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Analysis of lichen secondary metabolites and morphometrics in the *Cladonia chlorophaea* species group (Cladoniaceae, lichenized Ascomycota) in Hungary

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Analysis of lichen secondary metabolites and morphometrics in the *Cladonia chlorophaea* species group (Cladoniaceae, lichenized Ascomycota) in Hungary

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ABSTRACT
The genus *Cladonia* P.Browne is one of the richest genera in species among lichenized fungi, consisting of about 500 species based on both morphological and chemical diversity. Thalli of the *Cladonia chlorophaea* species group with horizontal primary thalline lobes and sorediate, cup-, funnel-, goblet- or wineglasss-shaped podetia contain twelve different lichen secondary metabolites (atranorin, congrayanic, cryptochlorophaeic, 4-O-methyl-cryptochlorophaeic, fumarprotocetraric, grayanic, 4-O-demethyl-grayanic, homosekikaic, merochlorophaeic, norrangiformic, quaesitic, rangiformic and thamnolic acids) in various combinations. Six taxa are currently distinguished at species level based mainly on these substances. The 281 specimens kept in herbaria as *Cladonia chlorophaea s.l.* collected in Hungary were analysed by high performance thin-layer chromatography (HPTLC). The chemical revision allowed to separate *C. asahinae* J.W.Thomson, *C. cryptochlorophaea* Asahina, *C. grayi* G.Merr. ex Sandst., *C. merochlorophaea* Asahina and *C. novochlorophaea* (Sipman) Brodo & Ahti from *C. chlorophaea s.str.* Three species – *C. asahinae*, *C. grayi* and *C. novochlorophaea* – represent new distribution records to Hungary. The morphological characters differentiating these species according to the literature data were less obvious. Therefore, a detailed morphometric study of 227 podetia – considering the size of podetia, cup, stalk, soredia and squamules – was carried out on selected specimens. Although *Cladonia asahinae* and *C. cryptochlorophaea* were usually smaller than the robust *C. chlorophaea* (Flörke ex Sommerf.) Spreng. or *C. merochlorophaea*, the chemical characteristics supplied more stable results than morphological metrics.

KEY WORDS
Cladoniaceae, lichen-forming fungus, lichen secondary metabolites, chemotaxonomy, geographical distribution, high performance thin-layer chromatography, morphometric analysis.

RÉSUMÉ

Analyse des métabolites secondaires et de la morphométrie des lichens du groupe d'espèces Cladonia chlorophaea *(Cladoniaceae, Ascomycota lichénisé) en Hongrie.*

Le genre *Cladonia* P.Browne est l'un des genres les plus riches en espèces de champignons lichénisés, composé d'environ 500 espèces sur la base de la diversité morphologique et chimique. Les thalles du groupe d'espèces *Cladonia chlorophaea* avec leurs lobes thallin primaires horizontaux et leurs podetia sorédiés en forme d'entonnoir contiennent douze métabolites secondaires différents (atranorin, acide congrayanique, acide cryptochlorophaeique, acide 4-O-méthyl-cryptochlorophaeique, acide fumarprotocetrarique, acide grayanique, acide 4-O-déméthyl-grayaniques, acide homosekikaique, acide mérochlorophaéique, acide norrangiformique, acide quaesitique, acide rangiformique et acide thamnolique) dans diverses combinaisons. Six espèces sont actuellement reconnues principalement sur la base de ces substances. Les 281 spécimens conservés dans des herbiers sous le nom de *Cladonia chlorophaea s.l.* collectés en Hongrie ont été analysés par chromatographie sur couche mince à haute performance (HPTLC). Cette analyse a permis de séparer *C. asahinae* J.W.Thomson, *C. cryptochlorophaea* Asahina, *C. grayi* G.Merr. ex Sandst., *C. merochlorophaea* Asahina et *C. novochlorophaea* (Sipman) Brodo & Ahti de *C. chlorophaea s.str.* en accord avec les résultats des études précédentes portant sur les variations chimiques. Trois espèces – *C. asahinae*, *C. grayi* et *C. novochlorophaea* – représentent de nouveaux relevés de distribution en Hongrie. Les caractères morphologiques différenciant ces espèces étaient moins clairs d'après les données de la littérature. C'est pourquoi une étude morphométrique détaillée des données de 227 podetia – tenant compte de la taille des podetia, de la cupule, de la tige, des sorédies et des squamules – a été réalisée sur des spécimens sélectionnés. Bien que *Cladonia asahinae* et *C. cryptochlorophaea* soient généralement plus petits que les robustes *C. chlorophaea* (Flörke ex Sommerf.) Spreng. ou *C. merochlorophaea*, les caractéristiques chimiques ont fourni des résultats plus stables que les mesures morphologiques lors de la révision du groupe.

MOTS CLÉS
Cladoniaceae, champignons formant des lichens, métabolites secondaires des lichens, chimiotaxonomie, distribution géographique, chromatographie en couche mince haute performance, analyse morphométrique.

INTRODUCTION

Cladonia P.Browne (Cladoniaceae, lichenised Ascomycota) is one of the most diverse genera of the lichen-forming fungi with *c*. 500 species (Ahti 1961, 2000; Jaklitsch *et al*. 2016). In spite of the extended studies dealing with this genus, including also recent molecular phylogenetic studies (DePriest 1994, 1995; Timsina *et al*. 2014; Stenroos *et al*. 2018), some details on their taxa – and especially the correlation between the secondary chemistry and morphology – are insufficiently known (Wirth 1980; Smith *et al*. 2009; Wirth *et al*. 2013; Roux *et al*. 2017) and little studied in several countries. Such a knowledge gap concerns the species of *Cladonia chlorophaea* (Flörke ex Sommerf.) Spreng. group rich in lichen secondary metabolites (LSMs) and especially its taxa occurring in Hungary (Verseghy 1994). Several national and regional studies have been prepared on the group (e.g. Holien & Tønsberg 1985; Kowalewska *et al*. 2008; Tsurykau & Golubkov 2015; Matwiejuk 2017). Furthermore, Osyczka (2013) has performed a morphometric study – including quantitative and qualitative parameters – comparing six species (*C. asahinae* J.W.Thomson, *C. chlorophaea s.str.*, *C. cryptochlorophaea* Asahina, *C. grayi* G.Merr. ex Sandst., *C. merochlorophaea* Asahina, *C. novochlorophaea* (Sipman) Brodo & Ahti) of the *C. chlorophaea* group with other scyphose *Cladonia* species (*C. fimbriata* (L.) Fr., *C. humilis* (With.) J.R.Laundon). The cluster analysis separated *C. fimbriata*, but did not separate species of the *C. chlorophaea* group and recognised morphological similarity of *C. conista* A.Evans and *C. humilis*. The correspondence analysis of the binary-coded qualitative characters resulted in four groups of species: *C. asahinae*, *C. chlorophaea*, *C. fimbriata* and *C. humilis*.

Standardised chromatographic studies (TLC: Culberson & Kristinsson 1970; Culberson 1972, 1974; HPTLC: Arup *et al*. 1993) were used to investigate the LSMs. The distribution patterns of LSMs characterising taxa have been widely used in lichen taxonomy and systematics (Culberson 1969, 1970, 1986a, 1986b; Hawksworth 1976; Carlin 1987; Schmitt & Lumbsch 2004; Nelsen & Gargas 2008; Leavitt *et al*. 2011) since they represent cryptic chemical diversity additional to morphological-anatomical biodiversity (Crespo & Lumbsch 2010). The presence/absence and composition of LSMs have been considered at various levels of taxa from chemosyndromes, chemical races – via species – to families (Hawksworth 1976; Nourish & Oliver 1976; Randlane *et al*. 2009; Osyczka & Skubała 2011; Lendemer 2012). HPTLC was also applied in addition to morphological investigations during identifications and revisions of Hungarian herbarium material (Farkas *et al*. 1998, 2021).

Our aim was to revise the Hungarian specimens of the *Cladonia chlorophaea* group kept in Hungarian herbaria under various names, mostly *C. chlorophaea*, its forms (*Cladonia chlorophaea* f. *costata* (Flörke) Sandst., *Cladonia chlorophaea* f. *hyalinella* Flörke, *Cladonia chlorophaea* f. *mesotheta* (Wallr.) Anders, *Cladonia chlorophaea* f. *pachythallina* Vain., *Cladonia chlorophaea* f. *prolifera* Anders, *Cladonia chlorophaea* f. *pterygota* (Flörke) Motyka), *C. cryptochlorophaea* and *C. merochlorophaea* (Verseghy 1994). Furthermore, to investigate the LSMs and the morphological characters available to recognise these species.

MATERIAL AND METHODS

The research object

Altogether 281 specimens of the herbaria BP and VBI (abbreviations according to Thiers 2023) were revised by HPTLC and analysis of macromorphological characters (colour, shape and rough size of podetia, the presence of soredia and squamules). Micromorphological parameters (the size of podetia and their various parts, cup, stalk, soredia and squamules; the angle between cup and stalk) were measured and statistically analysed. Altogether 213 specimens were found to belong to the group *C. chlorophaea s.l.* from Hungary (Appendix 1), 196 specimens in the lichen collection BP (Budapest), and 17 from the lichen herbarium VBI (Vácrátót). The remainder appeared to belong to other species.

Geography and climate in Hungary

Hungary has a varied relief ranging from *c*. 70 m (lowland) to *c*. 1000 m (lower montane regions) with a varied geomorphological origin – mostly marine, fluvial, and aeolian sediment of various ages and in smaller areas volcanic rocks covering the formations of older geographical periods. Six main geomorphological districts are distinguished: the Alföld (the Great Hungarian Plain), the Kisalföld (the Little Hungarian Plain), the Alpokalja (the Foot of the Alps), the Transdanubian Hills, the Transdanubian Range, and the North Hungarian Range (as a part of the Northwestern Carpathians) (Gábris *et al*. 2018; Kocsis 2018). The natural Pannonian vegetation consists of various deciduous forests in mountainous regions and montane rocky and lowland sandy grasslands with special microclimatic conditions allowing lichen colonization on various soil and rock surfaces (Molnár *et al*. 2018). The macroclimate is predominantly continental with oceanic and Mediterranean influence, with recent changes due to global climatic tendencies (Thomas *et al*. 2004; Thuiller *et al*. 2005; UNFCCC 2013; Bihari *et al*. 2018).

Chemicals

All chemicals were of analytical or higher grade. HPLC acetone (VWR) was applied to extract LSMs from intact lichen samples for chromatographic analysis. Toluene (CARLO ERBA), acetic acid (LACH-NER), dioxane (REANAL, Sigma Aldrich), cyclo-hexane (LACH-NER), methyl-tert-butyl ether (Fisher Scientific, United Kingdom), formic acid (LACH-NER), and sulphuric acid (CARLO ERBA) were obtained from Reanal for HPTLC investigations.

HPTLC method

HPTLC analysis was carried out according to the standard methods for analysing lichen samples described by Arup *et al*. (1993) and Molnár & Farkas (2011). A CAMAG horizontal chamber of 10 cm × 10 cm, a CAMAG TLC Plate Heater III, and 10 cm × 10 cm HPTLC plates (Merck, Kieselgel 60 F254) were used. Approximately 3-5 mm × 3-5 mm air-dried podetium fragments (a part of a single podetium/sample) were soaked in 0.2 ml acetone for *c*. 30 minutes in order to extract the lichen substances. Sampling was carried out by one of the authors, most often by K. V. Pretreated (50°C for five minutes, CAMAG TLC Plate Heater III, then cooled to room temperature), 10 cm × 10 cm thin-layer chromatographic plates (Merck, Kieselgel 60 F254) were used. 8 µl acetone extracts (1 µl at each time) were applied to each position (5 mm apart) on the plate. The solvent systems A (toluene – dioxene – acetic acid, 45 : 15 : 2 v/v/v), B (cyclo-hexane – methyl-tert-butyl ether – formic acid, 6.5 : 5 : 1 v/v/v) and most often solvent system C (toluene – acetic acid, 20:3 v/v) were applied. *Pleurosticta acetabulum* (Neck.) Elix & Lumbsch (norstictic acid) and *Leucodermia boryi* (Fée) Kalb (atranorin, zeorin) were used as controls. Plates were investigated under UV 254 nm and UV 366 nm after development, then fatty acids and water-repellent substances were studied, while sprayed with water, finally it was followed by spraying with 10% sulphuric acid and heating at 110°C for 5-10 minutes, then spots were observed at daylight and under UV light (366 nm).

Morphological investigations

The morphology and anatomy were studied by using a NIKON Eclipse/NiU (DIC, epifluorescence) compound microscope (Nikon Corporation, Tokyo, Japan), as well as an Olympus SZX7 stereomicroscope (Olympus Corporation, Tokyo, Japan). Micrographs were prepared by a Canon EOS 1300D (Canon Inc., Tokyo, Japan) camera (with Quick Photo Camera 3.2 software, Olympus Corporation, Tokyo, Japan) and Nikon DS-Fi1c camera (with NIS-Elements BR software, Nikon Corporation, Tokyo, Japan) with the above-mentioned microscopes. For the morphometric analysis the size of 227 podetia, cup, stalk, soredia and squamules were measured on selected specimens after revision based on LSMs and macromorphological investigations. The measured characters are illustrated in Figure 1.

Statistical analysis

The statistical analysis was carried out on 227 podetia belonging to six species and 50 specimens. The chemical and morphometric data were handled separately. The statistical difference between the species in the morphological characteristics was analysed by a one-way Analysis of Variance (ANOVA) followed by a Tukey HSD test in R environment (software version 3.6.3, R Core Team 2020). The normality of data distribution was checked visually by a Q-Q plot (quantiles of the residuals were plotted against the quantiles of the normal distribution with a 45° degree reference line) and by Shapiro-Wilk normality test. The homogeneity of variances was tested by Levene's test. A level of $p < 0.05$ was considered for a significant difference. Two conditional inference trees were prepared: one for chemical and one for morphological characteristics. Before creating the trees, two correlation matrices were prepared to exclude the strongly correlating variables during the data processing with the Hmisc package (Harrell 2022) with 'rcorr' function using Spearman rank correlation. The trees were prepared in the partykit package (Hothorn & Zeileis 2015) by 'ctree' function (Hothorn *et al*. 2006) in R.

