though sizes of these populations were significantly different (Table 2 and 3). The highest density of generative shoots in 100 m^2 was recorded in Rokai population; while their density in Kasčiūnai population was more than two times lower (Table 3).

Though the mean density of generative shoots of *E. telmateia* in the entire area of the population indicates the intensity of sporulation, it does not reflect their actual spatial distribution in the habitat. Generative shoots in all studied populations were recorded in somewhat drier places, usually in transitional areas between springs and mesic grasslands or forest stands. In Rokai population, only four generative shoots were found in the petrifying spring habitat, though they were located on small, 10–15 cm high hummocks. Similar tendencies of generative shoot formation in the drier and warmer marginal parts of habitats were also reported from Scandinavia and Central Europe (Dostál, 1984; Ollgaard, 2000).

Studies on *E. telmateia* sporulation were performed at the end of April and at the beginning of May in 2015–2016. In all populations, generative shoots of various development stages were recorded. Some shoots were just emerged from the ground, whereas others were fully shed spores and started to wilt. The development of generative shoots differed even between closely located sub-populations occurring in the same type of habitat. At the beginning of May in 2015, two subpopulations occurring in tall herb fringe habitats in Kasčiūnai were studied. About 70% of generative shoots were already shed spores and 10% were at the beginning of sporulation in the first sub-population. On the same day, about 25% of shoots were shedding spores, whereas most of shoots were in earlier stages of development in the second sub-population. Thus, we can conclude that the development of generative shoots and the time of spore shedding depends on micro conditions of a habitat (illumination, soil humidity, slope exposure, etc.).

Gametophytes of *E. telmateia* have not yet been recorded in Lithuania so far (Naujalis, 2007), however, the presence of generative shoots at least in some populations enable us to suppose that generative reproduction of this species is possible.

Variation

Equisetum telmateia is among the least variable species of the genus. One subspecies, two varieties and one form are listed in the *International Plant Name Index* (IPNI, 2016).

During the investigation on the state of *E. telmateia* populations in Lithuania, several individuals with unusual morphological features were recorded. In the populations of Rokai and Rusių Ragas, the plants with spiral sheath encircling the apical part of the stem and spirally arranged branches were found (Fig. 2). In Rokai population, the recorded individual had four transformed upper nodes and clearly shortened internodes, which were 0.5–0.6 cm long, whereas internodes below were 2.0–3.4 cm long. In Rusių Ragas population, the recorded individual also had four spirally transformed nodes in the upper third part of the stem. The length of transformed internodes varied from 1.5 cm to 2.0 cm, whereas internodes below were 6.0–7.0 cm long. This individual had six normally developed nodes located above the abnormally developed ones. In our opinion, this morpho-

logical transformation can be caused by the influence of external factors (low temperature, mechanical injuries, microorganism actions, etc.) during the early stages of the shoot development rather than with the action of genes (Wróbel, 2003). Our supposition is based on the fact that only solitary shoots had spirally arranged branches, whereas other shoots of the same clone were developed normally.

Fig. 2. Apical part of *Equisetum telmateia* stem with spirally arranged sheath and branches in the population of Rusių Ragas, 2016

Wróbel (2003) has recorded this phenomenon in three populations of *E. telmateia* in Poland and has described this morphotype as a form (f. *spiralis*). Despite Wróbel (2003) has provided Latin name for this morphotype at the rank of form, it cannot be treated as a validly described taxon, because (a) Latin description or diagnosis is absent, which was necessary until 31 December 2011 (Art. 39.1); (b) the type specimen of this taxon has not been indicated (Art. 40.1) (McNeill et al., 2012). Wróbel (2003) uses mainly the term 'morphotype' and occasionally replaces it with Latin term, which formally resembles the name of a taxon (e.g. fo. *spiralis*).

Evaluation applying the *IUCN* criteria

The IUCN (2012a, b) criteria are considered as one of the best methods to evaluate species extinction risk at the global and regional levels (Abeli et al., 2009). Evaluation of the status of *E. telmateia* in Lithuania applying the IUCN criteria resulted in its categorization as a vulnerable species (**VU A4; B 2a, b (iii, iv)**).

