

RANGE EXTENSION OF *ORTHODICRANUM TAURICUM* (BRYOPHYTA, DICRANACEAE) IN CENTRAL-EAST EUROPE

ADAM STEBEL, VITALIY M. VIRCHENKO, VÍTĚZSLAV PLÁŠEK, RYSZARD OCHYRA
& HALINA BEDNAREK-OCHYRA

Abstract. In a few recent decades a unique phenomenon of the remarkable range extension of *Orthodicranum tauricum* (Sapjegin) Smirnova in Europe is observed. This is in contrast to the reaction of many other epiphytic moss species which in the response to the heavy air pollution markedly reduced the number and size of their populations. The current distribution of *O. tauricum* (Sapjegin) Smirnova in Central-East Europe, including Poland, Ukraine, Czech Republic, Slovakia, Belarus and Russia, is reviewed. The species has rapidly expanded its range in most of these countries and at present it is known from about 500 localities in the vast territory of Central-East Europe, but still being less frequent eastwards. Maps of the current distribution of *O. tauricum* in the Czech Republic, Slovakia, Poland and the Ukraine are presented and the global distribution map of the species in Central-East Europe is also included. Information about the altitudinal range, habitats, size of populations and reproduction in the study area are provided.

Key words. Belarus, bryogeography, Czech Republic, expanding species, Musci, Poland, Slovakia, Russia, Ukraine

Adam Stebel, Department of Pharmaceutical Botany, Medical University of Silesia in Katowice, Ostrogórska 30, 41-200 Sosnowiec, Poland; e-mail: astebel@sum.edu.pl

Vitaliy M. Virchenko, Department of Lichenology and Bryology, Institute of Botany, National Academy of Sciences, Tereshchenkivska 2, 01601 Kiev, Ukraine; e-mail: v_virchenko@ukr.net

Vítězslav Plášek, Department of Biology and Ecology, University of Ostrava, Chittussiho 10, Ostrava CZ-710 00, Czech Republic; e-mail: vitezslav.plasek@osu.cz

Ryszard Ochyra & Halina Bednarek-Ochyra, Laboratory of Bryology, Institute of Botany, Polish Academy of Sciences, Lubicz 46, 31-512 Kraków, Poland; e-mails: h.bednarek@botany.pl and r.ochyra@botany.pl

INTRODUCTION

Orthodicranum tauricum (Sapjegin) Smirnova (Figs 1–2) is a Euro-North American species that is widespread throughout Europe and in western North America where it ranges along the Pacific coast from southeastern Alaska to central California, Utah and northern Colorado and extends eastward to Saskatchewan, South Dakota and Nebraska (Ireland 2007). A unique feature of this species is its rapid spreading in recent decades in Europe. In contrast to many epiphytic species which markedly decline their ranges and become threatened due to air pollution, *O. tauricum* exhibits an unusual opposite tendency.

Since the 1980's it is observed to have a remarkable expansion of its geographical range in many European countries (Düll & Meinunger

1989; Hegewald 1991; Greven 1992; Söderström 1992; Erzberger 1999; Meinunger & Schröder 2007; Németh 2009). The causes of the spread of *Orthodicranum tauricum* are still unclear, although it has been suggested that it may be associated with air pollution, especially acid rain. This phenomenon has almost always been considered devastating for bryophytes resulting in remarkable reductions in the number and size of moss populations, but it appears that it could be favourable for some species such as *O. tauricum* (Söderström 1992).

Until the 1990's *Orthodicranum tauricum* had its maximum occurrence in western Europe but in two recent decades it becomes more and more frequent in Central-East Europe, especially in



Fig. 1. Habit of *Orthodicranum tauricum* (photo by V. M. Virchenko).



Fig. 2. Plants of *Orthodicranum tauricum* with broken tips of leaves, a characteristic feature of the species (photo by V. Plášek).

Poland and the Czech Republic. However, the new records of the species also have been reported from the Eastern European Lowlands of the Ukraine and Russia.

The purpose of this article is to summarise all available data about distribution and habitat preferences of *Orthodicranum tauricum* in the countries of Central-East Europe. All available herbarium specimens were revised and details of particular localities were set in the data-base with the following categories: habitat, phorophyte, phytocoenoses and altitude. Results of analysis are

discussed and presented on graphs. Current distribution of *O. tauricum* in Central-Eastern Europe is mapped (Fig. 3).