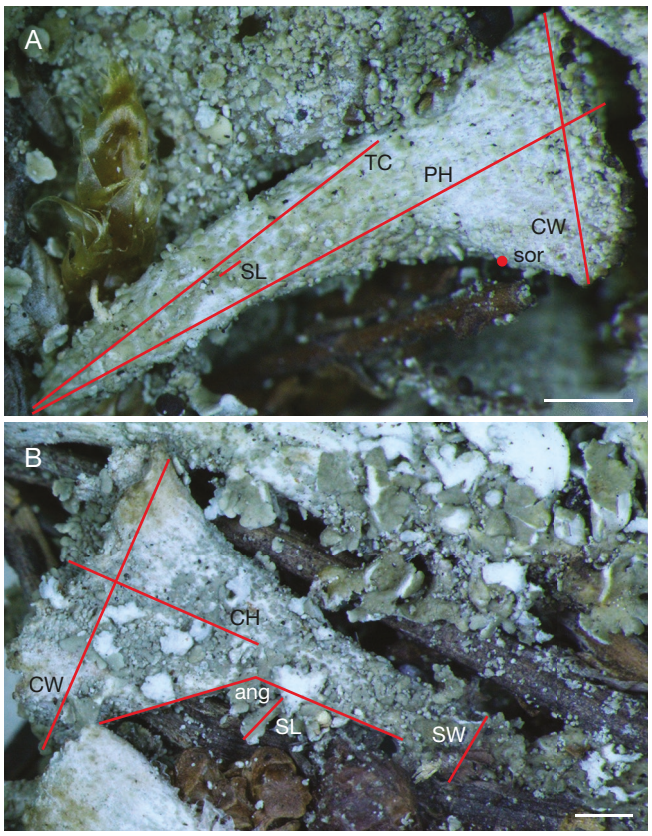

FIG. 1. — Indication of measurements for morphometric analysis: **A**, podetium of *Cladonia novochlorophaea* (Sipman) Brodo & Ahti (BP[BP 9314]); **B**, podetium of *C. merochlorophaea* Asahina (BP[BP 32926]). Abbreviations: **ang**, angle between cup and stalk; **CH**, cup height; **CW**, cup width; **PH**, podetium height; **SL**, length of squamules; **sor**, diameter of soredium; **SW**, stalk width; **TC**, corticated part of podetium. Scale bars: 1 mm.

DISTRIBUTION MAPS

Distribution maps were constructed by the computer program for geographical information system QGIS 3.28 Firenze (Qgis 2022), applying an adaptation of the Central European grid system (Niklfeld 1971; Borhidi 1984). The symbols (dots) illustrated represent units of *c*. 5 km × 6 km areas. Maps presenting distribution before and after revision were compared.

ABBREVIATIONS

ang	angle between cup and stalk;
CH	cup height;
CW	cup width;
HPTLC	high performance thin layer chromatography;
LSM	lichen secondary metabolite;
PH	podetium height;
PHCW	the ratio of podetium height to cup width;
SL	mean length of squamules;
sor	mean diameter of soredium;
SW	stalk width;
TC	corticated part of podetium;
TCPH	the ratio of the corticated part of the podetium to the height of the whole podetium;
TLC	thin layer chromatography.

RESULTS AND DISCUSSION

HPTLC ANALYSIS

The LSM content and composition were established for all 213 *Cladonia chlorophaea s.l.* specimens (Fig. 2).

The *Cladonia chlorophaea s.l.* specimens usually contained the LSMs described in the main literature sources (Culberson & Kristinsson 1969; Sipman 1973; Thomson 1976; Culberson *et al*. 1977; Holien & Tønsberg 1985; Culberson 1986a; Ahti *et al*. 2013), however, in some cases unusual LSMs were also found. It resulted in a certain diversity within the species. The following lichen secondary metabolites were found during the HPTLC analysis of the present investigation: atranorin, congrayanic, cryptochlorophaeic, 4-O-methyl-cryptochlorophaeic, fumarprotocetraric, grayanic, 4-O-demethyl-grayanic, homosekikaic, merochlorophaeic, norrangiformic, quaesitic, rangiformic and thamnolic acids.

The specimens of *C. asahinae* (6) contain fumarprotocetraric acid and rangiformic acid. The presence of the additional norrangiformic acid was found only in one specimen (BP[BP 87625]).

The specimens of *C. chlorophaea* (159) are usually characterised by the single appearance of fumarprotocetraric acid (probably sometimes with protocetraric acid not analysed separately).

The specimens of *C. cryptochlorophaea* (18) have a variable chemical composition. Normally fumarprotocetraric and cryptochlorophaeic acids were found, however, occasionally some other LSMs cooccurred with these LSMs: 4-O-methyl-cryptochlorophaeic acid, thamnolic acid, quaesitic acid (BP[BP 48938]), also with additional rangiformic acid and norrangiformic acid (BP[BP 51940]).

The specimens of *C. grayi* (6) contained normally fumarprotocetraric and grayanic acids, sometimes with additional 4-O-demethyl-grayanic acid. The appearance of additional cryptochlorophaeic acid was also found (BP[BP 32924]), where probably *C. cryptochlorophaea* occurred together with *C. grayi*.

The specimens of *C. merochlorophaea* (21) contained usually fumarprotocetraric and merochlorophaeic acids, often with 4-O-methyl-cryptochlorophaeic acid. In one specimen (BP[BP 65213]) merochlorophaeic acid was missing, but 4-O-methyl-cryptochlorophaeic acid was present together with fumarprotocetraric acid and congrayanic acid (BP[BP 65176]) appeared with the two main substances. Thus this species had a considerable diversity of LSMs.

The specimens of *C. novochlorophaea* (3) contained fumarprotocetraric and homosekikaic acids.

One specimen (BP[BP 52885]) contained a combination of LSMs characteristic for two species (fumarprotocetraric, cryptochlorophaeic, 4-O-methyl-cryptochlorophaeic and merochlorophaeic acids), therefore we concluded that probably thalli of *C. cryptochlorophaea* and *C. merochlorophaea* were found together.

A great number of further specimens (68) had to be excluded from the *Cladonia chlorophaea* group based on their different LSM composition and/or morphological characteristics. These mistakenly identified species turned out to be *C. conista*,

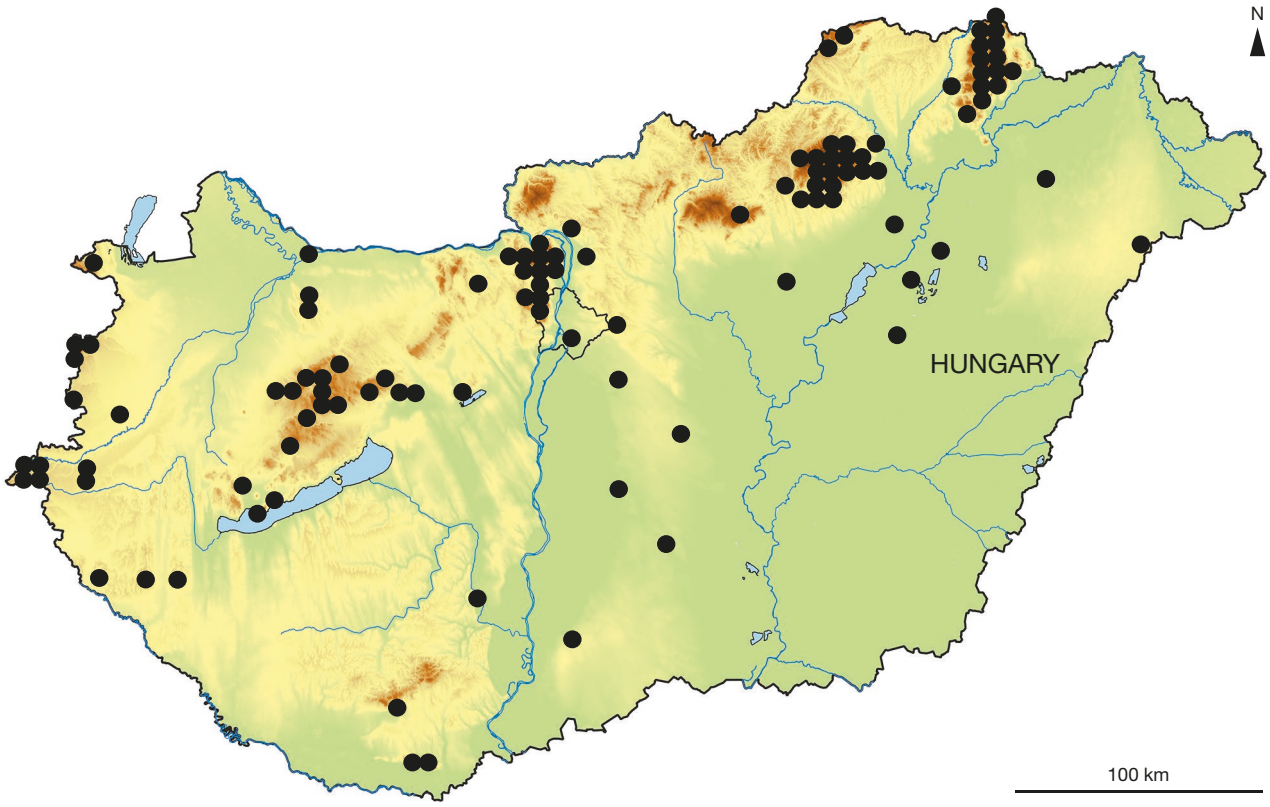

Fig. 2. — Distribution of *Cladonia chlorophaea s.l.* species in Hungary before revision.

C. fimbriata, *C. magyarica* Vain., *C. pocillum* (Ach.) O.J.Rich., *C. pyxidata* (L.) Hoffm. and various usnic acid and zeorin containing species, that usually carry red apothecia, but our specimens contained only sterile podetia.

The chromatographic analysis was followed by a statistical analysis based on LSMs. Then the specimens selected from the revised ones were measured for the morphometric analysis.

Statistical analysis based on lichen secondary metabolites

We carried out a statistical analysis for LSMs only that occurred in more than one species. We found significant strong correlation ($r > 0.9$) between the occurrence of 4-O-methyl-cryptochlorophaeic acid and grayanic acid. Therefore, the 4-O-methyl-cryptochlorophaeic acid was excluded from the further analysis.

A conditional inference tree (Fig. 3) was created that presents the chemical characteristics of the investigated species with two splits and three terminal nodes. The first split cuts the tree into two sides based on the presence of cryptochlorophaeic acid (cch), with the presence on the right side and the absence on the left side. Specimens containing cryptochlorophaeic acid and thamnolic acid were mainly *Cladonia cryptochlorophaea* (around 85%) and several *C. merochlorophaea* specimens (around 15%) also occurred on this node. The second split was based on the presence of rangiformic acid. Specimens containing rangiformic acid were mainly *C. asahinae* (*c.* 75%), and some *C. merochlorophaea* specimens (*c.* 25%) also contained the metabolite. Rangiformic acid was always missing in the specimens of *C. chlorophaea*, *C. grayi*, *C. novochlorophaea*. Specimens containing thamnolic acid were mainly *Cladonia cryptochlorophaea* (*c.* 85%) and several *C. merochlorophaea* specimens (*c.* 15%) also occurred on this node.

Statistical analysis based on morphological measurements

According to the results of the ANOVA, several characteristics caused dissimilarities between the species (Table 1). *Cladonia chlorophaea* (mean 10.35 mm) and *C. merochlorophaea* (mean 8.94 mm) had significantly taller podetia than *C. asahinae* (mean 5.00 mm), *C. cryptochlorophaea* (mean 6.53 mm) and *C. grayi* (mean 6.88 mm) (Tables 1; 2; Fig. 4).

C. novochlorophaea (mean 3.71 mm), *C. chlorophaea* (mean 3.03 mm) and *C. merochlorophaea* (mean 2.51 mm) showed significantly higher cup than *C. cryptochlorophaea* (mean 1.92 mm) and *C. asahinae* (mean 1.3 mm) (Tables 1; 2; Fig. 5). *C. asahinae* had the shortest cup among the investigated species.

C. asahinae (mean 1.75 mm) showed a significantly thinner cup compared to *C. cryptochlorophaea* (mean 3.32 mm), *C. chlorophaea* (mean 3.95 mm) and *C. merochlorophaea* (mean 3.89 mm) (Tables 1; 2; Fig. 6).

Cladonia asahinae (mean 0.53 mm) had a significantly narrower podetium stalk than *C. chlorophaea* (mean 1.01 mm) and *C. merochlorophaea* (mean 1.13 mm) (Tables 1; 2; Fig. 7).

TABLE 1. — Species pairs differing in morphometric characteristics. Abbreviations: **asa**, *C. asahinae*; **chlo**, *C. chlorophaea*; **cry**, *C. cryptochlorophaea*; **gra**, *C. grayi*; **mero**, *C. merochlorophaea*; **novo**, *C. novochlorophaea*; **ang**, the angle between cup and stalk; **CH**, height of cup; **CW**, width of cup; **PH**, height of podetium; **PHCW**, the ratio of podetium height to cup width; **SL**, mean length of squamule on podetia (n = 3 / podetium); **sor**, mean diameter of soredium (n = 10 / podetium); **SW**, width of stalk; **TCPH**, the ratio of the corticated part of the podetium to the height of the whole podetium.

	Variables								
Species pairs	**ang**	**CH**	**CW**	**PH**	**PHCW**	**SL**	**sor**	**SW**	**TCPH**
asah-chlo	ns	p < 0.001	p < 0.001	p < 0.001	0.002	ns	p < 0.001	p < 0.001	ns
asah-cry	ns	ns	0.006	ns	p < 0.001	ns	ns	ns	ns
asah-gra	ns	ns	ns	ns	p < 0.001	ns	ns	ns	ns
asah-mero	ns	0.027	p < 0.001	p < 0.001	p < 0.001	ns	p < 0.001	p < 0.001	ns
asah-novo	ns	0.002	ns	ns	0.046	ns	ns	ns	ns
gra-chlo	ns	ns	ns	0.021	ns	ns	ns	ns	ns
gra-cry	ns	ns	ns	ns	ns	ns	ns	ns	ns
gra-mero	ns	ns	ns	ns	ns	ns	0.019	0.054	ns
gra-novo	ns	ns	ns	ns	ns	ns	ns	ns	ns
mero-chlo	ns	ns	ns	ns	ns	0.006	ns	ns	ns
mero-cry	ns	ns	ns	0.011	ns	ns	0.012	0.001	ns
mero-novo	ns	ns	ns	ns	ns	0.004	ns	0.007	ns
chlo-cry	ns	0.005	ns	p < 0.001	ns	ns	ns	ns	ns
chlo-novo	ns	ns	ns	0.053	ns	ns	ns	ns	ns
novo-cry	ns	0.018	ns	ns	ns	ns	ns	ns	0.043

TABLE 2. — The mean values of morphological parameters in the different investigated species. Abbreviations: **asa**, *C. asahinae*; **chlo**, *C. chlorophaea*; **cry**, *C. cryptochlorophaea*; **gra**, *C. grayi*; **mero**, *C. merochlorophaea*; **novo**, *C. novochlorophaea*; **ang**, the angle between cup and stalk; **CH**, height of cup; **CW**, width of cup; **PH**, height of podetium; **SL**, mean length of squamule on podetia (n = 3 / podetium); **sor**, mean diameter of soredium (n = 10 / podetium); **SW**, width of stalk.

	Variables						
Species	**PH (mm)**	**CH (mm)**	**CW (mm)**	**SW (mm)**	**sor (µm)**	**ang (°)**	**SL (mm)**
asah	5.00	1.30	1.75	0.53	29	149	0.20
chlo	10.35	3.03	3.95	1.01	62	152	0.74
cry	6.53	1.92	3.32	0.80	48	149	0.74
gra	6.88	2.39	3.24	0.78	42	149	0.31
mero	8.94	2.51	3.89	1.13	65	154	0.75
novo	6.49	3.71	2.47	0.58	43	156	0.16

TABLE 3. — Correlation matrix between the morphological parameters. Abbreviations: **ang**, the angle between cup and stalk; **CH**, height of cup; **CW**, width of cup; **PH**, height of podetium; **PHCW**, the ratio of podetium height to cup width; **SL**, mean length of squamule on podetia (n = 3 / podetium); **sor**, mean diameter of soredium (n = 10 / podetium); **SW**, width of stalk; **TCPH**, the ratio of the corticated part of the podetium to the height of the whole podetium (n = 227).