One population of *E. telmateia* in Lithuania has become extinct (in the vicinities of Gražiškiai, Vilkaviškis district). Population of this species in the environs of Panemuninkai (Alytus district) is very small and can become extinct within less than 100 years. The area of occupancy of *E. telmateia* in Lithuania is about 80 km^2 (recorded in 8 grid cells), however, the total area of the stands of this species is 2.41 ha (24 120 m^2). Decline in the area of suitable habitats and their quality as well as in the number of localities have been observed.

Globally, *E. telmateia* is considered as a species of least concern (Akhani et al., 2014); however, in all neighbouring countries it is included into the lists of protected species. Single population of *E. telmateia* known in Latvia is the farthest north-eastern point of this species occurrence. In this country, *E. telmateia* is ascribed to the group of very rare species (Eglīte, 2003). In Kaliningrad region of Russia, *E. telmateia* is ascribed to the category of endangered species (Gubareva, 2010), in Belarus, it is very rare and considered as critically endangered (Skuratovich, 2015). In several European countries, including Denmark, Germany, Luxembourg, Switzerland and the United Kingdom, it is classified as species of least concern (Akhani et al., 2014).

Threats and measures for conservation

Evaluation of the size and state of populations and the habitats of *E. telmateia* in Lithuania enabled us to reveal the threats for this protected species. The major threat for the stability of *E. telmateia* populations and habitats is forest logging. Though this species is not particularly sensitive to changes in habitat illu-

mination, in logged areas the density of *E. telmateia* shoots decreases. This may be caused by mechanical destruction of underground parts during tree logging and their transportation from the site. Tree logging has also serious indirect negative impact on the stability of habitats of springs and forests of slopes. Mechanical disturbances of the soil and spring streams can induce changes in hydrological regime and erosion of slopes.

Most of the studied populations of *E. telmateia* (Panemuninkai, Lapainia, Rokai, Rusių Ragas and Naujoji Rėva) occur in the state-owned forests and, therefore, their conservation can be easier organised and controlled. However, two populations (Kasčiūnai and Šaltupys) of this species are in privately owned land areas and their protection can meet certain problems (Gudžinskas & Žalneravičius, 2016). A part of alluvial forest and spring habitats of *E. telmateia* in the privately-owned forest in Kasčiūnai was disturbed in 2015–2016 by tree logging.

Possible threat for the population of *E. telmateia* in Rusių Ragas is the change in water level in the River Neris, in case the planned construction of hydroelectric power station will be carried out. The population of *E. telmateia* is situated along the river in front of and on the lower part of a steep slope. Therefore, a part of the habitat of this species can be inundated, if the river is dammed, whereas the other part of the habitat can be easily destroyed by erosion of steep slope.

A part of *E. telmateia* plants in the population of Naujoji Rėva is periodically mown during the management of the mound slopes. The impact of mowing on the stability of *E. telmateia* populations has not been investigated; however, the survey of the state of population in periodically mown mesophyte meadows let us suppose that mowing is not favourable for this species. Plants growing in occasionally mown meadow habitats are smaller, their habit is not typical and the density of shoots is low. Therefore, mowing of *E. telmateia* during the management of the mound slopes should be avoided. If the maintenance of a proper condition of the mound requires cutting of the herbs and shrubs periodically, the biomass should be immediately collected and removed from the area. Artificially created thick layer of plant remnants is a significant obstacle for the growth of generative as well as of vegetative shoots of *E. telmateia*.