A REVIEW OF THE DISTRIBUTION IN CENTRAL-EAST EUROPE

CZECH REPUBLIC – In the Czech Republic *Orthodicranum tauricum* was first discovered in 1975 by Z. Pilous and the voucher specimen is housed in BRNM. Plášek (2001) assembled all the literature

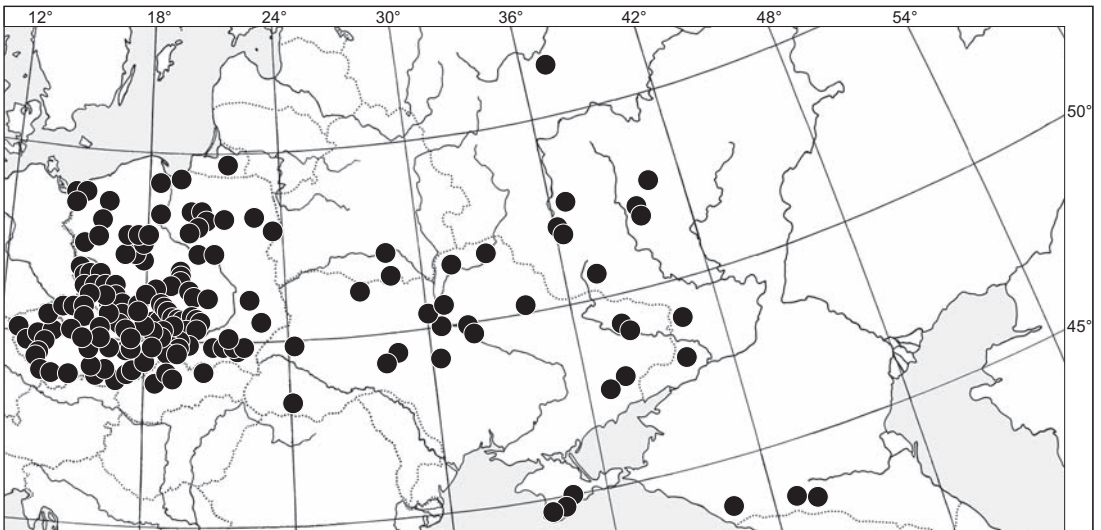


Fig. 3. Distribution of *Orthodicranum tauricum* in Central-East Europe.

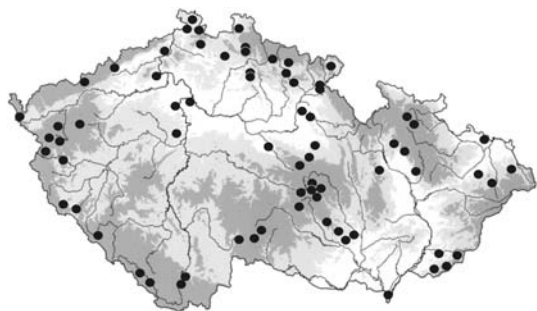


Fig. 4. Distribution of *Orthodicranum tauricum* in the Czech Republic.

and herbarium data and published the distribution of the taxa in the Czech Republic. In that article 52 known localities were reported together with map and results of analyses of ecological requirements of the species. Since then the number of records markedly increased and at present *O. tauricum* is known from about 120 stations (Fig. 4).

Most of them come from the submontane and montane areas and in the lowlands *O. tauricum* was recorded less often. Nevertheless, data about its distribution reflect the state of exploration of the country rather than its real distribution. More often visited areas, such as the Krkonoše mountains (Giant Mountains), Český les mountains, Bílé Karpaty mountains and Žďárské vrchy hills recorded most of the data. The highest increase of recorded sites was in the last 20 years but in the last decade the number of new discoveries increased twice in comparison to earlier records.

SLOVAKIA – As is the case with other bryophytes, knowledge of the distribution of *Orthodicranum tauricum* in Slovakia is still very poor. So far, no

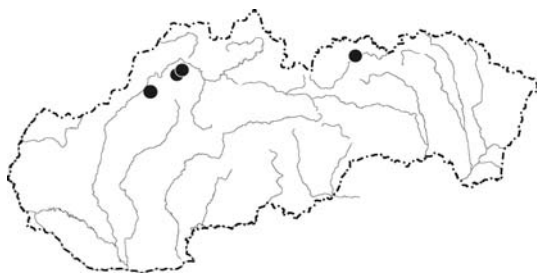


Fig. 5. Distribution of *Orthodicranum tauricum* in Slovakia.

account on the distribution or ecology of moss taxa was published in this country. Recently, on the basis of herbarium studies, only four records of *O. tauricum* in Slovakia have been detected (Fig. 5). The species was recorded for the first time in this country in 1994 by J. Duda (the voucher specimen is housed in BRNM). It was found in the northern part of Slovakia near the border with Poland in the eastern part of the Pieniny mountains.

The other three localities are situated in the western part of the country in the foothills of the Velká Fatra mountains. Considerable parts of these mountain ranges are made of various Mesozoic rocks (limestone, dolomite) and the mountain ridges are usually separated by canyon-like valleys. Nearly 90% of the area is covered by beech and beech-fir forests, or in some places by spruce plantations. The last finding of *O. tauricum* was made in 2009 also by J. Duda and the specimen is stored as part of the private collection of Z. Hradílek in Olomouc in the Czech Republic.

POLAND – It was generally accepted that in Poland *Orthodicranum tauricum* was recorded for the first time by Mondelska (1932) in Ludwikowo near Poznań in the Wielkopolska region. However, recently it was discovered that the first record of the species in Poland should be credited to F. Hintze who collected the moss near the village of Ubiedrze (*germ.* Ubedel) in Western Pomerania (Loeske 1922).

