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XANTHOPARMELIA MOUGEOTII (PARMELIACEAE, LICHENISED ASCOMYCETES) NEW TO THE LICHEN FLORA OF HUNGARY

Gábor Matus[1]*, János Szepesi[2], Péter Rózsa[3], László Lőkös[4], Nóra Varga[5] and Edit Farkas[5]

[1]*Department of Botany, Institute of Biology and Ecology, Faculty of Science and Technology, University of Debrecen, H–4032 Debrecen, Egyetem tér 1, Hungary; *matus.gabor@science.unideb.hu*
[2]*Volcanology Research Group, Eötvös Loránd University–Hungarian Academy of Sciences, H–1117 Budapest, Pázmány Péter sétány 1/C, Hungary*
[3]*Department of Mineralogy and Geology, Institute of Earth Sciences, Faculty of Science and Technology, Debrecen University, H–4032 Debrecen, Egyetem tér 1, Hungary*
[4]*Hungarian Natural History Museum, H–1431 Budapest, Pf. 137, Hungary*
[5]*Institute of Ecology and Botany, MTA Centre for Ecological Research, Hungarian Academy of Sciences, H–2163 Vácrátót, Alkotmány u. 2–4, Hungary*

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Abstract: *Xanthoparmelia mougeotii* is a usnic acid containing, small foliose, sorediate, parmelioid lichen species with a pantemperate distribution. In Europe it occurs in most countries especially in cool, humid, "suboceanic" habitats, mainly on acidic rocks, and rather sporadic in the continental areas, e.g. isolated populations in Slovakia (near Strečno) or in Ukraine (Crimea). Recently another isolated Central European population was discovered in the Zemplén Mts (NE Hungary), approx. 200 km far from the Slovak population.

Key words: Hungary, lichen-forming fungi, lichenicolous fungi, *Xanthoparmelia*

INTRODUCTION

Intensified field work and application of new techniques resulted in several new taxonomic and chorological findings in the macrolichen genus *Xanthoparmelia* worldwide (e.g. Crespo *et al.* 2010, Giordani *et al.* 2002, Hale 1974, 1990, Hawksworth *et al.* 2008, 2011, Kanigowski *et al.* 2016) and also in Hungary (Farkas *et al.* 2012, 2015, Matus *et al.* 2015, Molnár *et al.* 2012). The species-rich genus counts *ca* 14 usnic acid containing species in the Carpathian Basin and nearby areas, i.e. AT: 4; CZ: 7, DE: 7, HR: 4, HU: 7; RO: 2, RS: 4, SI: 2, SK: 9, UA: 7 (Bielczyk *et al.* 2004, Ciurchea 2004, Guttová *et al.* 2013, Hafellner and Türk 2001, Kondratyuk *et al.* 1998, Liška *et al.*

2008, Lőkös and Farkas 2009, Orthová-Slezáková 2004, Savić and Tibell 2006, Suppan *et al.* 2000, Türk and Hafellner 2010, Wirth *et al.* 2013).

The sub-Atlantic species, *Xanthoparmelia mougeotii*, is reported in decreasing frequencies in a NW–SE European gradient (climatically from oceanic to continental). Up to now a single locality of this species has been reported from Slovakia representing the only known habitat within the Carpathian Basin.

This paper gives an account on the discovery of the species in Hungary including the geological conditions of the new habitat. We provide data on population size of this new member of the Hungarian lichen flora and report on accompanying cryptogamic, as well as vascular species. Significance of the new discovery is discussed in a European context with special regard to substrate preference, altitude selection, and conservational status.

MATERIAL AND METHODS

Voucher specimens are deposited in BP (Hungarian Natural History Museum, Budapest, Hungary), DE (Soó Rezső Herbarium, Debrecen University, Debrecen, Hungary) and EGR (Eszterházy Károly University of Applied Sciences, Eger, Hungary). Herbarium acronyms follow the Index Herbariorum online (Thiers 2016). Hafellner and Calatayud (1999), Ihlen and Wedin (2008), Smith *et al.* (2009), and Wirth *et al.* (2013) were used for identifications. Morphological-anatomical investigations and KOH spot test were carried out by standard methods (Orange *et al.* 2010) using Olympus SZX-7 binocular dissecting microscope and Olympus CX-41 stereo microscope. HPTLC analysis for chemical substances was applied in solvent system C according to Arup *et al.* (1993). The distribution map of *Xanthoparmelia mougeotii* was prepared by the computer program for geographical information system, Quantum GIS (QGIS 2.18 Las Palmas, 2016) based on the Central European grid system of 5 km × 6 km units (Borhidi 1984, Niklfeld 1971).