The negative impact of wild boar activity on the state of *E. telmateia* stands in the habitats of mineral-rich springs and petrifying springs with tufa formation was evident. Spring habitats are favoured places for mud-baths of wild boars and they destroy significant areas of vegetation, including *E. telmateia* stands. It is not known whether wild boars eat rhizomes and buds of *E. telmateia*. Quite large areas of suitable habitats for this species were heavily disturbed by wild boars in Lapainia, Naujoji Rėva, Rusių Ragas and Šaltupys localities, whereas in Panemuninkai about 40% of the area occupied by the population of *E. telmateia* was disturbed in 2016. Negative impact of wild boars on the state of protected plant species has been noted in Lithuania, especially in the vicinities of game animal feeding installations (Gudžinskas & Žalneravičius, 2016). Two wild animal feeding areas were recorded in the Lapainia Botanical Reserve within less than 0.5 km distance from the locality of *E. telmateia*, which was apparently damaged by wild boars. In the surrounding habitats of feeding areas, the concentration of wild animals has increased several times (especially the density of wild boars) and their high concentration has a significant negative impact on almost all types of habitats (Gudžinskas, Ryla, 2006; Gudžinskas & Žalneravičius, 2016). Thus, the installation of game animal feeding areas should be legally prohibited in the vicinities of protected areas with high concentration of valuable habitats and protected species.

The stability of certain populations of *E. telmateia* is threatened by invasive alien species. The most expressed threat of invasive species was noted in Rusių Ragas population along the banks of the River Neris. Annual invasive species forming particularly dense stands (e.g. *Echinocystis lobata*, *Impatiens glandulifera*) competes for light during summer and autumn. Perennial clonal invasive species with long underground rhizomes and forming dense stands (e.g. *Solidago gigantea*, *Symphyotrichum lanceolatum*) strongly suppress the growth of the aboveground and underground parts of many native plant species (Pal et al., 2015; Lapin, 2016), therefore, the same impact on *Equisetum telmateia* during entire vegetation season is also expected. Impact of woody invasive species (e.g. *Acer negundo*) on the state of *Equisetum telmateia* is uncertain and should be evaluated in the future. Therefore, control and eradication of invasive

species in certain habitats of *E. telmateia* should be considered as an important measure of conservation.

At drained sites or other habitats undergoing changes in hydrological conditions, *E. telmateia* can survive for several decades, nevertheless, such populations gradually decline until extinction. Gradual decline and unavoidable delayed extinction is characteristic of the populations of long-lived perennials on drained or otherwise damaged habitats (Mattiasson, 2000). Implementation of conservation measures for damaged populations does not ensure their long-term stability and frequently only postpone the extinction.

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REFERENCES

Abeli T., Gentili R., Rossi G., Bedini G., Foggi B., 2009: Can the IUCN criteria be effectively applied to peripheral isolated plant populations? – Biodiversity and Conservation, 18: 3877–3890.

Akhani H., Zehzad B., Brummitt N., 2014: *Equisetum telmateia* (Great Horsetail). – The IUCN Red List of Threatened Species. http://dx.doi.org/10.2305/IUCN.UK.2014-1.RLTS. T203004A42315452.en.

Aplinkos ministerija, 2003: Dėl į Lietuvos raudonąją knygą įrašytų saugomų gyvūnų, augalų ir grybų rūšių sąrašo patvirtinimo. – Valstybės žinios, 100-4506.

Balvočiūtė J., Budriūnas R., Gaidienė E., Ferenca R., Furmonavičius L., Karazija S., Murkaitė R., Purvinas E., Steponavičienė V., Vaškelis J., 1992: Jiesios landšaftiniame draustinyje. – Kaunas.

Dagys J., Kuprevičius J., Minkevičius A., 1934: Vadovas Lietuvos augalams pažinti. – Kaunas.

Dostál J., 1984: *Equisetum* L. – In: Gustav Hegi. Illustrierte Flora von Mitteleuropa. Band 1. Pteridophyta. Teil 1: 55–79. – Berlin–Hamburg.

Eglīte Z., 2003: *Equisetum telmateia* Ehrh. – In: Andrušaitis G. (ed.), Latvijas sarkāna grāmata. Vaskulārie augi: 74. – Rīga.

Eglīte Z., Šulcs V., 2000: Latvijas vaskulāro augu flora. *Lycopodiophyta*, *Equisetophyta*, *Polypodiophyta*. – Rīga.

European Commission, 2013: Interpretation Manual of European Union Habitats. EUR 28. – Brussels.