For over half a century only a few additional records of the species were made and the first overview of *O. tauricum* in Poland yielded only several localities scattered throughout the country (Bocheński 1986). However, since the late 1980's many new localities of this species have been reported. This information was summarised by Stebel *et al.* (2008, 2012). At present, *O. tauricum* is known from over 200 localities, distributed through the whole country (Fig. 6). The concentration of its localities in certain regions, for example in Silesia (Stebel & Plášek 2001), reflects the best knowledge of the bryoflora of these areas rather than the lack of the species in other parts of the country.

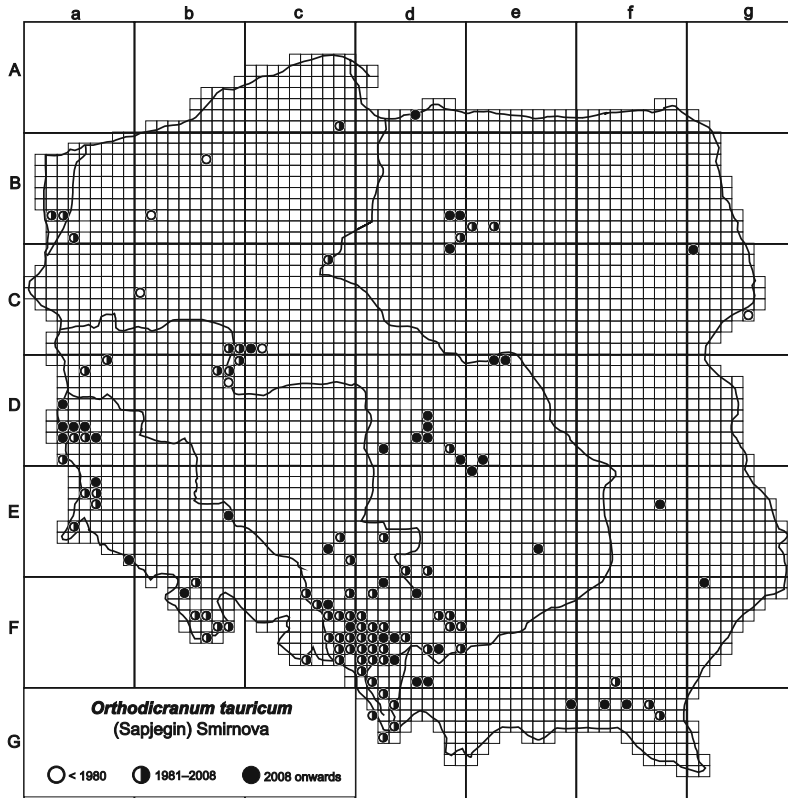


Fig. 6. Distribution of *Orthodicranum tauricum* in Poland.

UKRAINE – *Orthodicranum tauricum* was described for the first time as a species in its own right from the Crimea on the basis of the specimens collected at 11 localities (Sapjegin 1910). The species was subsequently collected in this area by other Ukrainian bryologists, including D. Zerov, V. Melnychuk, M. Slobodyan, L. Partyka and O. Vysotska. In the Crimea *O. tauricum* occurs sporadically in the southeastern coastal areas from Mt. Ai-Petri, in outskirts of Alupka, to the town of Sudak (Partyka 2005).

Apart from the Crimea, *Orthodicranum tauricum* was found in ten provinces in the Ukraine: Zakarpatska province (4 localities), Lviv province (1 locality), Rivne province (1 locality), Vinnytsia province (2 localities), Kiev province (5 localities), Chernihiv province (2 localities), Cherkasy province (1 locality), Poltava province (1 locality), Luhansk province (3 localities),

and Donetsk province (1 locality). In the lowland of the Ukraine the species was collected by V. Virchenko, H. Bachuryyna, M. Slobodyan, B. Balkovskiy and others. Most Ukrainian specimens of *O. tauricum* are kept in the bryological herbarium of the M. H. Kholodny Institute of Botany of National Academy of Sciences of the Ukraine (KW) and some of them are housed in the herbarium of the Lviv Natural History Museum (LWS). The Sapjegin collection of the Crimean mosses is probably lost. It should be added that the species is known from Transcarpathia only from the literature and no voucher specimens have been located (Slobodyan 1951; Šmarda & Vaňek 1955).