The studied species

Xanthoparmelia mougeotii (Schaer.) Hale
(*Parmelia mougeotii* Schaer.)
(Fig. 1)

Thallus small foliose, 2–4 cm in diam., tightly adnate to substrate, centrally may also be areolate; lobes shiny, green-grey, yellow-grey, yellow-green or partially brownish, smooth to rugulose or cracked, narrow, *ca* 0.2–0.5 mm wide, sublinear, flattened or somewhat convex, radiating, separate and contiguous to

subimbricate, lobe ends subtruncate, brown rimmed, smooth to crenate, eciliate; medulla white; lower surface and rhizines dark brown to black, rhizines simple, 0.1–0.2 mm long. Soredia farinose, orbicular, hemispherical to subglobose, yellow to grey-yellow. Apothecia and pycnidia not seen in Hungarian material.

Chemistry: upper cortex K+ yellow to orange, C–, KC–, P+ orange, UV–; medulla K+ yellow becoming dark red, C–, KC–, P+ orange (usnic acid, stictic acid complex, norstictic acid).

Substrate and ecology: mainly on siliceous rocks often in open, exposed habitats, with a pantemperate to subarctic distribution in Europe (Fig. 2), Asia, southern Africa, and western North America.

RESULTS AND DISCUSSION

The first specimens of a small, sorediate, parmelioid lichen have been collected on rock outcrops of Mt Fövenyes-tető (503 m; 48.46667° N, 21.40500° E; grid unit identifier: 7594.1), 4 km SE of Telkibánya, Zemplén Mts, NE Hungary in June 2015 (Fig. 3). Morphological features pointed to a limited set of species including two species still unreported from the country. Results of the usual morphological investigations and spot tests (K+ yellow, C–, P+ orange) and TLC (presence of usnic acid, stictic acid complex, as well as of norstictic acid) excluded the morphologically similar *Arctoparmelia incurva* and *Parmeliopsis ambigua*, therefore the new finding has been identified as *Xanthoparmelia mougeotii* (Schaer.) Hale, which was unknown from Hungary (Lőkös and Farkas 2009, Verseghy 1994). Voucher specimens have been deposited in the Soó Herbarium of the University of Debrecen (DE), in the Eszterházy Károly University of Applied Sciences, Eger (EGR) and in the Hungarian Natural History Museum, Budapest (BP), as follows.

Hungary. Borsod-Abaúj-Zemplén megye, Telkibánya, Mt Fövenyes-tető. Lat.: 48° 28' 00.0" N; Long.: 21° 24' 17.7" E; Alt.: 498 m a.s.l. Coll.: Matus, G., Takács, A., 06.06.2015 [DE 1493, EGR 6596, BP].

Hungary. Borsod-Abaúj-Zemplén County, Zemplén Mts, Telkibánya, Mt Fövenyes-tető, on siliceous rock (rhyolite). Lat.: 48° 28' 00.2" N; Long.: 21° 24' 17.5" E; Alt.: 500 m a.s.l. Coll.: Lőkös, L., Matus, G. and Varga, N., 08.08.2015 [BP, together with *Lichenostigma cosmopolites*].

Population size of *Xanthoparmelia mougeotii* in Hungary

A mapping survey carried out in August 2015 outlined a population area of *ca* 50 × 20 m between altitudes of 475–500 m in Mt Fövenyes-tető. The population occupies the upper part of the SW to SSE facing slopes around the summit.