Fasciani P., Pace L., 2015: Conservation of endangered species: *Androsace mathildae* Levier (*Primulaceae*) in Central Italy. – American Journal of Plant Sciences, 6: 3175–3186.

Gubareva I.J., 2010: *Equisetum telmateia* Ehrh. – In: Krasnaja Kniga Kaliningradskoj oblasti: 203. – Kaliningrad.

Gudžinskas Z., 1983: Didysis asiūklis. – Mūsų gamta, 5: 13.

Gudžinskas Z., Ryla M., 2006: Lietuvos gegužraibiniai (Orchidaceae). – Vilnius.

Gudžinskas Z., Žalneravičius E., 2016: Principles and measures of conservation of the protected plant species and their habitats in south-western Lithuania and recommendations for their implementation. – In: Conservation of Botanical Diversity in South-Western Lithuania: 205–222. – Kaunas.

Guillon J.-M., 2004: Phylogeny of horsetails (*Equisetum*) based on the chloroplast *rps4* gene and adjacent noncoding sequences. – Systematic Botany, 29(2): 251–259.

Guillon J.-M., 2007: Molecular phylogeny of horsetails (*Equisetum*) including chloroplast *atpB* sequences. – Journal of Plant Research, 120: 569–574.

Hauke R.L., 1993: *Equisetaceae*. – In: Flora of North America North of Mexico, 2: 76–84. – Oxford–New York.

Husby C., 2013: Biology and functional ecology of *Equisetum* with emphasis on the giant horsetails. – Botanical Review, 79: 147–177.

IPNI, 2016: International Plant Name Index. – http://www.ipni.org [viewed 12 December, 2016].

IUCN, 2012a: IUCN Red List Categories and Criteria: Version 3.1. Second edition. – Gland–Cambridge.

IUCN, 2012b: Guidelines for Application of IUCN Red List Criteria at Regional and National Levels: Version 4.0. – Gland–Cambridge.

Jalas J., Suominen J. (eds), 1972: Atlas Florae Europaeae. 1. Pteridophyta (*Psilotaceae* to *Azollaceae*). – Helsinki.

Jankevičienė R., 1978: Retieji globotini augalai. – Vilnius.

Jankevičienė R., Lazdauskaitė Ž., 1976: Retesnių Punios šilo floros rūšių apžvalga – In: Punios šilas: 91–106. – Vilnius.

Jankevičienė R., Lekavičius A., Tučienė A., Venckus Z., 1987: Rambynas. – Vilnius.

Lapelė M., 1992: Didysis asiūklis. – In: Balevičius K. (ed.), Lietuvos raudonoji knyga. Retos ir nykstančios gyvūnų, augalų bei grybų rūšys: 298–299. – Vilnius.

Lapin K., 2016: Management of the perennial invasive alien plant Giant goldenrod (*Solidago gigantea*) in the Greater Vienna area. – In: Van Ham C., Genovesi P., Scalera R. (eds), Invasive Alien Species: The Urban Dimension: 16–18. – Brussels.

Lazdauskaitė Ž., Lapelė M., Lekavičius A., Jankevičienė R., Jukonienė I., 1986: Proekt vidov rastenij Krasnoj knigi Litovskoj SSR. – In: Pakalnis R. (ed.), Osnovy ochrany rastitelnogo pokrova Litovskoj SSR: 20–97. – Vilnius.

Lehmann E., 1896: Flora von Polnisch-Livland mit besonderer Berücksichtigung der Florengebiete Nordwestrusslands, des Ostbalticums, der Gouvernements Pskow und St. Petersburg sowie der Verbreitung der Pflanzen durch Eisenbahnen. – Jurjew (Dorpat).

Maes J., Liquete C., Teller A., Erhard M., Paracchini M.L., Barredo J.I., Meiner A., 2016: An indicator framework for assessing ecosystem services in support of the EU Biodiversity Strategy to 2020. – Ecosystem Services, 17: 14–23.

Mattiasson G., 2000: *Equisetum telmateia* – expansion and decline. – Svensk Botanisk Tidskrift, 94(1): 53–55.