	PH	**CH**	**CW**	**SW**	**sor**	**ang**	**PHCW**	**SL**	**TCPH**
PH	–	0.78	0.76	0.75	0.80	0.05	0.24	0.20	0.15
CH	0.78	–	0.78	0.76	0.75	0.10	-0.11	0.11	0.14
CW	0.76	0.78	–	0.85	0.77	-0.09	-0.37	0.07	0.05
SW	0.75	0.76	0.85	–	0.77	0.02	-0.19	0.12	0.07
sor	0.80	0.75	0.77	0.77	–	0.10	-0.01	0.08	0.16
ang	0.05	0.10	-0.09	0.02	0.10	–	0.20	0.07	0.05
PHCW	0.24	-0.11	-0.37	-0.19	-0.01	0.20	–	0.18	0.13
SL	0.20	0.11	0.07	0.12	0.08	0.07	0.18	–	0.10
TCPH	0.15	0.14	0.05	0.07	0.16	0.05	0.13	0.10	–

Cladonia asahinae (mean 29 µm) had significantly smaller soredia than *C. chlorophaea* (mean 62 µm) and *C. merochlorophaea* (mean 65 µm) (Tables 1; 2; Fig. 8).

The angle between the cup and stalk (113-179°) did not show any significant difference between the species (Table 1). The length of squamules on podetia (0.11-2.1 mm) and the part of the corticated area on podetium did not show any differences between the species (Table 1).

Before creating the conditional inference trees, a correlation matrix (Table 3) was prepared to exclude the correlating variables during the data process.

We found significant strong correlations (Spearman correlation coefficient, r > 0.6) between the podetium height, cup height, cup width, stalk width and soredium diameter, respectively.

The conditional inference tree (Fig. 9) showed the basic morphological characteristics of the investigated species with five splits and six terminal nodes. The first split cut the tree into two sides based on the mean podetium height (PH) with lower than 5 mm on the left side and higher than 5 mm on the right side.

The first split on the left side was based on the cup width (CW), forming two branches: with a narrower or wider than

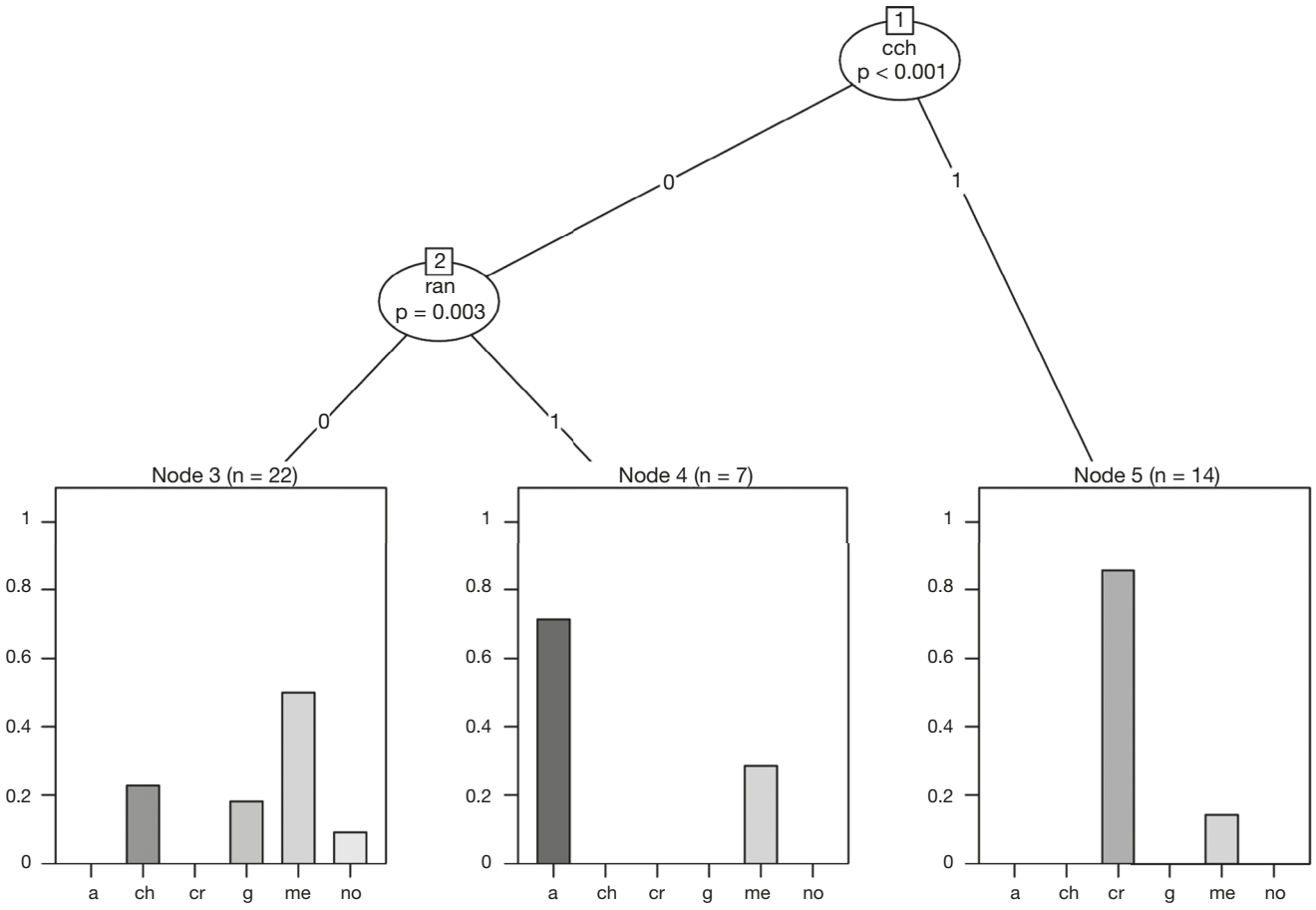

Fig. 3. — Conditional inference tree presenting the presence of the three most abundant lichen secondary metabolites occurring in more than one species of the *C. chlorophaea* species group. A level of $p<0.05$ was considered for a significant difference. Abbreviations: **cch**, cryptochlorophaeic acid; **ran**, rangiformic acid; **tha**, thamnolic acid; **a**, *C. asahinae*; **ch**, *C. chlorophaea*; **cr**, *C. cryptochlorophaea*; **g**, *C. grayi*; **me**, *C. merochlorophaea*; **no**, *C. novochlorophaea*. Boxes represent the highest probability of a species occurrence on the tree node.

1.2 mm cup on the podetium. The specimens in the group wider than 1.2 mm cup mainly (more than 40%) belonged to *C. cryptochlorophaea*. Going further, the second split divided the groups into two terminal nodes along podetium stalk width (SW). The specimens which were characterised by a thinner podetium stalk (0.3 mm) proved to be mainly *C. asahinae* (more than 60%), and some *C. novochlorophaea* (around 30%) and *C. grayi* (around 5%) specimens also occurred in this terminal node.

The first split on the right side of the tree was based on cup height (CH). Specimens with higher than 5.6 mm cups were mainly *C. novochlorophaea* (around 40%) and *C. chlorophaea* (around 50%). The second split on the right side of the tree was based on podetium stalk width (SW). Specimens with wider than 1 mm stalk were mainly *C. merochlorophaea* (almost 60%) or *C. cryptochlorophaea* (20%). More than half of the specimens with wider than 1 mm podetium stalks were mainly *C. chlorophaea*.

Though, similarly to the results of Osyczka (2013), the best separated taxon was *C. asahinae* among the *C. chlorophaea s.l.* species, our analyses could present differences also between the other five species and the differences based on LSM composition have been confirmed by morphometric studies.

Furthermore, the species had characteristic differences also in their geographical distsribution within the country as it is summarised below.

Studied species

Cladonia asahinae J.W.Thomson
(Fig. 10)

Notes

The Hungarian specimens contain rangiformic and norrangiformic acids. Though Thomson (1976) indicated the presence of fumarprotocetraric acid and protolichesterinic acid in the original description of the species, according to the chemical revision of Hennings (1983) the type specimen contains rangiformic and norrangiformic acids and not protolichesterinic acid, just as in the specimens investigated from Hungary.

The shape of the rather thin podetia is similar to that of *Cladonia fimbriata* having thin and short cups. According to various literature sources (Thomson 1976; Holien & Tønsberg 1985; Ahti *et al.* 2013) *C. asahinae* is less farinose than that species, since towards the not melanotic base corticated granules appear, furthermore the small squamules at the base of podetia

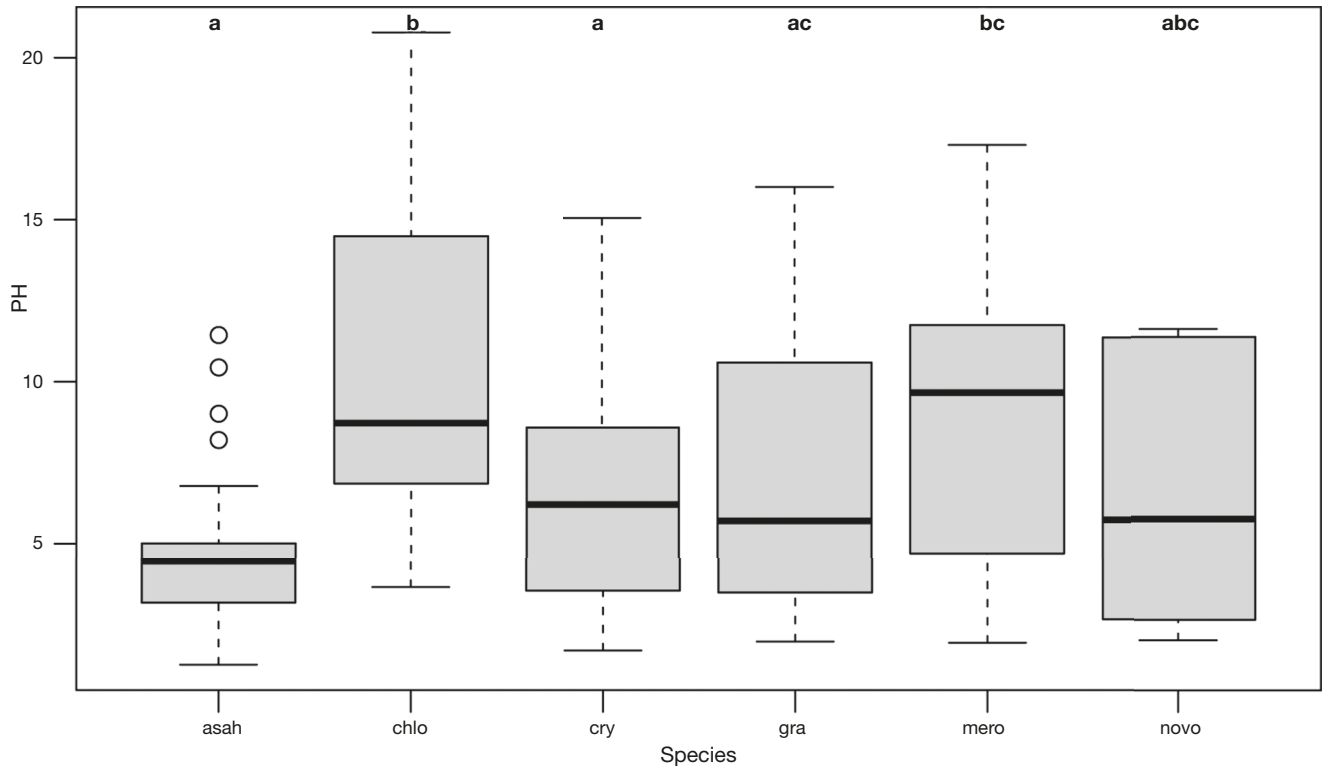

FIG. 4. — Height of podetia (mm) of the different species. Abbreviations: **asa**, *C. asahinae* (n=22); **chlo**, *C. chlorophaea* (n=55); **cry**, *C. cryptochlorophaea* (n=53); **gra**, *C. grayi* (n=17); **mero**, *C. merochlorophaea* (n=70); **novo**, *C. novochlorophaea* (n=10). The lines represent the minimum and maximum values, the box represents the 25% and 75% of the data, the thick line represents the median. Means with the same letter are not significantly different at 95% confidence.

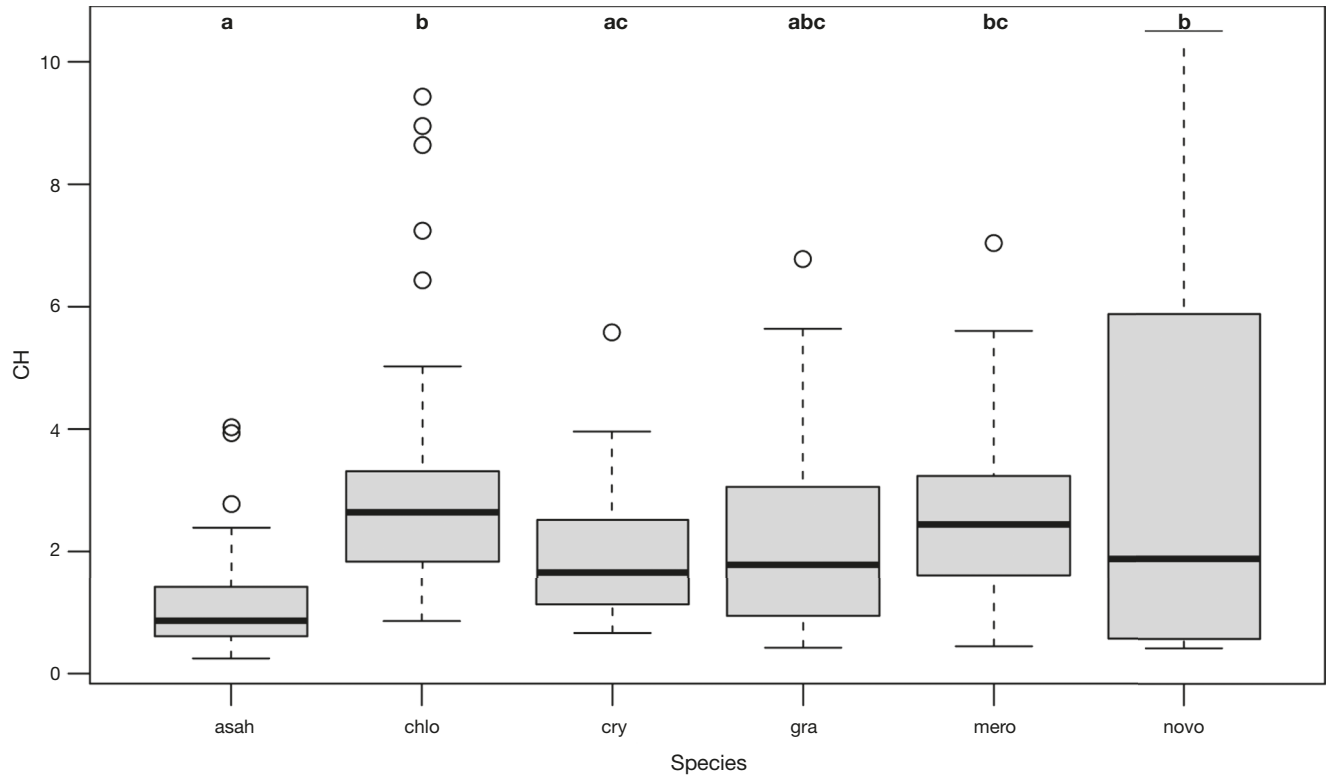

FIG. 5. — Height of cup (mm) in different species. Abbreviations: **asa**, *C. asahinae* (n=22); **chlo**, *C. chlorophaea* (n=55); **cry**, *C. cryptochlorophaea* (n=53); **gra**, *C. grayi* (n=17); **mero**, *C. merochlorophaea* (n=70); **novo**, *C. novochlorophaea* (n=10). The lines represent the minimum and maximum values, the box represents the 25% and 75% of the data, the thick line represents the median. Means with the same letter are not significantly different at 95% confidence.