Thus, *Orthodicranum tauricum* occurs in the western, central, northern and southeastern Ukraine and in the Crimea (Fig. 7). The discovery of the species at new stations in the central and northern

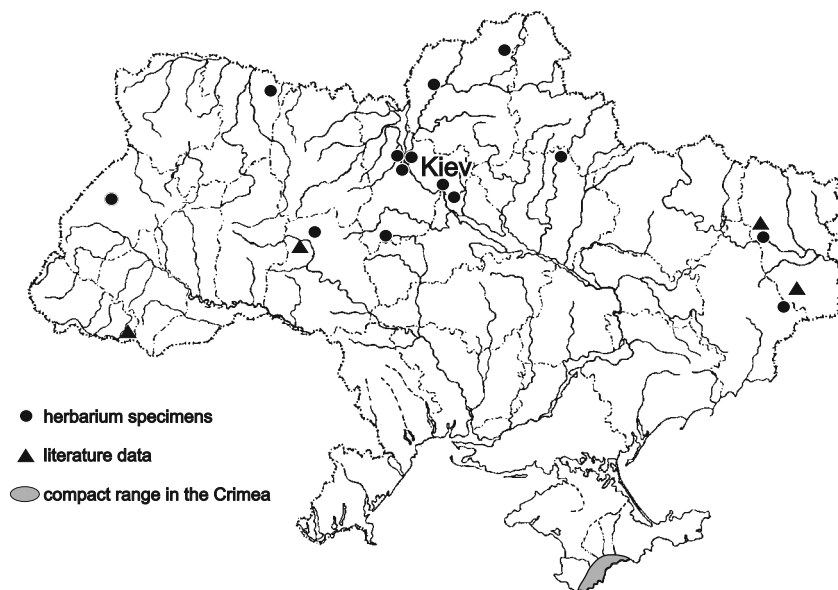


Fig. 7. Distribution of *Orthodicranum tauricum* in the Ukraine.

parts of the country during the last 20–25 years indicates that it has spread there.

BELARUS – There are only a few records of *Orthodicranum tauricum* in Belarus situated at elevations below 160 m a.s.l. For the first time the species was reported from one site in the south of Homel province by the Ukrainian bryologist A. S. Lazarenko (1951) and it has not been rediscovered since at this station. After that *O. tauricum* was recorded at two stations in the Pripjatskiy National Park of the same province (Rykovskiy & Maslovskiy 2004; Rykovskiy *et al.* 2010). There is also a record of the species from Białowieża Forest (Kujala 1936) but because the detailed locality data are missing it is uncertain whether the record is from the Polish or Belarus part of the forest.

RUSSIA – There are three centres of occurrence of *Orthodicranum tauricum* in Russia. Two of them were reviewed by Ignatova and Fedosov (2008). The species is widely distributed but scattered in Central Russian Upland including Moscow, Orel, Kursk, Belgorod, Voronezh, Lipetsk and Rostov

provinces (Popova, 2002; Ignatov *et al.* 2006) which are all situated at low elevations, generally below 290 m a.s.l. In the recent decade the species was discovered in the Northern Caucasus including Kabardino-Balkaria, Karachaevo-Cherkessia and North Ossetia where it occurs at montane elevations of 1600–2100 m. These records date from 1995 and it may indicate the species is spreading eastward. Additionally, *O. tauricum* was once recorded in Kaliningrad province in the Baltic region (Ignatov *et al.* 2006) (Fig. 3).

ALTITUDINAL RANGE

Orthodicranum tauricum is a lowland species. An analysis of 331 records of the species in Central-East Europe for which altitudinal data are available showed that 68.3% of its localities lie below an altitude of 399 metres (Fig. 8). The highest station of the species is situated at 1820 m a.s.l. on Mt. Neniska (*roman.* Mika-Mare) in the Marmaroske Karpaty mountains (Maramuresz Mountains) in the Eastern Carpathians on the Ukrainian-Romanian border (Slobodyan 1951). In Poland the highest

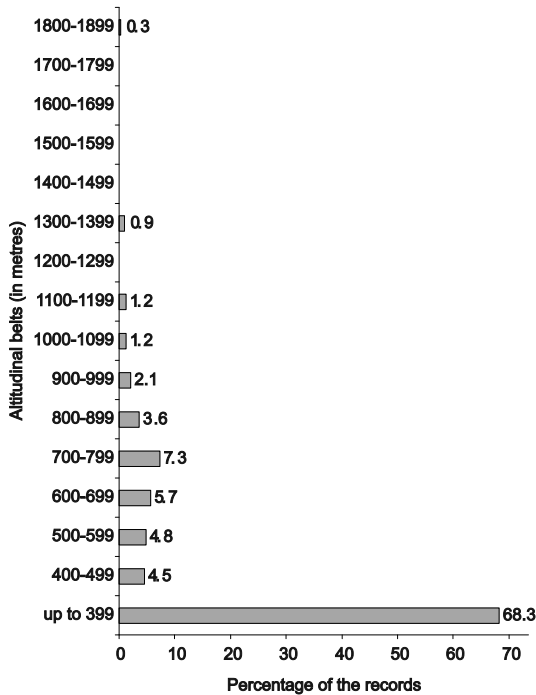


Fig. 8. Altitudinal distribution of *Orthodicranum tauricum*.

elevation of *O. tauricum* was recorded at 1186 m a.s.l. in the Karkonosze mountains (Giant Mountains) in the Sudetes (Dunajski & Fudali 2007). Finally, in the Czech Republic the highest locality of this species is at 1300 m a.s.l. in the Šumava mountains (Plášek 2001), whereas in Slovakia at 1164 m a.s.l. (*leg. J. Duda*, 23 September 2000, private herbarium of J. Duda, unpublished data).