McNeill J., Barrie F.R., Buck W.R., Demoulin V., Greuter W., Hawksworth D.L., Herendeen P.S., Knapp S., Marhold K., Prado J., Prud'homme van Reine W.F., Smith G.F., Wiersema J.H., Turland N.J. (eds), 2012: International Code of Nomenclature for algae, fungi, and plants (Melbourne Code), adopted by the Eighteenth International Botanical Congress Melbourne, Australia, July 2011. – Königstein.

Minkevičius A., 1959: Asiūkliniai – *Equisetaceae*. – In: Natkevičaitė-Ivanauskienė M. (ed.), Lietuvos TSR flora, 1: 52–69. – Vilnius.

Natkevičaitė-Ivanauskienė M., 1961: Merkio salpos pievos. – Lietuvos TSR aukštųjų mokyklų mokslo darbai. Biologija, 1: 225–254.

Natkevičaitė-Ivanauskienė M., 1994: Lietuvos herbaras. – Lietuvos mokslas, 2 (1(2)): 66–76.

Naujalis J.R., 2007: Didysis asiūklis – *Equisetum telmateia* Ehrh. – In: Rašomavičius V. (ed.) Lietuvos raudonoji knyga: 388. – Vilnius.

Ollgaard B., 2000: *Equisetaceae*. – In: Jonsell B. (ed.), Flora Nordica. 1. Lycopodiaceae to Polygonaceae: 20–25. – Stockholm.

Pal R.W., Chen S., Nagy D.U., Callaway R.M., 2015: Impacts of *Solidago gigantea* on other species at home and away. – Biological Invasions, 17(11): 3317–3325.

Parfenov V., Lekavičius V., Kozlovskaja N., Vynaev G., Jankevičienė R., Balevičienė J., Lazdauskaitė Ž., Lapelė M., 1987: Redkie i isčezajuščie vidy rastenij Belorusii i Litvy. – Minsk.

Piękoś-Mirkowa H., Mirek Z., 2003: Atlas roślin chronionych. Flora Polski. – Warszawa.

Priedītis N., 2014: Latvijas augi. – Rīga.

Rašomavičius V. (ed.), 2012: EB svarbos natūralių buveinių inventorizavimo vadovas. – Vilnius.

Skuratovich A.N., 2009: Equisetophyta. – In: Parfenov V.I. (ed.), Flora Belorusi. Sosudistye rastenija. 1. Lycopodiophyta, Equisetophyta, Polypodiophyta, Ginkgophyta, Pinophyta, Gnetophyta: 50–59. – Minsk.

Skuratovich A.N., 2015: *Equisetum telmateia* Ehrh. – In: Krasnaja kniga Respubliki Belarus. Rastenija (4th ed.): 18–19. – Minsk.

Snarskis P., 1954: Vadovas Lietuvos TSR augalams pažinti. – Vilnius.

Stanich N.A., Rothwell G.R., Stockey R.A., 2009: Phylogenetic diversification of *Equisetum* (*Equisetales*) as inferred from lower cretaceous species of British Columbia, Canada. – American Journal of Botany 96(7): 1289–1299.

Stępień E., 2009: The conditions of occurrence of *Equisetum telmateia* Ehrh. in lowland locality in Western Pomerania. – Ekologia (Bratislava), 28(4): 399–411.

Šidla L., 1960: Didysis asiūklis (*Equisetum maximum* Lamk.) Lietuvoje. – Vilniaus valstybinio V. Kapsuko vardo universiteto mokslo darbai, 36 (7): 41–45.

Vannestea K., Stercka L., Myburgc A.A., Van de Peera Y., Mizrachic E., 2015: Horsetails are ancient polyploids: evidence from *Equisetum giganteum*. – The Plant Cell, 27(6): 1567–1578.

Wang C.-J., Wan J.-Z., Zhang Z.-X., Zhang G.-M., 2016: Identifying appropriate protected areas for endangered fern species under climate change. – SpringerPlus, 5: 904. DOI 10.1186/s40064-016-2588-4.

Wróbel D., 2013: *Equisetum ×robertsii* (*E. telmateia* × *E. arvense*; Equisetaceae) in Poland. – Acta Botanica Silesiaca, 9: 57–66.