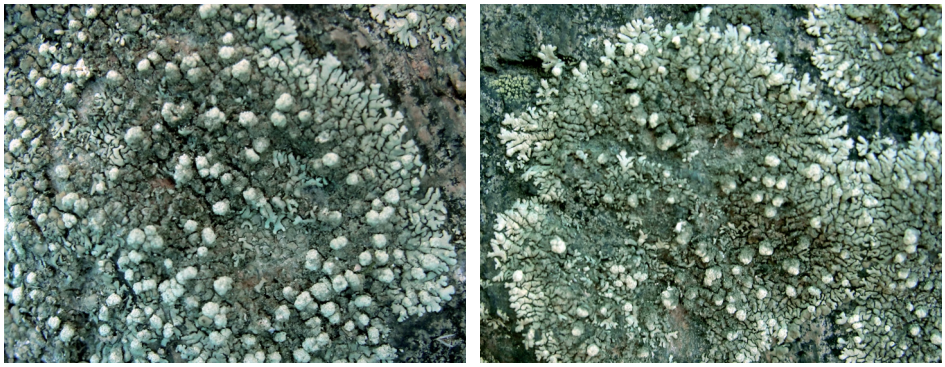

Fig. 1. *Xanthoparmelia mougeotii* at Mt Fövenyes-tető (Zemplén Mts, NE Hungary).

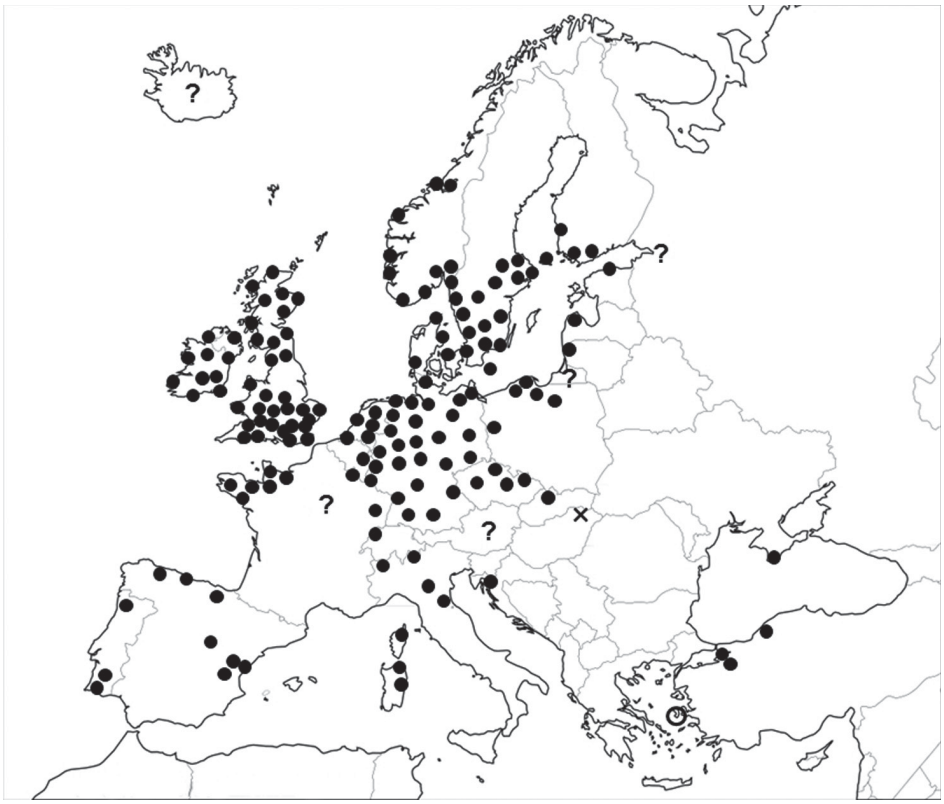

Fig. 2. European distribution of *Xanthoparmelia mougeotii.* ● (filled circle) = confirmed occurrence, ○ (empty circle) = doubtful record, × (cross) = new occurrence.

It is concentrated on exposed or half-shaded larger rock outcrops on the SSW slope, but becomes more scattered towards the S and SSE slopes, where only scattered exposed outcrops emerge from the moving scree field. Thalli mostly occupy smooth rock surfaces, vertical as well as leaning ones, but are also present on some more weathered, fractured rocks. Estimation of population size resulted in a few times ten of mature, sorediate thalli and a few hundred young, non-sorediate thalli of various size. Fertile specimens were not noticed.