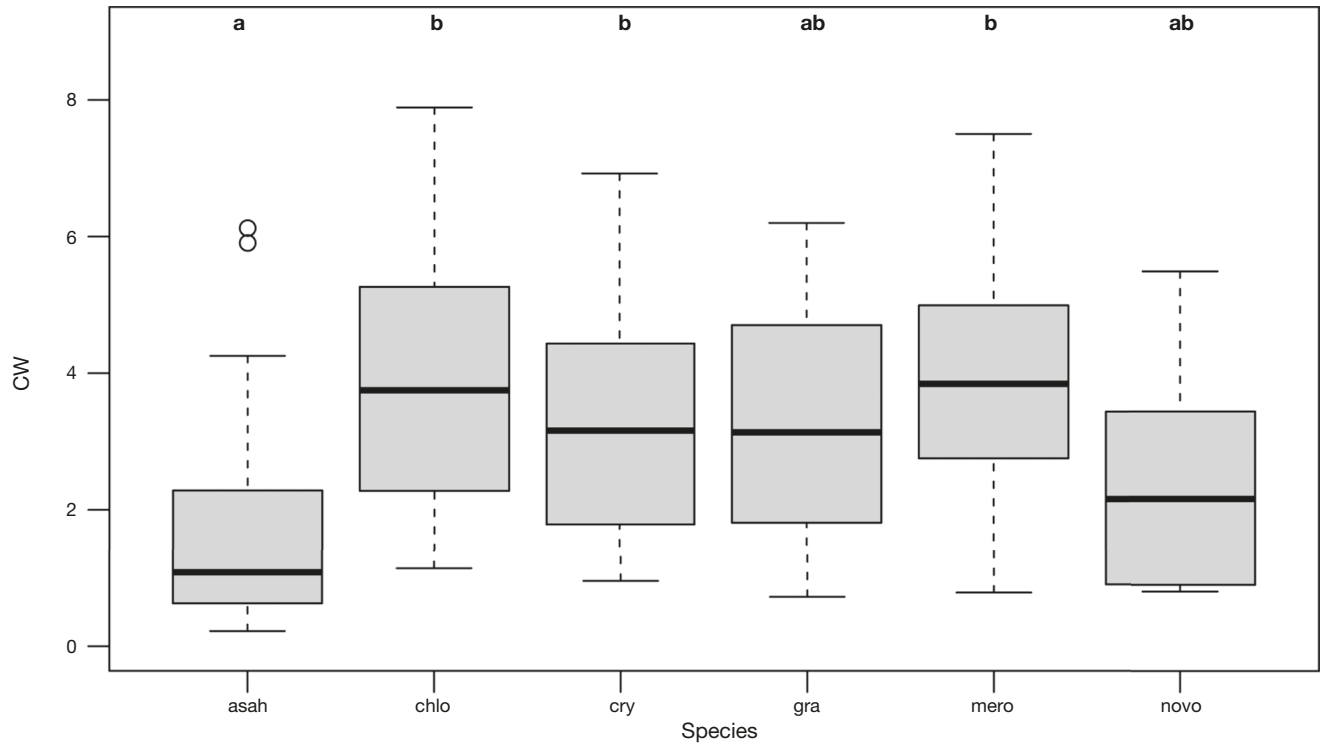

FIG. 6. — Width of cup (mm) in different species. Abbreviations: **asa**, *C. asahinae* (n = 22); **chlo**, *C. chlorophaea* (n = 55); **cry**, *C. cryptochlorophaea* (n = 53); **gra**, *C. grayi* (n = 17); **mero**, *C. merochlorophaea* (n = 70); **novo**, *C. novochlorophaea* (n = 10). The lines represent the minimum and maximum values, the box represents the 25% and 75% of the data, the thick line represents the median. Means with the same letter are not significantly different at 95% confidence.

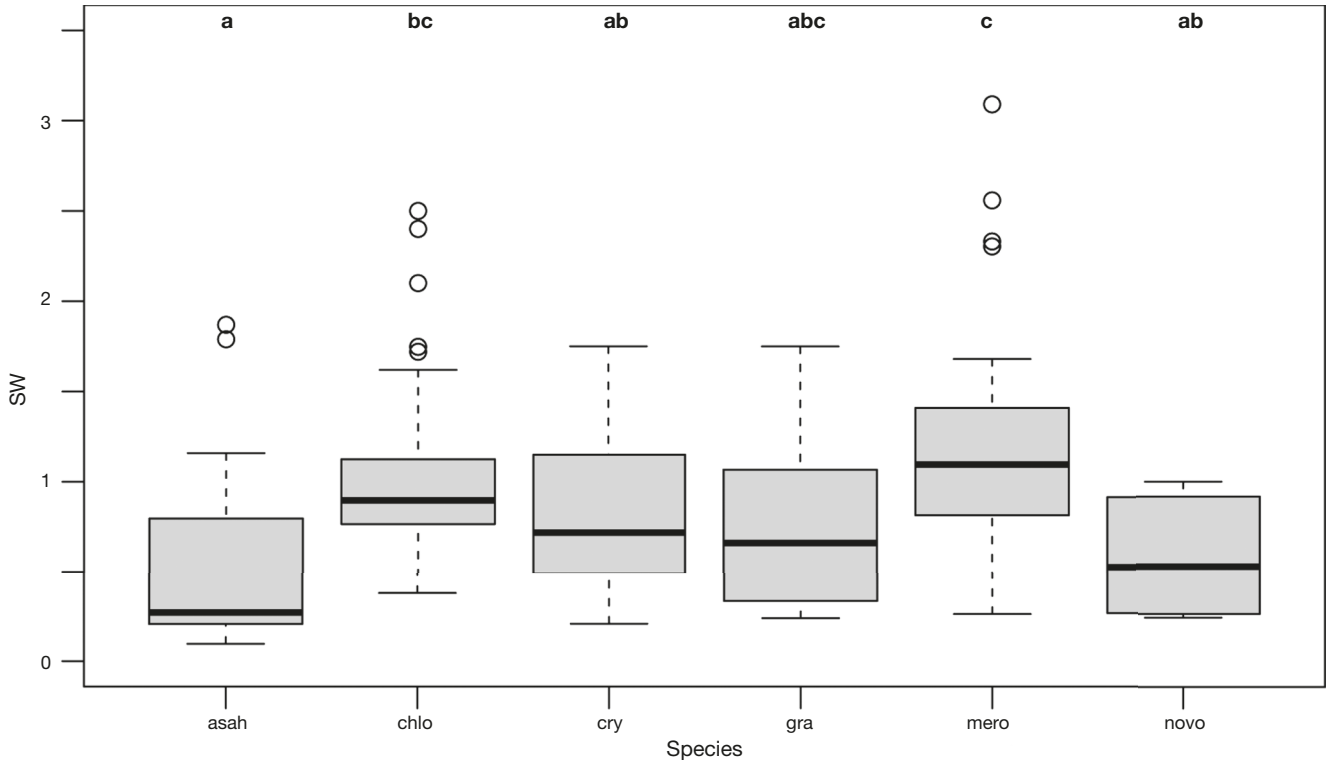

FIG. 7. — Width of podetium stalk (mm) in different species. Abbreviations: **asa**, *C. asahinae* (n = 22); **chlo**, *C. chlorophaea* (n = 55); **cry**, *C. cryptochlorophaea* (n = 53); **gra**, *C. grayi* (n = 17); **mero**, *C. merochlorophaea* (n = 70); **novo**, *C. novochlorophaea* (n = 10). The lines represent the minimum and maximum values, the box represents the 25% and 75% of the data, the thick line represents the median. Means with the same letter are not significantly different at 95% confidence.

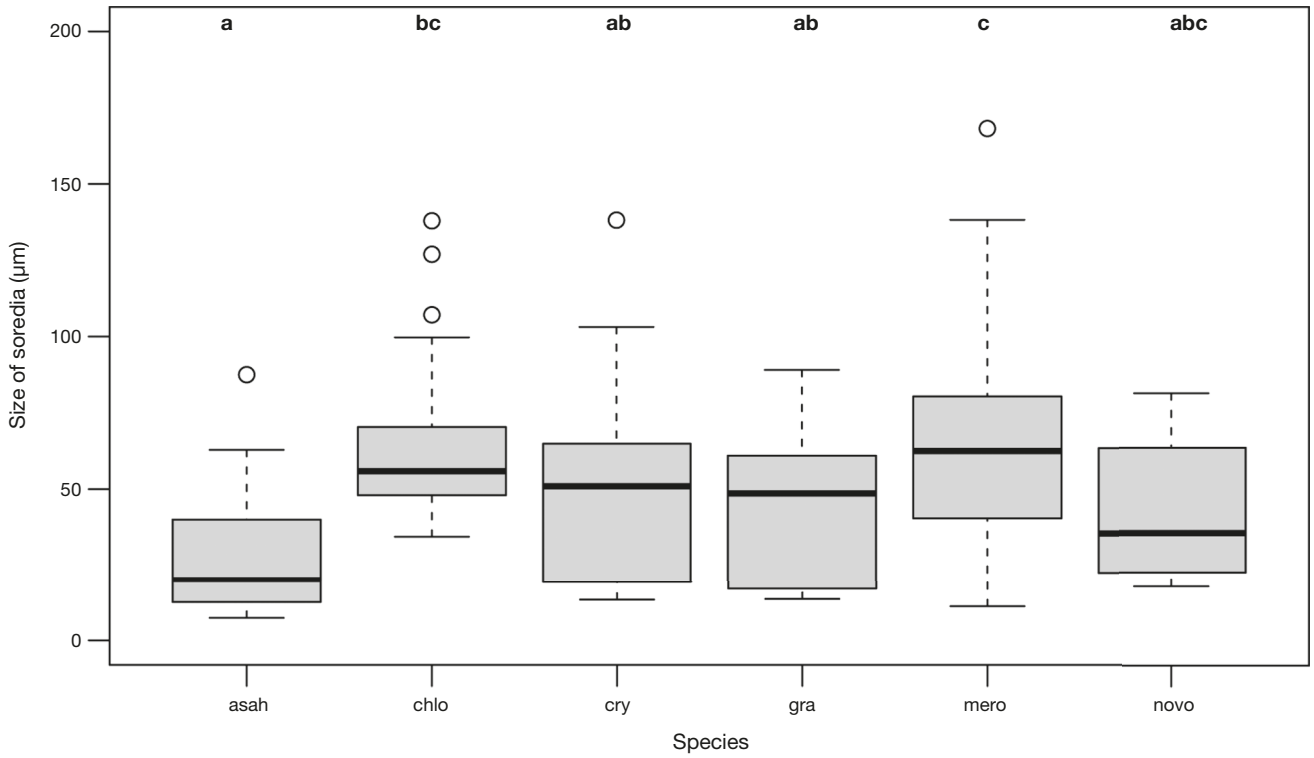

FIG. 8. — The mean diameter of soredia (µm) measured on podetia (n = 10). Abbreviations: **asa**, *C. asahinae* (n = 22); **chlo**, *C. chlorophaea* (n = 55); **cry**, *C. cryptochlorophaea* (n = 53); **gra**, *C. grayi* (n = 17); **mero**, *C. merochlorophaea* (n = 70); **novo**, *C. novochlorophaea* (n = 10). The lines represent the minimum and maximum values, the box represents the 25% and 75% of the data, the thick line represents the median. Means with the same letter are not significantly different at 95% confidence.

are regarded as important characters for *C. asahinae*. Its color is yellowish to slaty gray. While this species was found to be the smallest in the height of podetia (1.2-11.4 mm) and width (0.2-6.1 mm) and height (0.2-4 mm) of cups, and it had the thinnest stalk (0.1-1.9 mm), also the diameter of the soredia (7-88 mm) is among the smaller ones of the investigated species, the size of squamules (0.11-0.38 mm) was not significantly smaller than those of other species in Hungary. Differences were found from all species in a great number of characters (Table 1).

C. asahinae was seldom collected in Hungary and it represents a new distribution record to the country. It grows on both calcareous and siliceous soil, also among bryophytes in various hilly regions between 135 and 800 m a.s.l. in the Bakony, the Pilis and the Bükk Mts and in the Hegyalja. These are relatively humid regions within Hungary, and thus its distribution agrees well with the habitat preferences described by Holien & Tønsberg (1985).

Cladonia chlorophaea (Flörke ex Sommerf.) Spreng.
(Fig. 11)

NOTES

It contains fumarprotocetraric acid (itself or with related compound protocetraric acid – not analysed separately).

Their colour is pale greenish brown, the margin of the scyphi is dentate and becoming broken and denuded with age, the base of the podetia is not melanotic (Ahti *et al.* 2013). The soredia are granulose and thus measured as relatively larger (34-138 µm) than in other species in Hungary. It has relatively tall (3.6-20.8 mm) and broad (1.1-7.9 mm) scyphi with short stalk. Differences were found from *C. asahinae* in several characters (CH, CW, PH, PHCW, sor, SW), from *C. cryptochlorophaea* in height of cup and podetium, from *C. grayi* in the height of podetium, from *C. merochlorophaea* in the length of squamules and from *C. novochlorophaea* in the height of the podetium (Table 1).

It is the most frequent and most widely spread species in Hungary among the *C. chlorophaea s.l.* species. *C. chlorophaea* is found on calcareous soil, in deciduous and coniferous forests, at the basis of various tree species (e.g. *Alnus glutinosa* (L.) Gaertn., *Betula pendula* Roth, *Fagus sylvatica* L., *Quercus* spp., *Robinia pseudoacacia* L.), sometimes on stumps on lignum or thatched roof and almost equally frequent in the Hungarian Great Plain (70-200 m a.s.l.) and in hilly regions (up to *c.* 1000 m a.s.l.) in Hungary. However, specimens from hilly regions were mostly recognised as other *C. chlorophaea s.l.* species during our revision.