No elevational data are available for three records of *Orthodicranum tauricum* in Belarus. Here, the species was collected in the Pripjat Polesye region which is situated in the East European Lowlands where the highest elevations do not exceed 160 m a.s.l.

At similar altitudes the species grows in the lowland sites in Russia where the elevations extend from below 180 to 290 m a.s.l., whereas the mean elevation of Kaliningrad province in the Baltic region is below 100 m a.s.l. However, in the Caucasus *O. tauricum* was only found in fir and pine forests at elevations ranging from 1600 to 2100 m

a.s.l. but it is absent from the coastal areas of the Black Sea (Ignatova & Fedosov 2008).

HABITATS

Analysis of available data (374 records) showed that *Orthodicranum tauricum* occurs mainly in epiphytic habitats (58.8% records), whereas in terrestrial habitats it grows sporadically (only 0.6% of records) (Fig. 9).

Amongst phorophytes (234 available records), *Orthodicranum tauricum* often grows on bark of birch (23.5%) and of the two species of this tree on which it was found it definitely prefers *Betula pendula* Roth over *B. pubescens* Ehrh. The other tree on which the species thrives most often is oak (20.9%). Of several species of this genus, *O. tauricum* was most often recorded on *Quercus robur* L. and only occasionally on *Q. petraea* (Matt.) Liebl., *Q. rubra* L. and *Q. pubescens* Willd. On the latter tree it was found only in the Crimea. The third tree which *O. tauricum* prefers is beech (20.1%) including the widespread European species *Fagus sylvatica* L. and only in the Crimea it was also found on *F. sylvatica* subsp. *moesiaca* (Maly) Hjelm. Occasionally, *O. tauricum* was discovered on bark of such species, as *Cerasus avium* (L.) Moench, *Crataegus monogyna* Jacq., *Larix decidua* Mill., *Pinus pallasiana* D. Don (only in the Crimea), *Populus* spp., *Pseudotsuga taxifolia* Britton, *Pyrus communis* L., *Robinia pseudoacacia* L., *Sambucus nigra* L. and *Sorbus*

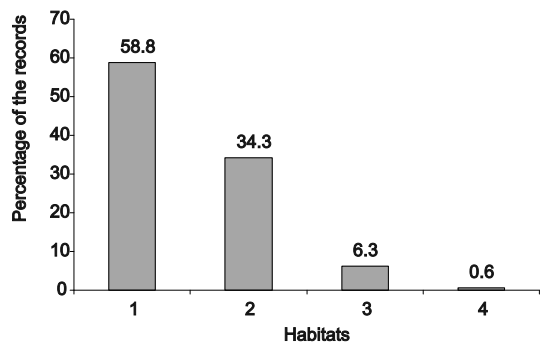


Fig. 9. Occurrence of *Orthodicranum tauricum* on main habitat types. 1 – epiphytic, 2 – epixylic, 3 – epilithic, 4 – terrestrial.

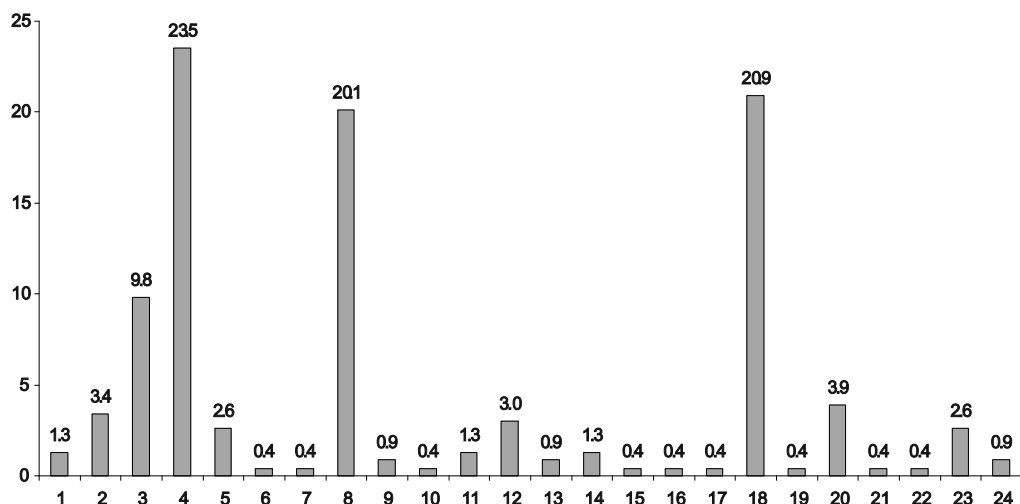


Fig. 10. Occurrence of *Orthodicranum tauricum* on main phorophytes in Central-East Europe. 1 – *Abies alba*, 2 – *Acer* spp., 3 – *Alnus glutinosa*, 4 – *Betula* spp., 5 – *Carpinus betulus*, 6 – *Cerasus avium*, 7 – *Crataegus monogyna*, 8 – *Fagus sylvatica*, 9 – *Fraxinus excelsior*, 10 – *Larix decidua*, 12 – *Picea abies*, 13 – *Pinus pallasiana*, 14 – *Pinus sylvestris*, 15 – *Populus* sp., 16 – *Pseudotsuga menziesii*, 17 – *Pyrus communis*, 18 – *Quercus* spp., 19 – *Robinia pseudoacacia*, 20 – *Salix* spp., 21 – *Sambucus nigra*, 22 – *Sorbus aucuparia*, 23 – *Tilia cordata*, 24 – *Ulmus* spp.