Vegetation of the habitat and accompanying species

Very seldom it can also grow on other substrata like acidic bark (on *Betula* or *Populus* in Europe, or on *Hebe elliptica*, a Plantaginaceae shrub at the Falkland Islands). Wooden structures as well as other artificial substrates in synanthropic surroundings (metal, glass, plastic or rubber) make rare exceptions. In figures, nearly 99% of the Dutch records is epilithic (over 73% on granite, 15% on basalt and 10% on brick (with acidic chemistry), *http://www.verspreidingsatlas.nl*).

An analogous explanation on this geographical pattern, originally applied for weedy vasculars (Holzner 1978), can be postulated. Acidophytes showing good competitive abilities and capable of tolerating high nutrient loads under preferred climatic conditions can turn into weak competitors and are confined to extremely acidic, low-nutrient habitats at the edge of their climatic tolerance.

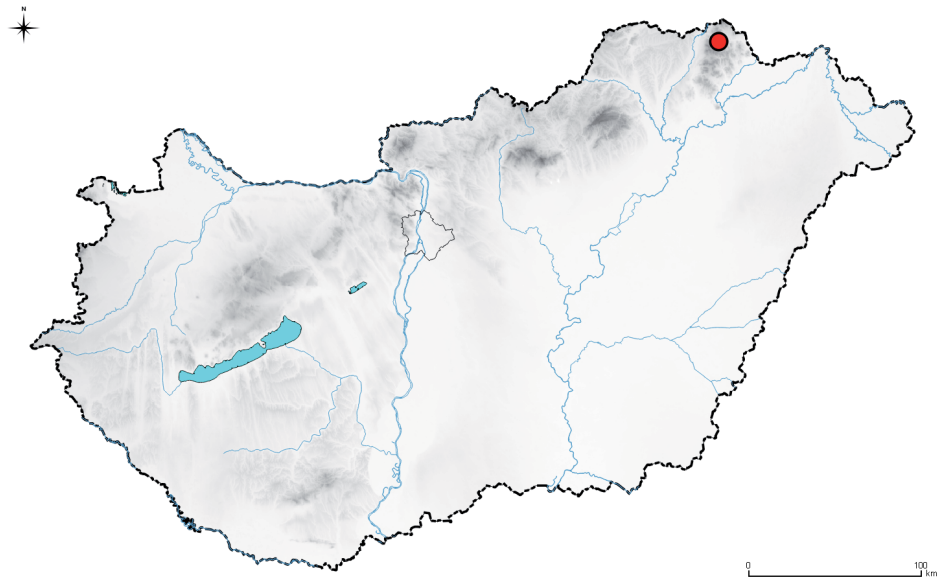

Fig. 3. The Hungarian locality of *Xanthoparmelia mougeotii*.

Vegetation of the Hungarian site (Fig. 4) is a sparse acidic forest with *Fagus sylvatica*, *Quercus petraea,* and *Betula pendula* in the canopy intermingled with barren moving scree fields. The sporadic herb layer consists of the acidophytes *Festuca ovina*, *Genista pilosa*, *Luzula luzuloides*, *Rumex acetosella,* and *Vaccinium myrtillus*. Accompanying cryptogams include saxicolous and some terricolous lichen species: *Acarospora fuscata*, *Cladonia mitis*, *C. squamosa*, *C. uncialis*, *Lecidea fuscoatra*, *Porina chlorotica* (= *Pseudosagedia ch.*), *Pycnothelia papillaria*, *Rhizocarpon geographicum*, *Vulpicida pinastri*, *Xanthoparmelia conspersa*, *X. protomatrae,* and *X. verruculifera*. Several thalli of *Xanthoparmelia mougeotii* are heavily covered by the lichenicolous microfungi *Lichenostigma cosmopolites*, similarly to the thalli of the accompanying *X. conspersa* and *X. protomatrae*. Presence of the mosses *Bartramia pomiformis* and *Grimmia muehlenbeckii* (Erzberger 2009) occurring sporadically on acidic volcanic outcrops, as well as of *Leucobryum glaucum* in more shaded habitats has been proved.

Fig. 4. Open, rocky habitat of *Xanthoparmelia mougeotii* at Mt Fövenyes-tető.