Zając A., Zając M. (eds), 2001: Atlas rozmieszczenia roślin naczyniowych w Polsce. – Kraków.

DIDŽIOJO ASIŪKLIO (*EQUISETUM TELMATEIA*) PAPLITIMAS, BŪKLĖ IR APSAUGA LIETUVOJE

Zigmantas Gudžinskas, Mindaugas Rasimavičius

Santrauka

Išsamūs saugomų augalų rūšių paplitimo, populiacijų ir buveinių dydžio bei būklės tyrimai ypač svarbūs siekiant nustatyti tinkamą rūšies apsaugos režimą ir būtinas apsaugos priemones. Didysis asiūklis (*Equisetum telmateia* Ehrh.) Lietuvoje yra retas saugomas augalas, tačiau iki šiol nebuvo išsamiai įvertintas jo populiacijų dydis, kylančios grėsmės ir apsaugos poreikis. Atliktų tyrimų tikslas buvo įvertinti dabartinį didžiojo asiūklio paplitimą Lietuvoje, nustatyti populiacijų užimamą plotą, įvertinti populiacijų ir buveinių būklę.

Išnagrinėjus literatūroje skelbtą, herbariumuose ir duomenų bazėse sukauptą informaciją nustatyta, kad dabar didysis asiūklis Lietuvoje aptinkamas septyniose vietovėse, kurių dauguma telkiasi pietinėje šalies dalyje. Viena populiacija, buvusi Gražiškių apylinkėse (Vilkaviškio r.) yra išnykusi. Manome, kad didžiojo asiūklio radavietė dabartiniame Rambyno regioniniame parke (Pagėgių sav.) nurodyta klaidingai. Kalesninkų apylinkėse (Šalčininkų r.) nurodyta šios rūšies radavietė nepatikrinta ir rūšies tapatybė kol kas nepatvirtinta.

Įvertinus didžiojo asiūklio populiacijas nustatyta, kad šalyje visos jos užima 2,41 ha plotą. Didžiausios rūšies populiacijos yra Lapainios upelio slėnyje (Kaišiadorių r.), Šaltupio k. apylinkėse (Utenos r.) ir Kasčiūnų k. apylinkėse (Varėnos r.). Blogiausia yra Nemuno kilpų regioniniame parke, netoli Panemuninkų k. esančios populiacijos būklė. Ji užima labai mažą plotą (apie 240 m^2), o visoje populiacijoje 2016 m. buvo tik 104 ūgliai. Dviejose iš septynių tirtų populiacijų 2015–2016 m. generatyvinių ūglių neaptikta, dar vienoje populiacijoje rastas tik vienas generatyvinis ūglis. Kitose populiacijose jų buvo aptikta po nedaug.

Dauguma didžiojo asiūklio populiacijų telkiasi upių slėniuose ir šlaituose. Augalas dažniausiai auga aliuviniuose miškuose, kurie sudaro buveinių kompleksus su nekalkingais šaltiniais arba šaltiniais su besiformuojančiais tufais. Daug rečiau didysis asiūklis įsikuria šlaitų miškų, aukštųjų eutrofinių žolynų ir mezofitų pievų buveinėse.

Įvertinus didžiojo asiūklio populiacijų dydį, būklę ir kylančias grėsmes nustatyta, kad ši rūšis turi būti priskirta prie pažeidžiamų rūšių (VU) kategorijos. Svarbiausios grėsmės, keliančios pavojų rūšies populiacijoms, yra buveinių pažaidos dėl miškų kirtimo ir drėkinimo režimo pokyčiai, kurie gali kilti tiek dėl natūralių priežasčių, tiek ir dėl žmonių poveikio. Tam tikrą neigiamą įtaką didžiojo asiūklio populiacijoms daro šernai, žmonių veikla buveinėse ir svetimžemių rūšių augalų invazijos į buveines.