aucuparia L. (Fig. 10). In the Crimea *O. tauricum* was found in beech, oak and pine forests growing on roots, bases of trunks, stumps, rotten wood of *Fagus sylvatica* subsp. *moesiaca* (= *Fagus* × *taurica* Popl.), *Quercus pubescens*, *Q. petraea*, and *Pinus pallasiana*. When growing on tree trunks, *O. tauricum* is found mostly from the base to a height of about 5 m.

Orthodicranum tauricum occurs fairly frequently on epixylic habitats (34.3% records), including stumps, logs and small pieces of wood. These two kinds of habitats, connected with trees and shrubs, comprise over 90% of occurrences of *O. tauricum* in the study area.

Moreover, *O. tauricum* grows also, though very rarely, in epilithic habitats. These include mainly erratic blocks (in the lowlands) and various types of acidic rock, such as basalt, gneiss and schist (in the mountains). According to a literature record (Balkovskiy & Savostianov 1939) *O. tauricum* occurs also on granite outcrops. Occurrence of the species on humic soil was observed occasionally.

Although *Orthodicranum tauricum* is primarily a forest species, it sometimes grows on wayside or solitary trees, but in these cases they are almost

always near the forest roads and paths. This species prefers deciduous forests, mainly dominated by beech which form associations of the *Fagion silvaticae* alliance (Fig. 11), riverside forest (associations of the *Alno-Ulmion* alliance) and oak-linden-hornbeam (associations of the *Carpinion betuli* alliance) (Fig. 12). In addition, there are frequent findings of the species in mixed forests, often of anthropogenic origin. In coniferous forests it occurs only rarely. Sometimes *O. tauricum* grows in old parks and orchards (Fig. 13). Phytocoenotic preferences of *O. tauricum* is presented in Figure 14.

POPULATIONS

Orthodicranum tauricum grows in compact, rigid, dark green tufts which covering mainly up to several dozen square decimetres. However, sometimes the populations are very large and occupy a few square metres.

ACCOMPANYING SPECIES

Orthodicranum tauricum usually forms pure stands, but quite often it grows with a small



Fig. 11. Beech forest – the most frequent habitat of *Orthodicranum tauricum*. Poland, Boże Oczko Nature Reserve in the Silesian Upland (photo by A. Stebel, 16 September 2010).

admixture of other bryophytes. These are mainly common, mainly acidophilous species, such as *Brachythecium rutabulum* (Hedw.) Schimp., *Calli-cladium haldanianum* (Grev.) H. A. Crum (mainly in the Ukraine), *Dicranum scoparium* Hedw., *Herzogiella seligeri* (Brid.) Z. Iwats., *Hypnum cupressiforme* Hedw., *H. pallescens* (Hedw.) P. Beauv., *Lophocolea heterophylla* (Schrad.) Dumort., *Orthodicranum montanum* (Hedw.) Loeske, *Plagiothecium curvifolium* Limpr., *P. denticulatum* (Hedw.) Schimp., *P. laetum* Schimp., *Platygyrium repens* (Brid.) Schimp., *Pohlia nutans* (Hedw.) Lindb., and *Ptilidium pulcherrimum* (F. Weber)



Fig. 12. Hornbeam-oak-linden forest *Tilio cordatae-Carpinetum betuli* – frequent habitat of *Orthodicranum tauricum*. Poland, Warta river valley near Kopaniny village (photo by A. Stebel, 27 April 2009).



Fig. 13. Park – rare habitat for *Orthodicranum tauricum*. Ukraine, Chernihiv (photo by V. M. Virchenko, 3 May 2010).

Vain. Only in the Crimea it sometimes grows with basophilic species, for example *Homalothecium sericeum* (Hedw.) Schimp., *Leucodon sciuroides*

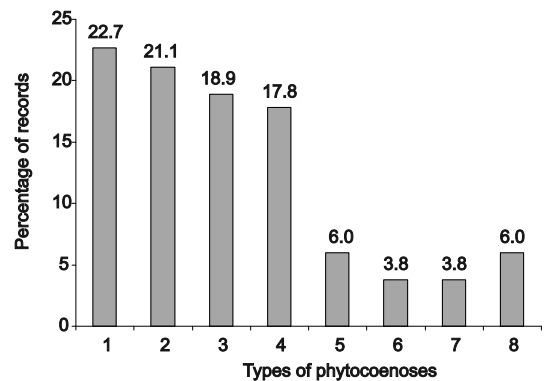


Fig. 14. Occurrence of *Orthodicranum tauricum* in main phytocoenosis types in Central-East Europe. 1 – beech forest (*Fagion sylvaticae*), 2 – alder forest (*Alno-Ulmion*), 3 – mixed forest (mainly of anthropogenic origin), 4 – hornbeam-oak-linden forest (*Carpinetum betuli*), 5 – oak forest (*Quercetea robur-petraeae*), 6 – pine forest (*Dicrano-Pinion*), 7 – spruce-fir forest (*Piceion-Abietis*), 8 – others.