Cladonia cryptochlorophaea Asahina
(Fig. 12)

NOTES

The Hungarian specimens contain fumarprotocetraric, cryptochlorophaeic, quesitic (?), norrangiformic and thamnolic acids.

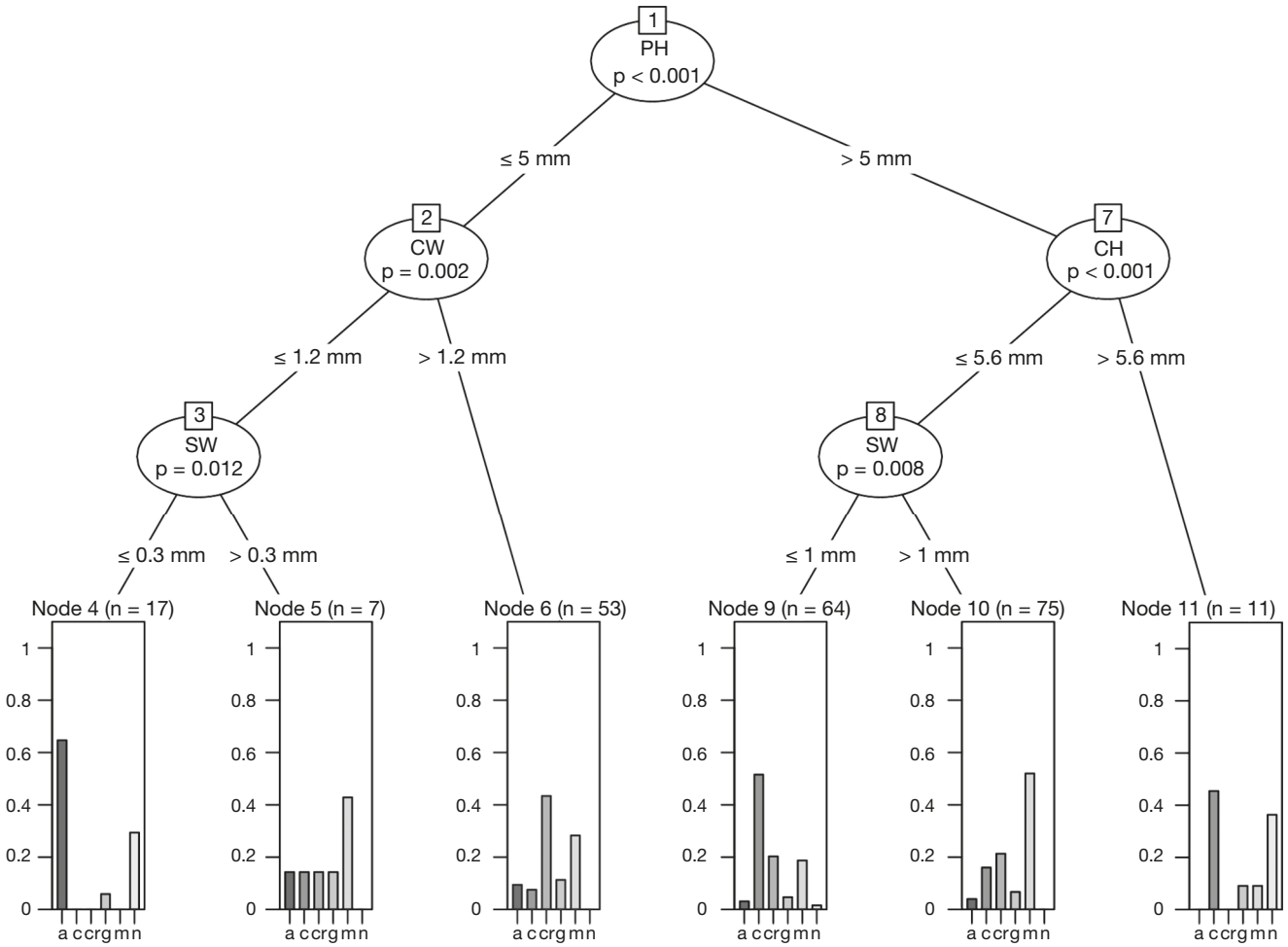

FIG. 9. — Conditional inference tree presenting the five most important morphological variables separating species: **CH**, height of cup; **CW**, width of cup; **PH**, height of podetium; **SW**, width of podetium stalk. The order of the species at the end of the nodes is as follows: **a**, *C. asahinae*; **c**, *C. chlorophaea*; **cr**, *C. cryptochlorophaea*; **g**, *C. grayi*; **m**, *C. merochlorophaea*; **n**, *C. novochlorophaea*. Boxes represent the highest probability of a species occurrence on the tree node. A level of $p < 0.05$ was considered for a significant difference.

Their colour is dark greenish grey, weakly black melanotic at base. The scyphi are hardly dentate at margin, the basis of the stalk is usually blackening (Stenroos *et al.* 2011, 2016; Ahti *et al.* 2013). The podetia are medium tall (1.7-15.1 mm) with relatively wide (1-6.9 mm) and short (0.7-5.6 mm) cup. The soredia are granulose, their diameter is medium to large (13-138 µm).

C. cryptochlorophaea differs from *C. asahinae* in the width of cup and podetium height related to cup width, from *C. chlorophaea* in the height of the cup and podetium height, from *C. merochlorophaea* in podetium height, size of soredia and width of stalk and from *C. novochlorophaea* in the height of the cup and the ratio of the corticated part of the podetium to the height of the whole podetium. None of the measured characters were significantly different between *C. cryptochlorophaea* and *C. grayi* (Table 1).

It is a rare species, collected on calcareous and siliceous soil, in deciduous, more often in coniferous forest, at the edge of the forests or along paths between 200 and 650 m a.s.l. in the Őrség, the Vendvidék, the Little Hungarian Plain, the Bakony, the Bükk and the Zemplén Mts, more or less covering the country's hilly regions.

Cladonia grayi G.Merr. ex Sandst.
(Fig. 13)

NOTES

The Hungarian sepecimens contain fumarprotocetraric, grayanic and 4-O-demethyl-grayanic acids.

Their colour is rather grayish, from greenish to pale gray, at base weakly melanotic (Stenroos *et al.* 2011, 2016; Ahti *et al.* 2013). Podetia are medium tall (1.9-16 mm) with relatively wide (0.7-6.2 mm) and high (0.4-6.8 mm) cup. *C. grayi* differs from *C. asahinae* in the ratio of podetium height to cup width, from *C. chlorophaea* in podetium height, from *C. merochlorophaea* in size of soredia and width of stalk. None of the measured characters were significantly different between *C. cryptochlorophaea*, *C. novochlorophaea* and *C. grayi* (Table 1).

The species is extremely rare in Hungary and it represents a new distribution record to the country, collected on acidic soil mostly, more often in coniferous forests, but occasionally on *Quercus* spp., between 200-300 m a.s.l. in the Vendvidék, W-Hungary only. Matwiejuk (2017) reported its frequency

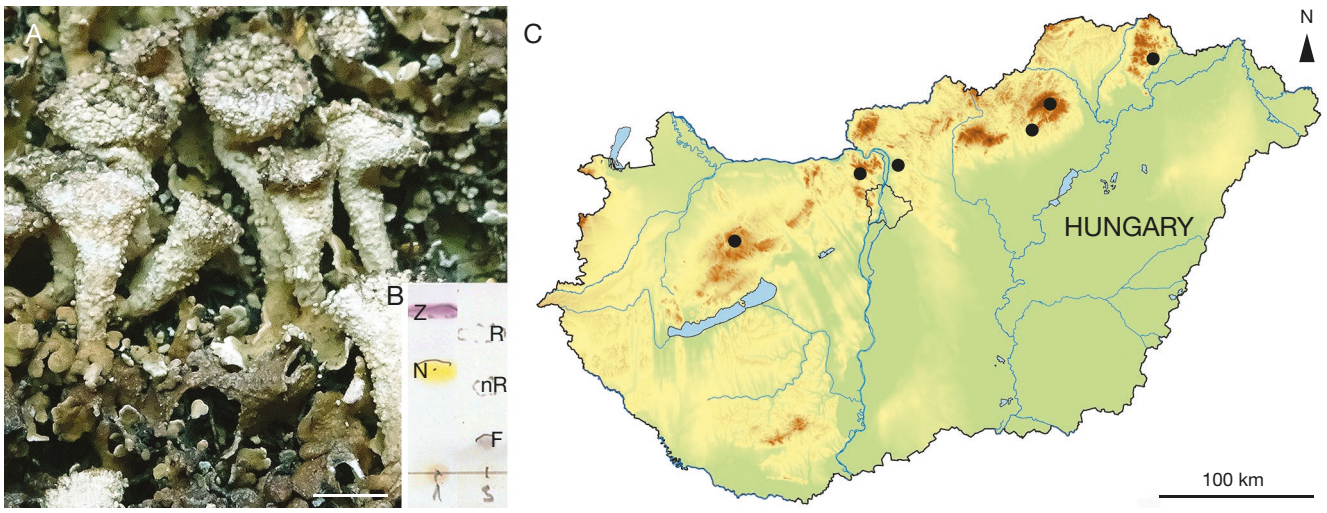

Fig. 10. — *Cladonia asahinae* J.W.Thomson: **A**, habit (BP[BP 9421]); **B**, spots of lichen secondary metabolites on chromatographic plates; **C**, distribution in Hungary. Abbrevations: **R**, rangiformic acid; **nR**, norrangiformic acid; **F**, fumarprotocetraric acid; **Z**, zeorin; **N**, norstictic acid. Scale bar: A, 2 mm.

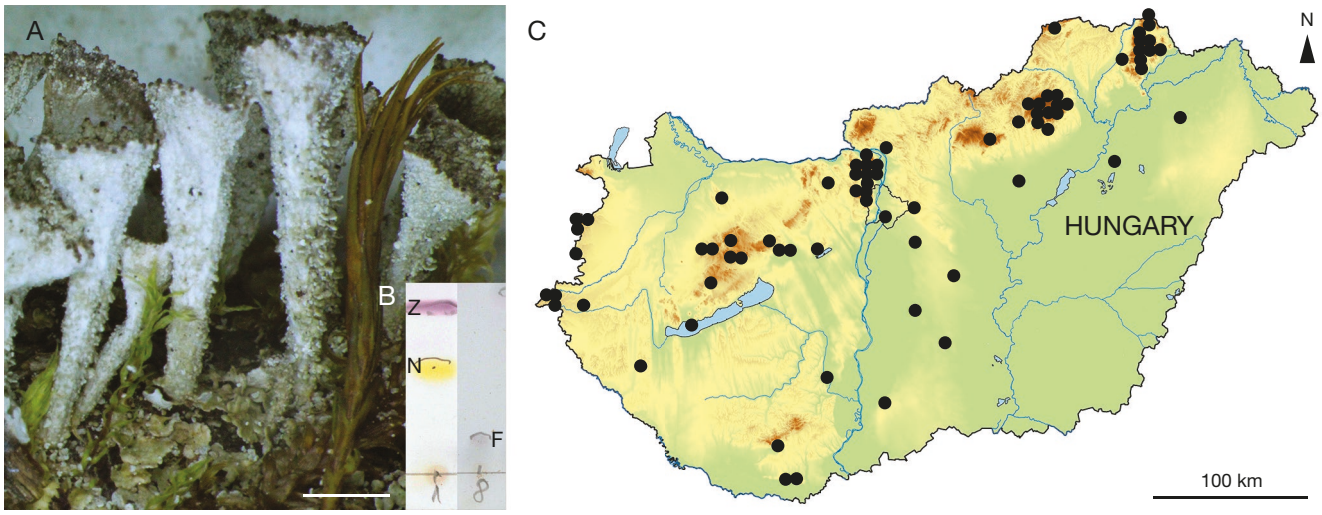

Fig. 11. — *Cladonia chlorophaea* (Flörke ex Sommerf.) Spreng.: **A**, habit (BP[BP 49014]); **B**, spots of lichen secondary metabolites on chromatographic plates; **C**, distribution in Hungary. Abbreviations: **F**, fumarprotocetraric acid; **Z**, zeorin; **N**, norstictic acid. Scale bar: A, 2 mm.

from pine forests. The localities in W-Hungary are also rich in pine forests.

Cladonia merochlorophaea Asahina
(Fig. 14)

Notes

The Hungarian specimens contain fumarprotocetraric, cryptochlorophaeic, congrayanic, 4-O-methyl-cryptochlorophaeic, 4-O-demethyl-grayanic, rangiformic and merochlorophaeic acids and they belong to the chemically most diverse species of the group.

The podetia are darker brown or gray, strongly melanotic at base (Stenroos *et al.* 2011, 2016; Ahti *et al.* 2013). Soredia are relatively larger (11-168 µm) than at other species. It is characterised by relatively tall (1.9-17.3 mm) and broad (0.8-7.5 mm) scyphi with wide (0.3-3.1 mm) stalk. *C. merochlorophaea* differs from *C. asahinae* in a number of characters (CH, CW, PH, PHCW, sor, SW), from *C. chlorophaea* and *C. novochlorophaea* in the mean length of squamules on podetia, from *C. grayi* in size of soredia and width of stalk, from *C. novochlorophaea* it also differs in stalk width and in the length of squamules. (Table 1).

It is collected more often on acidic, but also on calcareous soil, mossy soil, in coniferous forest, sometimes in oak or mixed forest, between 200 and 760 m a.s.l. in hilly regions in Hungary, in the Soproni-hegység, Őrség, the Vendvidék, the Balaton Uplands, the Bükk and the Zemplén Mts, similarly to *C. cryptochlorophaea*. Holien & Tønsberg (1985), Kowalewska *et al.* (2008) and Matwiejuk (2017) reported its frequency from pine forests. Localities of *C. merochlorophaea* in Hungary are more rich in pine forests than other regions within the country.