APPENDIX 1. THE LIST OF EXAMINED HERBARIUM SPECIMENS OF *EQUISETUM TELMATEIA*

Herbarium specimens in the list were arranged chronologically. The text of herbarium labels was translated into English and some orthographical errors of geographical names were corrected as well as all abbreviations were expanded. Four-digit code in square brackets (e.g. [5225]) refers to the number of the grid-cell on the map (Fig. 1). The acronym of the herbarium follows by the specimen number (*in italics*).

Kybartai distr. (now Vilkaviškis distr.), environs of Gražiškiai, between Duonelaičiai and Gražupiai villages, springy valley of a rivulet in a ravine, 10 August 1957, leg. et det. L. Šidla [5517]. BILAS, *17165*.

Varėna distr., Puvočiai, right bank of the River Merkys, grazed springy forest of black alder, 19 June 1959, leg. et det. R. Murkaitė [5825]. WI, *P05704*.

Varėna distr., Puvočiai, right springy bank of the River Merkys, in alder stand, 20 June 1975, leg. et det. R. Bandžiulienė [5825]. WI, *P05701*.

Varėna distr., Puvočiai, near pine forest, at a spring, 16 May 1976, leg. et det. E. Šaltytė [5825]. WI, *P0703*.

Varėna distr., Puvočiai, on a slope at the spring, 12 August 1976, leg. et det. E. Šaltytė [5825]. WI, *s. n.*

Kaišiadorys distr., 5.5 km southwest of Kruonis, springy bank of the River Lapainia, very abundant, 25 July 1982, leg. et det. Z. Gudžinskas [5225]. BILAS, *65306*.

Kaišiadorys distr., 5.5 km southwest of Kruonis, valley of the River Lapainia, on springy slope, 25 July 1982, leg. et det. Z. Gudžinskas [5225]. BILAS, *43236*.

Širvintos distr., environs of Čiobiškis, at the foot of the right bank of the River Neris, among shrubs, abundant, 15 July 1986, leg. et det. M. Lapelė [5027]. BILAS, *68312*.

Širvintos distr., 4 km east of Čiobiškis, slope of the River Neris, quite abundant, 7 July 1987, leg. et det. A. Kulbis [5027]. BILAS, *42911*.

Varėna distr., Kasčiūnai village, springy slope of the River Merkys, 20 July 1999, leg. et det. J. Naujalis and L. Balčiūnaitė [5825]. WI, *P27443*; *P27443*, *P27444*.

Varėna distr., environs of Puvočiai, Kasčiūnai village, sandy bank of the River Merkys, 20 July 1999, leg. et det. J. Naujalis and L. Balčiūnaitė [5825]. WI, *P27445*.

Varėna distr., Puvočiai, Dzūkija National Park, right bank of the River Merkys, slope of the upper terrace, black alder stand with springs, in calcareous soil, quite abundant, 12 June 2000, leg. et det. R. Čiuplys [5825]. BILAS, *65749*.

Varėna distr., environs of Puvočiai, Kasčiūnai village, right bank of the River Merkys, on a slope at the edge of pine forest, quite abundant, 12 June 2000, leg. et det. Z. Gudžinskas [5825]. BILAS, *70328*.

Varėna distr., environs of Puvočiai, on the right bank of the River Merkys, on a slope at a rivulet, quite abundant, 12 June 2000, leg. et det. Z. Gudžinskas [5825]. BILAS, *70330*.

Utena distr., between Karveliškės and Šaltupys villages, forest block No. 480, parcel No. 55, in mineral-rich spring and spring fen habitat, 21 July 2013, leg. et det. V. Kreile and B. Kalva [4433]. BILAS, *s. n*.

Kaišiadorys distr., 5.5 km southwest of Kruonis, valley of the River Lapainia, in black alder stand, few generative shoots, 25 April 2015, leg. et det. Z. Gudžinskas [5225]. BILAS, *77249*.

Kaunas distr., environs of Rokai, Vingytė village, springy slope of a hill, quite few generative shoots, 25 April 2015, leg. et det. Z. Gudžinskas [5123]. BILAS, *77250*.