(Hedw.) Schwägr. and *Isothecium alopecuroides* (Dubois) Isov.

REPRODUCTION

Orthodricranum tauricum produces sporophytes very seldom in Europe. In Poland it has only once been found with sporophytes in the northern part of the Kraków-Częstochowa Upland (Kuc 1959). In the Ukraine fertile plants of the species have been found only in the Crimea. On the other hand, in the Czech Republic and Slovakia only sterile plants have been discovered and the sporophytes have never been observed in *O. tauricum*.

In contrast, the species produces sporophytes quite often in North America. Bob Ireland (personal communication) checked the herbarium holdings of *Orthotrichum tauricum* in the Smithsonian Bryological Herbarium (US) and he found that exactly half of the total 68 specimens preserved in this herbarium bore sporophytes. In particular regions the results are as follows: from British Columbia there are 11 specimens and six with sporophytes; from Alberta there is one specimen

and it has sporophytes; from Alaska there are nine specimens and none has sporophytes; from California there are seven specimens and one has sporophytes; from Washington there are four specimens and two have sporophytes; from Oregon there are eight specimens and five have sporophytes; from Montana there are nine specimens and seven have sporophytes; from Idaho there are 13 specimens and 11 have sporophytes; and from Wyoming there are six specimens and one has sporophytes. In Europe *O. tauricum* commonly propagates by caduceus leaf tips (Fig. 2) but the plants with clusters of gemmae which are abundant on leaf apices and in leaf axils (Fig. 15) are quite frequent (Stebel & Plášek 2001).

ACKNOWLEDGEMENTS. This contribution is part of a research project of the Institute of Environmental Technologies, reg. no. CZ.1.05/2.1.00/03.0100, supported by the 'Research and Development for Innovations' Operational Programme financed by the Structural Funds of the European Union and by the state budget of the Czech Republic for Vítězslav Plášek. Ryszard Ochrya and Halina Bednarek-Ochrya gained financial support from the Polish Ministry of Science and Higher Education through grants Nos. N N 303 796 940 and N N 303 469 338, respectively, and, in part, from the statutory fund of the Institute of Botany of the Polish Academy of Sciences. The authors thank all collaborators who sent their data for distribution of the species. Finally, special thanks are due to Bob Ireland, Washington, D.C., for improving the English, valuable comments and information about frequency of fruiting plants from North America deposited in US.

REFERENCES

- BALKOVSKIY B. & SAVOSTIANOV O. 1939. Materialy do brioflory Vinnytskoi i Kamyanetskoj oblastei. III. *Ukrains'k. Bot. Zhurn.* **21–22**: 299–305.
- BOCHEŃSKI W. 1986. Nowe stanowisko *Dicranum tauricum* Sap. i występowanie tego gatunku w Polsce. *Badan. Fizjogr. Polsk. Zachodn.*, **B 39**: 187–191.
- DUNAJSKI A. & FUDALI E. 2007. Materiały do brioflory lasów Karkonoskiego Parku Narodowego. *Przyroda Sudetów* **10**: 13–24 (in Polish with English summary).
- DÜLL R. & MEINUNGER L. 1989. Deutschlands Moose. Die Verbreitung der deutschen Moose in der Bundesrepublik Deutschland in der heutigen Grenzen, ihre vertikale und



Fig. 15. Gemmiferous plants of *Orthodricranum tauricum* (photo by V. Plášek).