Distribution

Xanthoparmelia mougeotii with a dominantly pantemperate distribution has mostly been recorded at cool and humid regions of North, Central and South America, South Africa, New Zealand, as well as Hawaii and has some scattered data from the Far East (Japan). Subtropical and tropical records from Brazil, Colombia, Ecuador, Peru, Uruguay, and Venezuela are from higher altitudes characterised by similar climates. This holds for the only record from the Middle East (Asir province in SW of Saudi Arabia with monsoon and over 2000 m of elevation).

Like in other continents, most European records originate from regions under the influence of oceanic climate (Klement 1958). Most data have been gathered from the UK, where the species is probably the most widespread. Further countries with higher frequencies are Ireland, the Netherlands and certain parts of Belgium, France, Germany, Spain, and Portugal (Beguinot 1981, Cezanne and Eichler 1991, Klement 1958, Lambinon 1966, Lambinon and Sérusiaux 1985, Stordeur *et al.* 2015, Van den Broeck *et al.* 2008). In the Scandinavian countries it is the most abundant in the seaside provinces (Høiland 1973, Reve 1981, Santesson *et al.* 2004) and, with significantly lower number of total records, the same holds for Poland (Fałtynowicz 2003, Kukwa 2005, Kukwa and Zduńczyk 2011), Latvia (Abolina *et al.* 2015, Piterāns 1996), and Estonia (Randlane and Saag 1999). Recent discoveries from Ukraine and Turkey refer to the Crimean Peninsula (Khodosovtsev 2013) and the Black Sea–Marmara Sea region (Çobanoğlu Özyiğitoğlu and Yavuz 2015, Halici and Cansaran-Duman 2007), respectively. Data from landlocked countries are rather scarce. A dozen of records is assigned to the Czech Republic from the 1930s to the 1960s (Liška *et al.* 2008, Müller 1949, Suza 1949), whereas Slovakia has a recently rediscovered single locality (Orthová 2003, Suza 1934).

Only old records of *Xanthoparmelia mougeotii* are available from Switzerland (Jura Mts; Clerc and Truong 2012, Magnin 1906), whereas none from Austria (Hafellner and Türk 2001, Türk and Hafellner 2010), Romania (Ciurchea 2004), Serbia (Savić and Tibell 2006), and Slovenia (Suppan *et al.* 2000).

Wirth *et al.* (2013) characterised the European distribution of *Xanthoparmelia mougeotii* as wide as the southern boreal-temperate-sub-Atlantic-Mediterranean (montane) species.

The new locality forms the first record of the species in Hungary, as well as the second occurrence within the Carpathian Basin. As such it is a highly isolated occurrence, which lies over 200 km to the closest known one in Strečno, Slovakia and between 350 to 550 km far from occurrences in the Czech Republic

(Orthová 2003, Suza 1934, GBIF query). Distance of the new site from the Baltic and Adriatic Sea is *ca* 630 and 670 km, respectively. These figures are about 100 km more than those of the Strečno site, suggesting an even more continental position. The recent Crimean and Turkish occurrences are *ca* 1100 km from the Hungarian locality.

Climate

Mean annual temperature of the region is *ca* 8 °C (< –4 °C in January, < 19 °C in July) with >100 frosty days. Mean annual precipitation is over 700 mm (probably over 750 mm, but due to the lack of measuring infrastructure the data is uncertain) with a midsummer maximum (Havassy and Németh 2007).

In England, forming the European climatic optimum of *Xanthoparmelia mougeotii*, the species is abundant in urban habitats, such as churchyards.

Geology, substrate preference and chemistry

The species is dominantly saxicolous, mostly occupying base-poor stones. Preferred ones are smooth, usually vertical or steep surfaces of acidic (rarely basic), volcanic and metamorphic rocks, such as granite, schist, shales, quartz(ite), porphyry, rhyolite, sandstone and basalt. (Older collections have often been labelled with the term "igneous rock"). Primary habitats are typically scree fields, rock outcrops, cliffs, boulders, stones, pebbles or siliceous conglomerates. In lack of substrate naming often the geographical name itself implies epilithic occurrence (e.g. "tor", which is equivalent for steep craggy hill or "crag" meaning steep rugged rock or cliff). Secondary habitats include disused quarries, mines or slate debris.