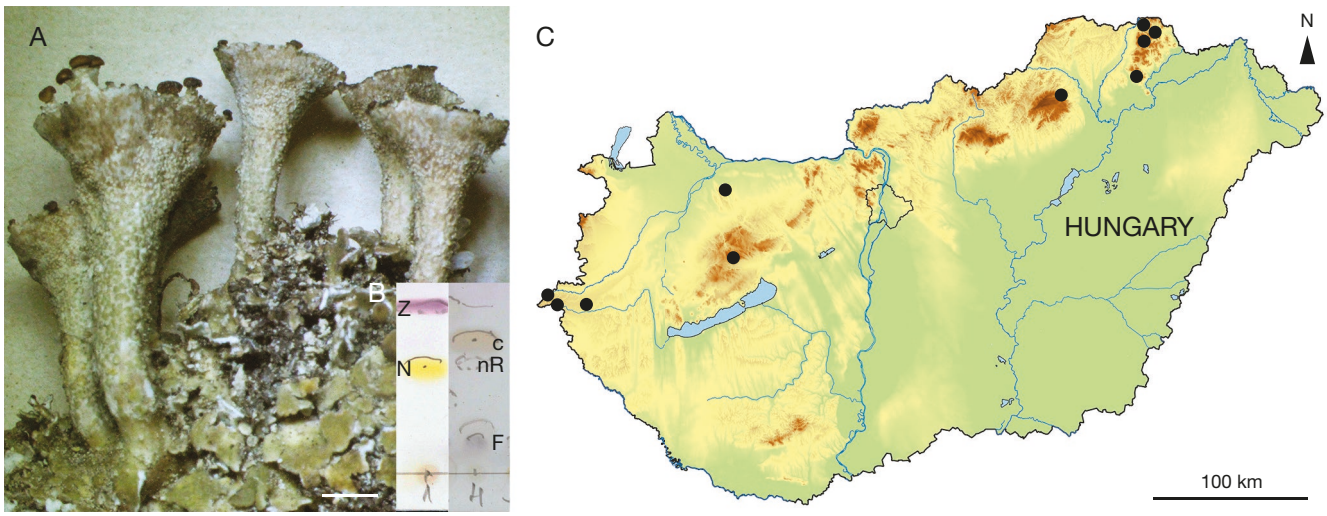

FIG. 12. — *Cladonia cryptochlorophaea* Asahina: **A**, habit (BP[BP 48938]); **B**, spots of lichen secondary metabolites on chromatographic plates; **C**, distribution in Hungary. Abbreviations: **c**, cryptochlorophaeic acid; **nR**, norrangiformic acid; **F**, fumarprotocetraric acid; **Z**, zeorin; **N**, norstictic acid. Scale bar: A, 2 mm.

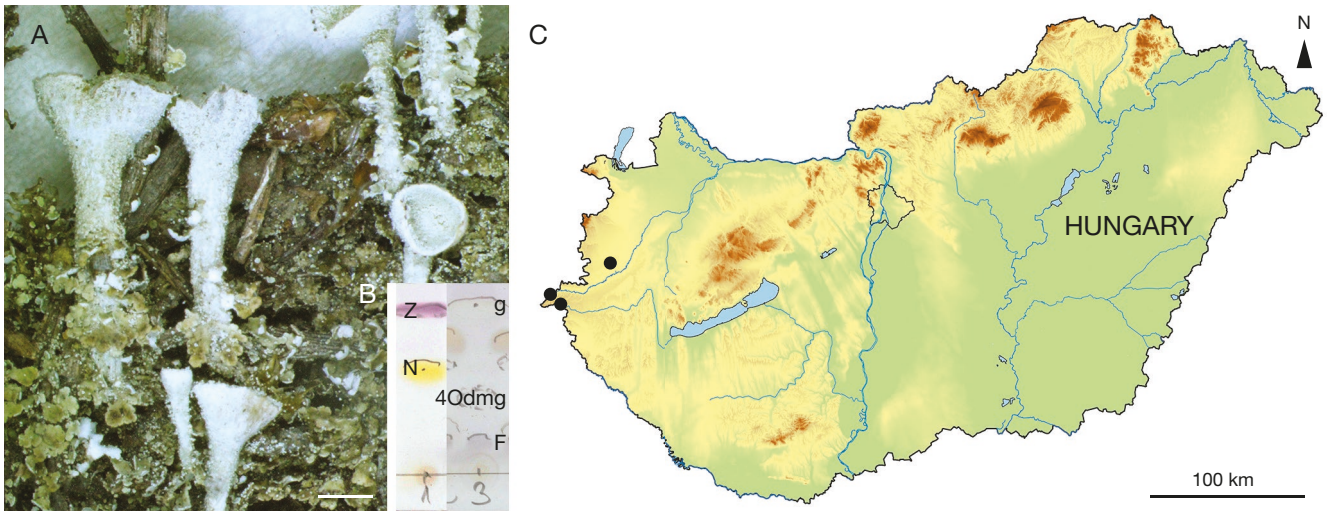

FIG. 13. — *Cladonia grayi* G.Merr. ex Sandst.: **A**, habit (BP[BP 52041]); **B**, spots of lichen secondary metabolites on chromatographic plates; **C**, distribution in Hungary. Abbreviations: **g**, grayanic acid; **4Odmg**, 4-O-demethylgrayanic acid; **F**, fumarprotocetraric acid; **Z**, zeorin; **N**, norstictic acid. Scale bar: A, 2 mm.

Cladonia novochlorophaea (Sipman) Brodo & Ahti
(Fig. 15)

NOTES

The Hungarian specimens contain fumarprotocetraric and homosekikaic acids.

Their colour is dark to blackish brown, darker at base (Stenroos *et al.* 2011, 2016; Ahti *et al.* 2013). They have medium sized podetia (2-11.6 mm high) and stalk (0.24-1 mm wide) with tall (0.4-10.5 mm) cup and medium diameter (18-81 µm) of granulose soredia. *C. novochlorophaea* differs from *C. asahinae* in cup height and podetium height related to cup width, from *C. chlorophaea* in podetium height, from *C. cryptochlorophaea* in cup height and in the ratio of the corticated part of the podetium to the height of the whole podetium and from *C. merochlorophaea* in stalk width and in the length of squamules.

None of the measured characters were significantly different between *C. novochlorophaea* and *C. grayi* (Table 1).

C. novochlorophaea is a very rare species in Hungary and it represents a new distribution record to the country, collected on acidic soil between 250 and 450 m a.s.l. in the Bakony Mts, the Balaton Uplands and the Visegrádi Mts, lignicolous, while in NE Poland it was found on soil, wood and bark of *Picea abies* (L.) H.Karst. in open habitats and forests (Matwiejuk 2017).

CONCLUSIONS

The combined study of lichen secondary metabolites and measurable microscopic morphological characters in a LSM rich species group offers a useful tool for taxonomic revision

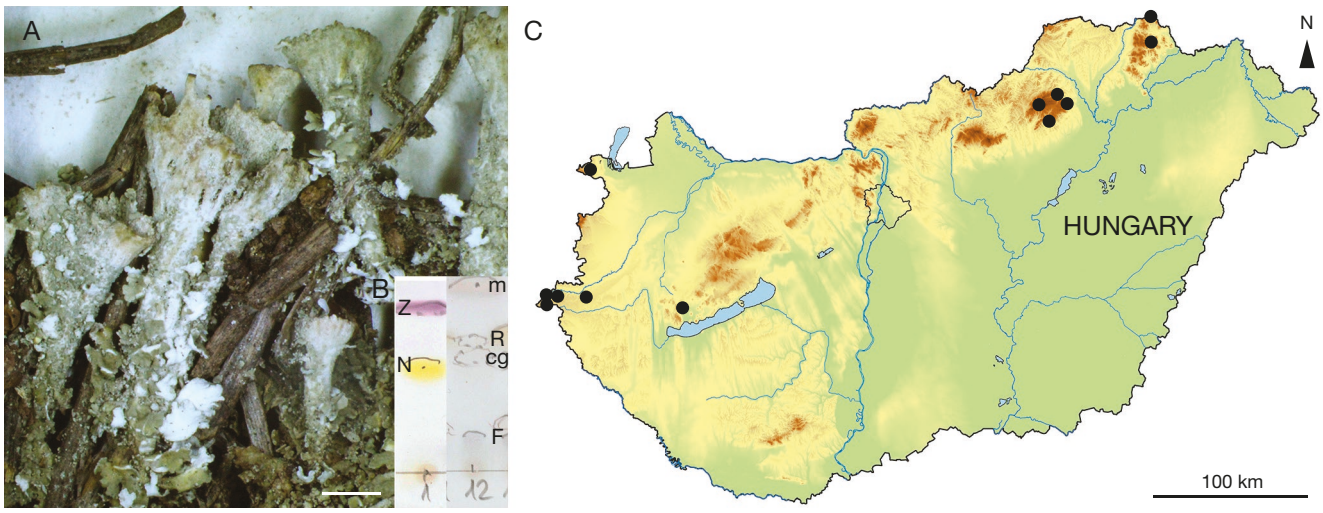

FIG. 14. — *Cladonia merochlorophaea* Asahina: **A**, habit (BP[BP 32926]); **B**, spots of lichen secondary metabolites on chromatographic plates; **C**, distribution in Hungary. Abbreviations: **m**, merochlorophaeic acid; **R**, rangiformic acid; **cg**, congrayanic acid; **F**, fumarprotocetraric acid; **Z**, zeorin; **N**, norstictic acid. Scale bar: A, 2 mm.

of so far insufficiently known taxa and for analysing the biodiversity of an area of varied habitats from geographic and climatic points of view. Since the statistical analysis mostly, but not exclusively confirmed our preliminary, unpublished measurements at a coarser scale, the measurements of the selected parameters in microscopic scale and larger number obviously led to a more precise and advisable direction for analysing taxa of similar scyphose habit. Furthermore, a new perspective on genes and metabolic paths of lichen secondary metabolite production (Singh *et al*. 2021a, 2021b; Singh 2023) opens further possibilities for phylogenetic studies also within the *Cladonia chlorophaea* group for revealing or confirming species boundaries, where additional data gained by other methods – like the results presented above – will have an important role.

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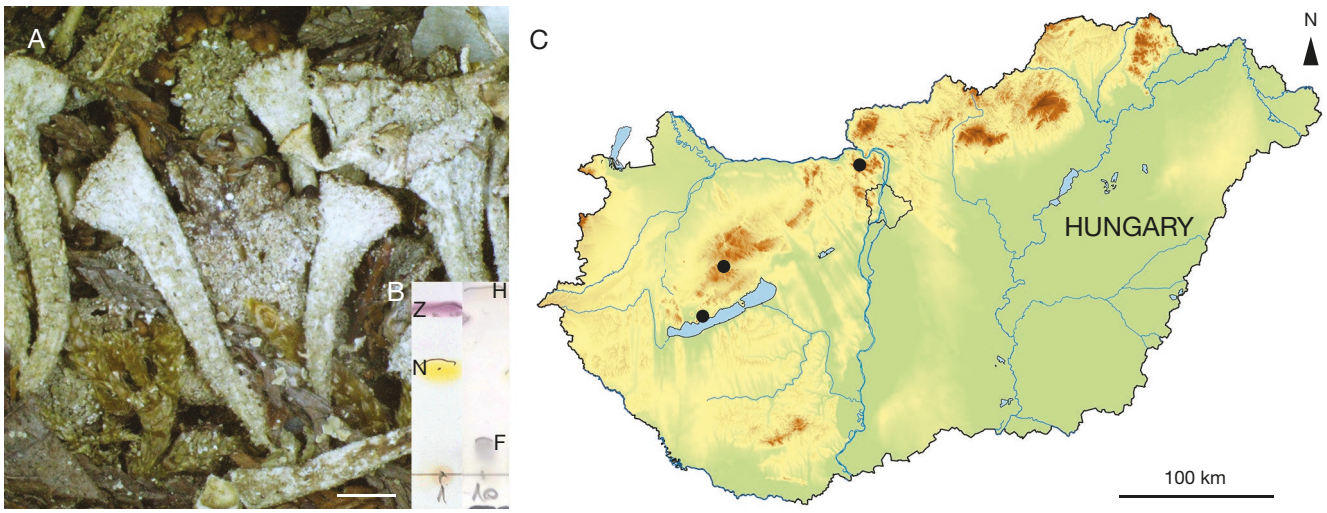

FIG. 15. — *Cladonia novochlorophaea* (Sipman) Brodo & Ahti: **A**, habit (BP[BP 9314]); **B**, spots of lichen secondary metabolites on chromatographic plates; **C**, distribution in Hungary. Abbreviations: **H**, homosekiaic acid; **F**, fumarprotocetraric acid; **Z**, zeorin; **N**, norstictic acid. Scale bar: A, 2 mm.

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APPENDIX

Appendix 1. — Herbarium records of the investigated 213 *Cladonia chlorophaea s.l.* specimens from BP (Budapest) and VBI (Vácrátót).