- zonale Verbreitung, ihre Arealtypen, Sporophytenhäufigkeit, sowie Angaben zum Rückgang der Arten und zu ihrer Gefährdung. 1. Teil: Anthocerotae, Marchantiatae, Bryatae: Sphagnidae, Andreaeidae, Bryidae: Tetraphidales – Pottiales. IDH-Verlag, Bad Münstereifel – Ohlerath.
- ERZBERGER P. 1999. Distribution of *Dicranum viride* and *Dicranum tauricum* in Hungary. *Stud. Bot. Hung.* **29**: 35–47.
- GREVEN H. 1992. Changes in the Dutch bryophyte flora and air pollution. *Diss. Bot.* **194**: 1–237.
- HEGEWALD E. 1991. Die Verbreitung von *Dicranum tauricum* in Nordeuropa. *Lindbergia* **17**: 83–85.
- IGNATOV M. S., AFONINA O. M. & IGNATOVA E. A. 2006. Check-list of mosses of East Europe and North Asia. *Arctoa* **15**: 1–130.
- IGNATOVA E. A. & FEDOSOV V. E. 2008. Species of *Dicranum* (Dicranaceae, Bryophyta) with fragile leaves in Russia. *Arctoa* **17**: 63–83.
- IRELAND, R. R. 2007. *Dicranum*. In: FLORA OF NORTH AMERICA EDITORIAL COMMITTEE (ed.), *Flora of North America north of Mexico*. **27**. *Bryophytes: mosses (I)*, pp. 397–420. Oxford University Press, New York – Oxford.
- KUC M. 1959. The mosses of the northern part of the Cracow-Częstochowa Jurassic Upland. *Fragm. Florist. Geobot.* **5**: 443–470 (in Polish with English summary).
- KUJALA V. 1936. Waldvegetationsstudien im östlichen Mitteleuropa (Eestland, Litauen, Polen, Tschechoslowakei, Deutschland). *Communicationes Instituti Forestalis Fenniae* **22**(6): 1–115.
- LAZARENKO A. S. 1951. Opredelitel listvennikh mkhov BSSR. Izdatel'stvo AN BSSR, Minsk.
- LOESKE L. 1922. Bryologische Notizen. *Herbarium* **62**: 129–133 (11. *Dicranum strictum*, pp. 130–131).
- MEINUNGER L. & SCHRÖDER W. 2007. Verbreitungsatlas der Moose Deutschlands. Band 2. Regensburgische Botanische Gesellschaft, Regensburg.
- MONDELSKA J. 1932. Bryofityczna szata Ludwikowa. *Spraw. Komis. Fizjogr.* **66**: 1–15.
- NÉMETH CS. 2009. Data on the distribution of *Dicranum tauricum* Sapjegin in Hungary. *Flora Pannonica* **7**: 51–55 (in Hungarian with English summary).
- PARTYKA L. YA. 2005. Brioflora Kryma. Institut Botaniki im. N. G. Kholodnogo, Kiev (in Ukrainian).
- PLÁŠEK V. 2001. *Orthodicranum tauricum* (Sapég.) Z. Smirn. (Bryophyta) in the Czech Republic – distribution and ecology. *Čas. Slez. Mus. v Opavě, Ser. A, Nat. Hist.* **50**: 97–104.
- POPOVA N.N. 2002. Brioflora Srednerusskoi vozvyshehnosti *Arctoa* **11**: 101–168.
- RYKOVSKIY G. F. & MASLOVSKIY O. M. 2004. Flora Belarusi. Mokhoobraznye. Tom 1. Andreaeopsida – Bryopsida. Technalohija, Minsk.
- RYKOVSKIY G. F., KLAKOTSKAYA T. N., PETRIKOVA ZH. M. & UGLYANETS A. V. 2010. Mokhoobraznye Natsionalnogo Parka "Pripyatskiy" (Evolutsyonnyy aspekt, taksonomia, ekologiya, geografiya, zhiznennyye strategii). Belorusskiy Dom Pechati, Minsk.
- SAPEHIN A. 1910. Mkhii Gornoho Krima. *Zapiski Novorossijsk. Obsc. Estestvoisp.* **36**: 15–274.
- SLOBODYAN M. 1951. Materialy do brioflory Marmaroskykh Karpat. *Naukovi Zapysky Lvivskoho Naukovoho Pryrodovnavchoho Muzeju Akademii Nauk Ukrainkoi RSR* **1**: 50–65.
- ŠMARDA J. & VAŇEK R. 1955. Třetí doplněk k mechům Slovenska. *Práce II. Sekcie Slovenskej Akademie Vied, Ser. Biol.* **1**(9): 5–42.
- SÖDERSTRÖM L. 1992. Invasions and range expansions and contractions of bryophytes. In: J. W. BATES & A. M. FARMER (eds), *Bryophytes and lichens in a changing environment*. Oxford University Press, Oxford.
- STEBEL A., OCHYRA R., WIERZCHOLSKA S., FOJCIK B., RUSIŃSKA A., ROSADZIŃSKI S. & SZCZEPAŃSKI M. 2008. Current distribution of *Orthodicranum tauricum* (Bryophyta, Dicranaceae) in Poland. In: A. STEBEL & R. OCHYRA (eds), *Bryophytes of the Polish Carpathians*, pp. 293–302. Sorus, Poznań.
- STEBEL A. & PLÁŠEK V. 2001. *Dicranoweisia cirrata* and *Orthodicranum tauricum* (Musci) in the Polish and Czech part of Upper Silesia – distribution and ecology. *Natura Silesiae Superioris* **5**: 21–31.
- STEBEL A., ROSADZIŃSKI S., WOLSKI G. J., STANIASZEK-KIK M., FUDALI E., ARMATA L. & SZCZEPAŃSKI M. 2012. Further spreading of *Orthodicranum strictum* (Bryophyta, Dicranaceae) in Poland. *Botanika Steciana* **16** (in press).

Received 7 July 2012