In NW Europe records from anthropogenic surroundings greatly outnumber natural ones, partly because of their easy accessibility compared to natural ones. Highest portion of these are the churchyard (graveyard, cemetery) records (2240), which make up over 50% of GBIF records from GB, a result of the Lowland Churchyard project of the British Lichen Society, but also close to 20% in Sweden. Except for tombstones often other stone or slate structures or buildings can provide habitats. These include churches (167), bridges (90), houses (27), chapels (24), farms (21), walls (18), prehistoric monuments (10, e.g. stone circles of Stonehenge or the dolmens of Friesland or Sweden), fences, slated roofs, even a cathedral and a lighthouse.

Due to old mining traditions, geology of the Telkibánya district has been thoroughly studied (Hermann 1952, Ilkeyné Perlaki 1972, Kozák 1994, Liffa 1953, Richthofen 1861, Székyné Fux 1970). Recently detailed palaeovolcanic reconstruction has been completed (Szepesi 2009, Szepesi and Kozák 2008).

The studied region (incl. also Mt Fövenyes-tető and its surroundings), referred to as "Northern Rhyolite District" (Szádeczky 1887), forms an about 35 km^2 sized area in the northern Hungarian section of the mountain range Tokaj–Slanské Vrchy Mountains (Tokaj–Szalánci-hegység), which is especially and uniquely rich in siliceous lavas.

The substrate of *Xanthoparmelia mougeotii* identified as highly acidic, coherent rhyolite predominantly shows grey-veined, flow-banded pattern representing core region of lava domes and flows of Sarmatian Stage (Middle–Late Miocene, 13–11 Myr) (Szepesi *et al.* 2016). The erosional forms show very steep sided morphology (Cser-hegy, Kis-Ork-hegy, Nagy-Ork-hegy, Ó-Gönc) with dense periglacial debris (dm sized) and boulders.

Chemical composition of the substrate at the Telkibánya site (Table 1) is similar to the Strečno one as rhyolite forms the surface equivalent of the plutonic granite. A common similarity is the high proportion of silica (over 77% of SiO_2), resulting in very low surface pH values.

Table 1. Chemical composition of the substrate rock of *Xanthoparmelia mougeotii* at Mt Fövenyes-tető (Zemplén Mts, NE Hungary).

Szepesi *et al.* (unpubl.)	mean (range) % (n = 4)
SiO_2	77.35 (77.29–77.53)
Al_2O_3	12.67 (12.60–12.80)
K_2O	4.30 (4.18–4.44)
Na_2O	3.57 (3.48–3.74)
Fe_2O_3	1.31 (1.07–1.46)
CaO	0.72 (0.68–0.77)

Altitude preference

Distance of the new site from the closest sea is about 100 km more from the Adriatic Sea and about 200 km more from the North Sea, than that of the Strečno site. Macroclimate data also underline the peculiarity of this landlocked location. Forming the most continental site in Europe, it does not seem to make a favourable habitat. The region numbers over 100 frosty days, while midsummer drought is common.

In Fennoscandia, where acidic substrates are widespread, climate seems to limit vertical distribution. For example altitude records vary from 2 to 155 m in Norway (n = 95; *http://www.nhm2.uio.no*) and 1 to 90 m in Sweden (n = 197; GBIF query). We know little about occurrences in the Mediterranean region, but the available data suggest a preference of intermediate heights. In Spain, for example, altitude of the 15 GBIF records varies between 870 and 1600 m.

Higher precipitation due to higher altitude may compensate air humidity at least in periods when thalli are active. Worldwide distribution data suggest that higher altitude and humid climate can support the species also out of the temperate zone. Records from (sub)tropics are confined to higher altitudes and, at least seasonally, to humid climate. This holds for South American records of the Andes (Peru, Colombia, and Venezuela at 3200 to 4100 m) and for the monsoon-influenced "wet corner" at SW Saudi Arabia (up to 3100 m, Abha, Asir Province, GBIF ID: 1030428941).

All Central European elevation data fall in the same range. Altitudes of our record (475 to 500 m) are very similar to ones in the Czech Republic (464 ± 173 m; 260 to 765 m; n = 17), as well as to the Slovakian collections (380 to 425 m). These figures are somewhat higher than those from NW Europe or Fennoscandia and the Baltic countries.