Name	Year	CES code	Locality	Herb. ID
Cladonia asahinae	1948	7989.1	Montium Bükk: Ómassa, in regione Kismező. Substr.: saxa calcarea musc.; alt. 800 m.	BP 65174
Cladonia asahinae	1950	7694.4	Hegyalja: Erdőhorváti: Gát oldal. Substr.: saxa silicea musc.; alt. 180 m.	BP 65206
Cladonia asahinae	1925	8772.2	Prope pagum Porva, in cacumine montis “Kőrős hegy”, ad rupem calcaream umbrosam supra muscos.	BP 74831
Cladonia asahinae	1880	8088.3	Eger.	BP 9421
Cladonia asahinae	1985	8379.1	Pilis. Mts “Pilis-hegység” on the SW side of the Mt. “Pilis” W of Pilisszentkereszt; alt. 700 m (8522/M).	VBI 347
Cladonia asahinae	1952	8281.3	Hungary. Pest. Vácrátót. Ass. Festucetum vaginatae danubiale.	VBI 5843
Cladonia chlorophaea	1915	8380.1	Agyagos földön árnyékban füves, mohás helyen a “Kőhegy” bokros oldalán Pomáz mellett; alt. 330 m.	BP 10319
Cladonia chlorophaea	1903	8479.4	Budapest.	BP 10335
Cladonia chlorophaea	1940	9577.2	Mezőföld. Szedres, terricola.	BP 10338
Cladonia chlorophaea	1925	8186.1	Mátra: mohás törmelékes földön a “Disznókő” alatt Óhuta közelében; alt. 500 m.	BP 10340
Cladonia chlorophaea	1916	8279.2	In valle “Apátkúti völgy” prope Visegrád.	BP 32929
Cladonia chlorophaea	1918	8479.4	In valle Zugliget ad Budapestinum.	BP 32930
Cladonia chlorophaea	1917	8279.2	In declivibus inter Zebegény et Nagy-Maros.	BP 32931
Cladonia chlorophaea	1916	8380.1	In monte Kőhegy, prope Pomáz.	BP 32932
Cladonia chlorophaea	1916	8580.4	Ad terram arenaceam in insula “Csepelsziget” prope Csepel; alt. *c*. 120 m.	BP 39709
Cladonia chlorophaea	1916	8380.1	Ad corticem Quercus in silva “Kis Kartalja” prope Pomáz; alt. *c*. 200 m.	BP 39738
Cladonia chlorophaea	1931	7594.4	Kishuta.	BP 39739
Cladonia chlorophaea	1926	8479.2	Prope Máriaremete, Remetehegy. Solo: dolomitica; alt. 426 m.	BP 39746
Cladonia chlorophaea	1916	8096.1	Ad tectum domi in vineas “Ószölö” prope Nyiregyháza; alt. *c*. 110 m.	BP 40109
Cladonia chlorophaea	1918	8280.3	ad saxam in silvis “Dugacka livoda” supra Pilisszentlászló; alt. *c*. 400 m.	BP 40115
Cladonia chlorophaea	1953	9975.1	Mt. Mecsek. In Quercetis declivium montis Misina supra opp. Pécs.	BP 48690
Cladonia chlorophaea	1963	9063.4	Apátistvánfalvától kb. 6 km-re északra, fenyő erdőben.	BP 48782
Cladonia chlorophaea	1962	7694.1	Zemplén hg.: Hajagos oldala Erdőhorváti felett.	BP 48813
Cladonia chlorophaea	1963	9063.4	Apátistvánfalvától északra lévő láp környékén, fenyvesben.	BP 49014
Cladonia chlorophaea	1963	7694.1	Zemplén hg.: Középhuta, az erdészettel szembeni szikla alatt az erdőben, út mentén.	BP 49117
Cladonia chlorophaea	1955	9165.1	Szőcei határban.	BP 49133
Cladonia chlorophaea	1959	7594.1	Zemplén hg.: Amadé vár és Potácsház közötti úton.	BP 49178
Cladonia chlorophaea	1955	7494.4	Zemplén hg.: Füzéri vár.	BP 49296
Cladonia chlorophaea	1963	9063.3	Szakonyfalutól délre, hegyoldalban, árnyékban; alt. *c*. 250-300 m.	BP 49350
Cladonia chlorophaea	1955	7594.3	Sátorhegység: Köves patak völgyében.	BP 49387
Cladonia chlorophaea	1960	7794.1	Zempléni hegység: Nagy Sasvölgy Erdőbénye mellett.	BP 49389
Cladonia chlorophaea	1959	7694.2	Zemplén hegység: Vadas tető gerinc, Ujhuta mellett.	BP 49425
Cladonia chlorophaea	1963	9063.3	Vas m.: Grajka völgytől nyugatra lévő hegytetőn; alt. *c*. 300 m.	BP 49496
Cladonia chlorophaea	1965	7594.1	Zemplén hg.: Telkibánya, Nagykirály hegy oldalán, fiatal fenyvesben és az út mentén, földön; alt. *c*. 200-250 m.	BP 49530
Cladonia chlorophaea	1965	7494.4	Zemplén hg.: Füzéri vár, ad saxa andesitica; alt. *c*. 450-500 m pr. Füzéi.	BP 51879
Cladonia chlorophaea	1965	8186.1	Mátra: Kékestető és Saskő közötti uton; alt. *c*. 900-1000 m.	BP 51989
Cladonia chlorophaea	1964	8971.4	Öcs: Öcsi nagy tó melletti andezit köveken.	BP 52370
Cladonia chlorophaea	1966	9063.3	Vend vidék: Kétvölgy és Szakonyfalu között, a Szakonyfalvi patak mentén, hegyoldalban, fenyvesben; alt. 200 m.	BP 52809
Cladonia chlorophaea	1964	9163.2	Vend vidék: Apátistvánfalvától K-re az úttörő tábor feletti erdei fenyő fenyvesben.	BP 52969
Cladonia chlorophaea	1964	8665.1	Kőszegi hg.: Kőszeg, Hétforrástól kb. 1-3 km-re, út mentén Kőszeg felé.	BP 52995
Cladonia chlorophaea	1964	8664.4	Kőszegi hg.: Bozsok Kalaposkőtől ny.-ra lévő Ény.-i fekvésü, kb. 80 m hosszú pala vonulaton; alt. *c*. 600 m.	BP 52996
Cladonia chlorophaea	1964	8664.4	Kőszegi hg.: Kalaposkőtől ny.-ra lévő Ény.-i fekvésü kb. 80 m hosszú pala vonulaton; alt. 600 m.	BP 53017
Cladonia chlorophaea	1964	8665.1	Kőszegi hg.: Királyvölgy felett száraz földön, Kőszeg mellett.	BP 53018
Cladonia chlorophaea	1935	7988.4	Bükk: Zsérc, in m. Kavicsostető, Törökut, substr.: terra muscosa; alt. 540 m.	BP 65171
Cladonia chlorophaea	1938	7988.1	Montium Bükk: Bélapátfalva, in cac. m. Örkő, substr.: saxa calcarea musc.; alt. 870 m.	BP 65194
Cladonia chlorophaea	1960	7693.3	Boldogkőváralja: in m. Tóhegy, substr.: saxa and. musc.; alt. 350 m.	BP 65215

Appendix 1. — Continuation.

Name	Year	CES code	Locality	Herb. ID
Cladonia chlorophaea	1912	8379.4	Pilisborosjenő: sub rad. m. Nagykevély, substr.: terra humosa; alt. 350 m.	BP 65218
Cladonia chlorophaea	1912	7990.1	Bükk: M.-Diósgyőr, in jugo m. Bányabükk, substr.: terra muscosa; alt. 400 m.	BP 65219
Cladonia chlorophaea	1927	7889.4	Bükk: Ómassa, sub rad. montis Kovácskő, substr.: terra muscosa; alt. 420 m.	BP 65222
Cladonia chlorophaea	1930	8088.2	Bükk: Felsőtárkány, juxta Isaák menház, substr.: trunc. Querc. musc.; alt. 520 m.	BP 65224
Cladonia chlorophaea	1934	7889.3	Bükk: Ómassa, in jugo montis Magoskő, substr.: terra muscosa; alt. 620 m.	BP 65228
Cladonia chlorophaea	1935	7989.4	Bükk: Kisgyőr, inter Bogárzástető et Előgalya, substr.: terra muscosa; alt. 500 m.	BP 65230
Cladonia chlorophaea	1927	7990.1	Bükk: M.-Diósgyőr, in cac. montis Veresbérc, substr.: terra graminosa; alt. 420 m.	BP 65285
Cladonia chlorophaea	1941	8472.3	Comit. Győr. In silva Écsi erdő, ad terram.	BP 72803
Cladonia chlorophaea	1968	8873.1	Mt. Bakony: in cacumine m. Papod tető pr. Hárskút, in pratis montis ad saxa calc.; alt. 646 m.	BP 74942
Cladonia chlorophaea	1968	8873.1	Mt. Bakony: in cacumine m. Papod tető pr. Hárskút, in pratis ad saxa calc.; alt. 646 m.	BP 74944
Cladonia chlorophaea	1968	8873.1	Mt. Bakony: in cacumine m. Papod tető pr. Hárskút, in pratis montis ad saxa calc.; alt. 646 m.	BP 74946
Cladonia chlorophaea	1968	7694.3	Mt. Zemplén: in jugo m. Kőrösbérc pr. Baskó, ad saxa and., ad terram; alt. *c*. 560 m.	BP 74989
Cladonia chlorophaea	1968	7694.3	Mt. Zemplén: in jugo m. Körösbérc pr. Baskó, ad cort.; alt. *c*. 560 m.	BP 74993
Cladonia chlorophaea	1968	7694.1	Mt. Zemplén: Baskó: in decl. or. m. Bogolyka hegy, in sylvis ad saxa and.; alt. *c*. 550 m.	BP 75042
Cladonia chlorophaea	1968	7694.1	Mt. Zemplén: Baskó: sub cac. m. Bogolyka hegy, in rupibus and.; alt. *c*. 600 m.	BP 75064
Cladonia chlorophaea	1968	7694.3	Mt. Zemplén: supra Baskó: in decl. bor. occ. m. Kőröshegy, in pratis siccis ad saxa and.; alt. *c*. 300-400 m.	BP 75116
Cladonia chlorophaea	1968	8771.3	Mt. Bakony: Döbrönte, m. "Várhegy", ad saxa arenaceis, exp.: N.; alt. *c*. 250 m.	BP 75374
Cladonia chlorophaea	1968	8771.4	Mt. Bakony, pr. Bakonyjákó, ad vias, ad saxa calc., exp.: N.; alt. *c*. 250 m.	BP 75401
Cladonia chlorophaea	1969	8872.2	Mt. Bakony: Hárskút, in jugo m. Kőrisgyőrhegy, supra cava, in saxis apricis; alt. *c*. 350 m.	BP 75511
Cladonia chlorophaea	1915	8479.2	Budapest, pr. pag. Máriaremete, in decl. m. Hosszúerdő, supra muscos in rup. calc.; alt. *c*. 260 m.	BP 75552
Cladonia chlorophaea	1970	0176.1	Mt. Villányi hg.: in jugo m. Harsány h. pr. Nagyharsány, ad terram; alt. 350-440 m.	BP 75752
Cladonia chlorophaea	1968	8380.1	Pomázi Kőhegy sziklái alatt, dombtetőn Stipetum szélén, Festucetumban; alt. *c*. 260 m.	BP 75945
Cladonia chlorophaea	1968	8380.1	Pomázi Kőhegy sziklái alatt, dombtetőn Stipetum szélén; alt. *c*. 260 m.	BP 75946
Cladonia chlorophaea	1972	8774.2	Mt. Bakony: cca Várpalota, pr. Királyszállás ad versus Burok völgy, ad saxa cacl. musci; alt. *c*. 400 m.	BP 76914
Cladonia chlorophaea	1884	8479.4	Buda Állatkerthegy földön mohgyepen.	BP 80118
Cladonia chlorophaea	1884	8479.4	János hegy.	BP 80125
Cladonia chlorophaea	1904	8582.1	Pécel, Lőtér. supra muscos in silvis.	BP 80174
Cladonia chlorophaea	1905	8279.3	In silvis ad montem "Dobogókő" (com. Pest) supra terram.	BP 80416
Cladonia chlorophaea	1846	8479.4	4. Budai Lindenberg hegyen.	BP 80422
Cladonia chlorophaea	1976	8292.4	Hortobágy: Ujszentmargita, legeltetett Festucetumban.	BP 87161
Cladonia chlorophaea	1981	7989.3	BNP: Pazsagi vadászház felett nyugati hegyoldalon, árnyas mészkő sziklán; alt. 560 m.	BP 87560
Cladonia chlorophaea	1981	7989.3	BNP: Pazsagi vadászház mellett, a sárga jelzéses út mentén, öreg bükkös erdő szélén, földön; alt. 550 m.	BP 87564
Cladonia chlorophaea	1956	9975.1	Mtes. Mecsek. In silvaticis ad Dömörkapu pr. opp. Pécs. Solum calc.; alt. *c*. 350 m.	BP 88147
Cladonia chlorophaea	1936	8775.3	In declivibus occident. valle Hidegvölgy prope Inota.	BP 88148
Cladonia chlorophaea	1998	8377.4	Bajna (Komárom-Esztergom megye): Kablás-hegy, S of Epöl, on soil.	BP 90333
Cladonia chlorophaea	1994	0175.2	Villányi-hegység. Siklós, Máriagyűd: southern slope of Tenkes, on rocky soil.	BP 90611
Cladonia chlorophaea	1916	8280.3	In monte "Duboka bara" prope Izbég; alt. *c*. 350 m.	BP 9302
Cladonia chlorophaea	1915	8479.2	Mohboritotta Megalodus-mészkősziklán az "Ördögárok" völgyében; alt. *c*. 270 m. Mária Remete mel.	BP 9303
Cladonia chlorophaea	1911	7889.3	Mohán. Bükkhegység. Szentléleki zárdarom tájáról.	BP 9304
Cladonia chlorophaea	1954	9468.3	Ad margines silvarum pr. pag. Nagybakónak; alt. *c*. 200 m.	BP 9305
Cladonia chlorophaea	1912	8479.2	Hosszúerdő, Mária-Remete mel., moha között mészkősziklán; alt. *c*. 350 m.	BP 9307
Cladonia chlorophaea	1912	8089.3	Régi szalmás háztetőn Cserépváralja.	BP 9308
Cladonia chlorophaea	1912	8479.1	Nagykopaszhegy, Nagykovácsi mel., Megalodus mészkőtuskón moha között; alt. *c*. 300 m.	BP 9311
Cladonia chlorophaea	1911	8279.2	Nagymarosi hegyek.	BP 9313
Cladonia chlorophaea	1916	8279.2	In valle "Malomkert" prope Visegrád; alt. *c*. 120-180 m.	BP 9316
Cladonia chlorophaea	1920	8280.3	In rupibus trachyticis montis Asztal supra vallem Stara voda ad oppid. Szt. Endre.	BP 9318
Cladonia chlorophaea	1912	8479.4	Feketefej, Budapest mel., moha között mészkősziklán; alt. *c*. 300 m.	BP 9443
Cladonia chlorophaea	1924	8775.4	Sárrét: ad terram declivibus meridionalibus montis Iszkahegy supra pagum Csór; alt. *c*. 260 m., solo andesitica.	BP 9449
Cladonia chlorophaea	1965	8186.1	Comit. Heves, Matricum, in cacumine montis "Kékes", ad truncum Fagi silvaticae.	BP 94853