Utena distr., between Karveliškės and Šaltupys villages, in black alder stand with mineral-rich springs, abundant, 18 September 2016, leg. et det. Z. Gudžinskas [4433]. BILAS, *77251*.

Vilnius distr., 2 km north-west of Šilėnai, foot of north east slope of Naujoji Rėva mound, at a spring, abundant, 18 September 2015, leg. et det. Z. Gudžinskas [5230]. BILAS, *77257*.

Utena distr., environs of Karveliškės village, in depression with springs, 12 August 2016, leg. et det. M. Rasimavičius [4433]. WI, *P33605*.

Varėna distr., environs of Puvočiai, Kasčiūnai village, upper part of a slope, on the bank of a pond, in wet gravel, very abundant, 27 September 2016, leg. et det. Z. Gudžinskas [5825]. BILAS, *77252*.

Kaunas distr., environs of Rokai, Vingytė village, about 200 m from the River Jiesia, springy slope of a hill, abundant, 31 August 2016, leg. et det. Z. Gudžinskas [5123]. BILAS, *77253*.

Kaunas distr., environs of Rokai, Vingytė village, about 150 m from railway, springy slope at the pond overgrown with reeds, abundant, 31 August 2016, leg. et det. M. Rasimavičius [5123]. WI, *P33601*.

Širvintos distr., about 3 km north-west of Čiobiškis and north of Rusių Ragas, on the right bank of the River Neris, in eutrophic tall herb habitat, quite sparsely, 5 September 2016, leg. et det. Z. Gudžinskas [5027]. BILAS, *77254*.

Širvintos distr., about 3 km north-west of Čiobiškis and north of Rusių Ragas, on the right bank of the River Neris, forms several isolated patches, 5 September 2016, leg. et det. M. Rasimavičius [5027]. WI, *P33602*.

Alytus distr., Nemuno Kilpos Regional Park, Punia forest, 2 km north of Panemuninkai, left bank of the River Nemunas, springy slope, quite sparsely, 9 September 2016, leg. et det. Z. Gudžinskas [5424]. BILAS, *77255*.

Alytus distr., Nemuno Kilpos Regional Park, Punia forest, 2 km north of Panemuninkai, left bank of the River Nemunas, in front of Staniava village, springy slope, sparsely, 9 September 2016, leg. et det. M. Rasimavičius [5424]. WI, *P33603*.

Vilnius distr., 2 km north-west of Šilėnai, foot of north east slope of Naujoji Rėva mound, at a spring, abundant, 6 September 2016, leg. et det. Z. Gudžinskas [5230]. BILAS, *77256*.

Vilnius distr., 2 km north-west of Šilėnai, foot of north east slope of Naujoji Rėva mound, at a spring, abundant, 6 September 2016, leg. et det. M. Rasimavičius [5230]. WI, *P33604*.

Erroneously identified specimens

Druskininkai, in forest park, springy clay slope of the River Nemunas in front of the river islet, 1 June 1974, leg. et det. A. Lekavičius [5923]. BILAS, *20768*. – *Equisetum arvense* L.

Varėna district (now Druskininkai distr.), the Raigardas Landscape Reserve, at a foot of springy slope, few individuals, 5 August 1975, leg. et det. A. Lekavičius [6023]. BILAS, *66166*. – *Equisetum arvense* L.

Varėna distr. (now Druskininkai distr.), the Raigardas Landscape Reserve, at a foot of the slope, 6 August 1975, leg. et det. A. Lekavičius [6023]. BILAS, *20769*. – *Equisetum arvense* L.

Varėna distr. (now Druskininkai distr.), Druskininkai Forest Enterprise, Druskininkai Forestry, the Raigardas Landscape Reserve, on a bank of drained rivulet, in black alder stand, 11 July 1991, leg. et det. M. Lapelė [6023]. BILAS, *51219*. – *Equisetum fluviatile* L.

Druskininkai, the Druskininkai Botanical Reserve, on the right bank of the River Nemunas, in front of Meilė Islet, on springy slope, 12 July 1991, leg. et det. M. Lapelė [5923]. BILAS, *51218*. – *Equisetum arvense* L. and *Equisetum fluviatile* L.