Survey for other potential habitats for more populations

Some of the nearby rock outcrops with the presence of fluidal rhyolite (e.g. Tér-hegy, Kis-Tér-hegy, Halyagos-tető, Csoszota-tető) have partly or fully been forested with *Picea abies* or *Pinus sylvestris* in the 1960s, therefore a number of potential habitats has been eliminated. Survey of non-forested neighbouring outcrops with similar geology (i.e. Kis-Ork-hegy, Nagy-Ork-hegy, Solymos, Ó-Gönc) in 2015 and 2016 yielded no further records of the species.

Conservational status

The species is common in parts of NW Europe under oceanic influence and with abundant acidic substrata. No data on possible vulnerability emerged from Great Britain (> 3800), Belgium (> 30), Ireland (> 70), Atlantic part of France (> 20), Luxembourg (> 10), Norway (> 100) or Sweden (> 500). In Denmark (~10) and the Netherlands (~40) it is already rare, but conservational status is of "least concern" (Søchting and Alstrup 2008, *http://bios.au.dk*) or not threatened yet (*http://www. verspreidingsatlas.nl*), respectively. Little is known about the conservational status in the Mediterranean. The species seems to be less widespread as suggested by > 35 records from Spain. In Italy its status is labelled from rare to extremely rare in the few provinces where present (*http://dbiodbs.univ.trieste.it*). (Number of GBIF and *http://www.lichenology.info* records are given in brackets).

Further from the seas it becomes more threatened, which is reflected in legal handling. In Germany, being present in <50 floristical grid cells, it is considered as very rare and vulnerable in recent evaluation (Wirth *et al.* 2011, *http://www. flechten-deutschland.de*).

In Poland it is considered as vulnerable (Cieśliński *et al.* 2003, 2006) and the same holds for the Baltic countries (endangered in Latvia, Piterāns 1996, *http://latvijas.daba.lv*; threatened in Lithuania, Motiejūnaitė 2002; endangered in Estonia, Trass 1958, Randlane *et al.* 2008, *http://www.ut.ee*) and least concern in Finland (Stenroos *et al.* 2016), where considered as endangered. Further along the NW to SE continentality gradient, *X. mougeotii* is endangered in the Czech Republic (Liška *et al.* 2008). Recent status of the species in Slovakia can be considered as "critically endangered" (Guttová *et al.* 2013). Rediscovery of an apparently very small population (Strečno, Malá Fátra Mts; Orthová 2003) proved its presence in the Carpathian Basin after already believed extinct for decades (1922: Suza 1934, Pišút 1993, Pišút *et al.* 1993, 1998, 2001). Since 2004 it is legally protected (in category 2) in Estonia (Randlane *et al.* 2008).

The new Hungarian site forms a Natura 2000 area and part of the Zemplén Protected Landscape area. Intensive erosion, caused by a significant population of the introduced moufflon, may pose a threat to the site. Thin rocky soils are badly eroded and vascular vegetation greatly damaged, resulting in the possible loss of the legally protected *Vaccinium vitis-idaea* (Hulják 1997), though this effect did apparently not influence much the outcrops.

As a species of oceanic character ($K_{Wirth} = 2$) (Wirth 2001, 2010) it forms a unique member of this kind in the lichen flora of the Carpathian Basin. Up to now the presence of only 16 $K_{Wirth} = 2$ species (<2% of the lichen flora) has been proved in the continental Hungary. Taking these circumstances into consideration *Xanthoparmelia mougeotii* is worth for legal protection also in Hungary. Being rare with only one locality in Hungary it is also suggested as critically endangered species in the Hungarian lichen red list, until we have more information about its population dynamics and its detailed distribution.

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Összefoglaló: A *Xanthoparmelia mougeotii* mérsékelt övi, illetve trópusi magashegységi elterjedésű, uzneasav-tartalmú, kis termetű, szorédiumos, parmelioid lombos zuzmófaj. Európa legtöbb országában honos, súlypontosan a hűvös, nedves klímájú "szubóceánikus" területeken, zömmel savanyú kémhatású kőzeteken. Kontinentális területeken szórványos, izolált előfordulású, a Kárpát-medencében eddig csak egyetlen populációja volt ismert (Sztrecsnó, Kis-Fátra, Szlovákia). A közelmúltban egy további, izolált közép-európai előfordulásra derült fény a Zempléni-hegységben (Tokaj–Szalánci-hegység), a szlovákiai populációtól mintegy 200 km-re.

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