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Name	Year	CES code	Locality	Herb. ID
Cladonia chlorophaea	2007	8984.1	Pest County, Kiskunság National Park, Nagykőrös, on sand.	VBI 5170
Cladonia chlorophaea	1985	8279.3	Pilis. Mts “Visegrádi-hegység” in valley “Rámszakadék”, S of Dömös; alt. 350 m.	VBI 276
Cladonia chlorophaea	1984	8279.4	Pilis. Mts “Visegrádi-hegység” Mt. “Keserűs-hegy” on the rocks under the summit “Prédikálószék” S of Dömös; alt. 630 m.	VBI 272
Cladonia chlorophaea	1984	8279.4	Pilis. Mts “Visegrádi-hegység” on a small rock of the Mt. “Üstök-hegy” S of Dömös; alt. 400 m.	VBI 271
Cladonia chlorophaea	1984	8379.1	Pilis. Mts “Pilis-hegység”, Mt. “Vaskapu-hegy” at rocks of “Vaskapu”, NW of Pilisszentkereszt; alt. 550 m.	VBI 269
Cladonia chlorophaea	1984	8379.2	Pilis. Mts “Pilis-hegység”, Mt. “Hosszú-hegy” near “Hosszú-hegyi-zsomboly” NW of Csobánka; alt. 470 m.	VBI 2554
Cladonia chlorophaea	1985	8279.3	Pilis. Mts “Visegrádi-hegység”, on the rocks “Thirring-sziklák” NW of the peak “Dobogó-kő”; alt. 600 m a.s.l.	VBI 344
Cladonia chlorophaea	1983	8279.4	Pilis. Mts “Visegrádi-hegység”. Mt. “Keserűs-hegy” at cottage “Hubertus kunyhó”, SSE of Dömös; alt. 600 m (8340/D, 8340/N).	VBI 6049
Cladonia chlorophaea	1983	8087.2	County Heves. At the surroundings of the peat-bog near Egerbakta (8372/B).	VBI
Cladonia chlorophaea	1984	8280.3	Pilis. Mts “Visegrádi-hegység” on the E side of the Mt. “Urak asztala” – “Urasztal-oldal” W of Tahi; alt. 450 m (8443/A, F).	VBI 335
Cladonia chlorophaea	1985	8279.3	Pilis. Mts “Pilis-hegység” in the valley “Vaskapu-völgy” NW of Pilisszentkereszt; alt. 500 m (8516/B).	VBI
Cladonia chlorophaea	1982	8782.1	County Pest. Junipero-Populetum at Csévharaszt; alt. 150 m (8202/H).	VBI
Cladonia chlorophaea	1938	7989.2	Bükk: Ujhuta, circa fontem Hollóskút, substr.: trunc. putr. Abietis; alt. 550 m.	BP 65195
Cladonia chlorophaea	1937	7489.4	Derenk: in decl. montis Szádvár, substr.: saxa calcarea musc; alt. 440 m.	BP 65175
Cladonia chlorophaea	1956	7695.1	Sárospatak: in decl. m. Királyhegy, substr.: terra. Alt. 210 m.	BP 64011
Cladonia chlorophaea	1937	7989.2	Montium Bükk: sub rad m. Hollós hegyek pr. pag. Ujhuta, substr.: cort. Laricis. Alt. 511 m.	BP 64214
Cladonia chlorophaea	1930	8088.2	Bükk: Felsőtárkány, juxta Isaák menház, substr.: trunc.Querc. musc; alt. 520 m.	BP 65224
Cladonia chlorophaea	2020	8777.3	Velencei-hegység Leg.: Veres, K.	VBI
Cladonia chlorophaea f. *carpophora*	1965	7594.4	Zemplén hg.: Kemence völgyben Kőkapu környékén; alt. 250 m.	BP 90951
Cladonia chlorophaea f. *costata*	1916	8280.3	Ad terram in silva “Duboka bara” prope Izbég; alt. *c*. 350 m.	BP 39733
Cladonia chlorophaea f. *costata*	1922	8279.3	Ad terram in monte “Dobogókő” pr. Dömös; alt. *c*. 600 m.	BP 39741
Cladonia chlorophaea f. *costata*	1916	8380.1	In monte “Messelja hegy” prope Pomáz; alt. *c*. 300 m.	BP 39744
Cladonia chlorophaea f. *costata*	1960	7694.2	Zemplén hegység: Simonostető szikláin.	BP 48789
Cladonia chlorophaea f. *costata*	1959	7694.2	Zemplén hg.: Középhutától délre Élesbérc szikláin.	BP 48797
Cladonia chlorophaea f. *costata*	1959	7594.3	Zemplén hegység: Hemzsőkő szikláin, Telkibányától délre.	BP 49076
Cladonia chlorophaea f. *costata*	1959	7594.1	Zemplén hg.: Amadé vár és Potácsház közötti uton.	BP 49102
Cladonia chlorophaea f. *costata*	1956	7594.3	Zemplén hegység: Pengőkő szikla.	BP 49393
Cladonia chlorophaea f. *costata*	1959	7694.2	Zemplén hegység: Vadaskert, Ujhuta mellett.	BP 49422
Cladonia chlorophaea f. *costata*	1940	9270.2	Balatonicum. Ovár pr. Szigliget, muscicola ad rup. vulcanic.tof.	BP 51217
Cladonia chlorophaea f. *costata*	1941	7988.2	Bükk: Ómassa, in monte Lyukasgerinc, substr.: trunc. musc.; alt. 860 m.	BP 65185
Cladonia chlorophaea f. *costata*	1911	8279.2	Visegrád: circa ruinis Salamon torony, substr.: saxa and.musc.; alt. 200 m.	BP 65187
Cladonia chlorophaea f. *costata*	1939	7989.2	Montium Bükk: Lillafüred: in decl. m. Jávor h., substr.: terra argillacea. Alt. 520 m.	BP 65202
Cladonia chlorophaea f. *costata*	1968	7694.1	Mt. Zemplén: Baskó: in decl. or. m. Bogolyka hegy, in sylvis ad saxa and.; alt. *c*. 550 m.	BP 75043
Cladonia chlorophaea f. *costata*	1968	8772.2	Mt. Bakony: pr. Bakonybél, in collibus, in pratis montanis, ad saxa calc., exp.: N.; alt. 500 m.	BP 75366

Appendix 1. — Continuation.

Name	Year	CES code	Locality	Herb. ID
Cladonia chlorophaea f. *costata*	1979	9383.2	Kiskunsági Nemzeti Park: Bugac, ősborókásban, homokon.	BP 85740
Cladonia chlorophaea f. *costata*	1977	9182.1	Duna Tisza köze: Fülöpháza, Solt felé vezető út mentén a homokbuckákon.	BP 85763
Cladonia chlorophaea f. *costata*	1977	9182.1	KNP: Fülöpháza, Poetum annuae társulásban, egyéves moha szinuziumban.	BP 87523
Cladonia chlorophaea f. *costata*	1913	8387.4	Homokos földön a posta úti Tölgyesben, Heves határában; alt. 110 m.	BP 9396
Cladonia chlorophaea f. *costata*	1872	8479.4	Budapest, Hárshegy.	BP 9402
Cladonia chlorophaea f. *costata*	1965	8186.1	Comit. Heves, Matricum, in summo montium “Kékestető”, ad cort. Fagi silvaticae.	BP 95748
Cladonia chlorophaea f. *costata*	1965	7594.1	Zemplén hg.: Telkibánya, Nagykirály hegy oldalán, fiatal fenyvesben és az út mentén, földön; alt. *c*. 200-250 m.	BP 51860
Cladonia chlorophaea f. *epistelis*	1961	7494.2	Zemplén hegység: Nagy Milic.	BP 49490
Cladonia chlorophaea f. *epistelis*	1953	7889.3	Bükk: Ómassa, Jávorkút: Bolhás rét. Substr.: trunc.Fagi musc.; alt. 630 m.	BP 65182
Cladonia chlorophaea f. *epistelis*	1958	7889.3	Bükk: Ómassa, in valle Tekenős. Substr.: terra argill.muscosa; alt. 560 m.	BP 65183
Cladonia chlorophaea f. *hyalinella*	1965	8186.1	Comit. Heves, Matricum, in summo montium “Kékestető”, ad cort. Fagi silvaticae.	BP 95749
Cladonia chlorophaea f. *mesothetum*	1960	7694.2	Zemplén hegység: Simonostető szikláin.	BP 49382
Cladonia chlorophaea f. *mesothetum*	1960	7794.1	Zempléni hegység: Nagy Sasvölgy Erdőbénye mellett.	BP 49391
Cladonia chlorophaea f. *prolifera*	1962	7694.1	Zemplén hg.: Középhuta, az erdészettel szembeni szikla alatt az erdőben, út mentén.	BP 49018
Cladonia chlorophaea f. *prolifera*	1959	7594.1	Zemplén hegség: Amadé vár és Potácsház közötti uton.	BP 49139
Cladonia chlorophaea f. *prolifera*	1955	7494.4	Zemplén hegység: Füzéri vár.	BP 49298
Cladonia chlorophaea f. *prolifera*	1963	8864.2	Pornóapátitól délre, *c*. 3 km-re, gyertyán elegyes erdei fenyvesben.	BP 49355
Cladonia chlorophaea f. *prolifera*	1960	7694.2	Zemplén hegység: Simonostető szikláin.	BP 49421
Cladonia chlorophaea f. *prolifera*	1965	7594.1	Zemplén hg.: Telkibánya, Nagykirály hegy oldalán, fiatal fenyvesben és az út mentén, földön; alt. *c*. 200-250 m.	BP 51857
Cladonia chlorophaea f. *prolifera*	1964	8664.2	Kőszegi hg.: Kőszeg, Hét forrás és Keresztkut közötti ut mentén.	BP 53034
Cladonia chlorophaea f. *prolifera*	1935	7989.3	Bükk: Zsérc, Pajzak: Derecske rét. Substr.: terra muscosa; alt. 450 m.	BP 65178
Cladonia chlorophaea f. *prolifera*	1921	7989.2	Montium Bükk: Diósgyőr. in jugo m. Bányahegy. Substr.: terra arg. muscosa; alt. 400 m.	BP 65180
Cladonia chlorophaea f. *prolifera*	1912	8089.3	Bükk: Tard, in valle Mélyvölgy. Substr.: terra muscosa; alt. 200 m.	BP 65188
Cladonia chlorophaea f. *prolifera*	1937	7889.3	Bükk: Mályinka, in decl. montis Czakókő. Substr.: terra arg. muscosa; alt. 580 m.	BP 65191
Cladonia chlorophaea f. *prolifera*	1931	7988.2	Montium Bükk: Szilvásvárad, Bánkút. Substr.: trunc. putr. musc.; alt. 860 m.	BP 65198
Cladonia chlorophaea f. *prolifera*	1938	7988.2	Montium Bükk: Ómassa, in pratum Nagymező. Substr.: saxa calc. muscosa; alt. 880 m.	BP 65200
Cladonia chlorophaea f. *prolifera*	1968	7694.3	Mt. Zemplén: in jugo m. Körösbérc pr. Baskó, ad cort.; alt. *c*. 560 m.	BP 74991
Cladonia chlorophaea f. *prolifera*	1968	7694.3	Mt. Zemplén: supra Baskó: in decl. bor.occ. m. Kőröshegy, in pratis siccis ad saxa and.; alt. *c*. 300-400 m.	BP 75120
Cladonia chlorophaea f. prolifera	1962	7494.2	Zemplén hg.: Köves hegy árnyas szikláin, Füzértől ény.-ra; alt. *c*. 500 m északi oldalon.	BP 75142
Cladonia chlorophaea f. *pseudotrachyna*	1916	8380.1	In monte “Messelja hegy” prope Pomáz; alt. *c*. 300 m.	BP 39808

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Name	Year	CES code	Locality	Herb. ID
Cladonia chlorophaea f. *pterygora*	1915	0176.1	Mészkősziklát takaró mohán a “Harsányhegy” sziklás gerincén Nagyharsány mel.; alt. *c*. 400 m.	BP 9470
Cladonia chlorophaea f. *pterygota*	1916	8180.4	Ad terram in monte “Nagyszál” prope Vác; alt. *c*. 400-500 m.	BP 39811
Cladonia chlorophaea f. *pterygota*	1918	8280.3	Ad saxam muscosam in silvis “Dugacka livoda” prope Pilisszentlászló; alt. *c*. 400 m.	BP 39812
Cladonia chlorophaea f. *pterygota*	1955	7594.4	Zemplén hg.: Kőkapuval szembeni sziklán.	BP 48951
Cladonia chlorophaea f. *pterygota*	1912	9680.4	Nádudvar mel., Homokbuckán. Hildpuszta közelében; alt. *c*. 110 m.	BP 9469
Cladonia chlorophaea f. *pterygota*	1912	8089.3	Régi szalmás háztetőn Cserépváralja (Borsod m.).	BP 9472
Cladonia cryptochlorophaea	1954	9063.3	Vendvidék, Betuleto-Callunetum pr. pg. Szakonyfalu, supra vall. riv. Cselin.	BP 32924
Cladonia cryptochlorophaea	1954	9165.1	Praenoricum: Őrség, Betuleto-Callunetum in colle Kovácsszer, supra pg. Szőce.	BP 32925
Cladonia cryptochlorophaea	1955	7594.2	Zemplén hg.: Dedó völgy.	BP 48938
Cladonia cryptochlorophaea	1963	9063.3	Szakonyfalvi pataktól keletre, hegyoldalon, Szakonyfalu alatt.	BP 49243
Cladonia cryptochlorophaea	1961	7494.3	Zemplén hg.: Kishegytől északra, a Szurokhegy felé vivő uttól jobbra lévő hegy gerincén, sziklákon.	BP 49467
Cladonia cryptochlorophaea	1963	9063.3	Vas m.: Grajka völgytől nyugatra lévő hegytetőn; alt. *c*. 300 m.	BP 49481
Cladonia cryptochlorophaea	1965	7594.3	Zemplén hg.: Istvánkut; Mlaka réttől az Ördögvölgy felé, utmentén, elhalt füvön; alt. 450 m.	BP 51937
Cladonia cryptochlorophaea	1965	7594.3	Zemplén hg.: Istvánkut: Mlaka réttől az Ördögvölgy felé, út mentén.	BP 51939
Cladonia cryptochlorophaea	1965	7594.3	Zemplén hg.: Istvánkút; Mlaka réttől az Ördögvölgy felé, út mentén; alt. *c*. 450 m.	BP 51940
Cladonia cryptochlorophaea	1965	7594.3	Zemplén hg.: Istvánkút; Mlaka réttől az Ördögvölgy felé, út mentén; alt. *c*. 450 m.	BP 51941
Cladonia cryptochlorophaea	1965	7594.3	Zemplén hg.: Istvánkut; Mlaka réttől az Ördögvölgy felé, út mentén.	BP 51946
Cladonia cryptochlorophaea	1965	9063.3	Vend vidék: Szakonyfalu, Szakonyfalvi patak völgye mentén, földön, erdő tisztáson vagy út mentén.	BP 52047
Cladonia cryptochlorophaea	1966	9163.2	Vend vidék: Apátistvánfalvától kb. 3 km-re, tölgy-fenyő elegyes erdő szélén, földön.	BP 52751
Cladonia cryptochlorophaea	1964	9163.1	Vend vidék: Kétvölgy községtől északra völgyárok szélén, napos, de nyirkos mohos helyen; alt. *c*. 300 m.	BP 52885
Cladonia cryptochlorophaea	1937	7889.4	Bükk: M.-Diósgyőr, in valle Forrásvölgy, substr.: terra arg.musc; alt. 280 m.	BP 65236
Cladonia cryptochlorophaea	1951	7793.4	Com. Zemplén. Mád: in declivibus montis Dióshegy, substr.: terra argillosa; alt. 400 m.	BP 65290
Cladonia cryptochlorophaea	1913	8472.1	Comit. Győr, Nagyécshegy, in silva.	BP 72792
Cladonia cryptochlorophaea	1969	8872.2	Mt. Bakony: Hárskút, in decl. bor.-or. m. Borzás hegy, in pratis montanis, ad saxa dol., in apricis; alt. *c*. 450 m.	BP 75481
Cladonia grayi	1889	8866.3	S.-Tótfalu.	BP
Cladonia grayi	1910	8191.3	Humuszon erdőben. Mezőcsát.	BP 10353
Cladonia grayi	1954	9063.3	Vendvidék, Betuleto-Callunetum pr. pg. Szakonyfalu, supra vall. riv. Cselin.	BP 32924
Cladonia grayi	1965	9063.3	Vend vidék: Szakonyfalu, Szakonyfalvi patak völgye mentén, földön, erdő tisztáson vagy út mentén.	BP 52041
Cladonia grayi	1966	9063.3	Vend vidék: Kétvölgy és Szakonyfalu között, a Szakonyfalvi patak mentén, hegyoldalban, fenyvesben; alt. *c*. 200 m.	BP 52780
Cladonia grayi	1964	9163.2	Vend vidék: Apátistvánfalva és Orfalu között fenyőkkel kevert tölgyesben.	BP 52941
Cladonia merochlorophaea	1954	9065.3	Praenoricum: Őrség. Dicrano-Pinetum callunetosum in silv. Csonkás-e., ad. Sóliktó, supra pg. Szőce.	BP 32926
Cladonia merochlorophaea	1961	7594.4	Zemplén hg.: Kerekkő észak és keleti oldalán Rostallótól dk.-re.	BP 48886
Cladonia merochlorophaea	1957	7594.4	Zemplén hg.: Laczkó hegy déli oldalában, Kemencepataki erdészet közelében.	BP 49153
Cladonia merochlorophaea	1963	9063.3	Szakonyfalutól délre csarabos erdei fenyvesben; alt. *c*. 300 m.	BP 49561
Cladonia merochlorophaea	1953	9170.1	In Callunetis collium glareosarum ad stat. ferroviae Uzsa.	BP 51194
Cladonia merochlorophaea	1965	9063.3	Vend vidék: Szakonyfalu, Szakonyfalvi patak völgye mentén, földön, erdő tisztáson vagy út mentén.	BP 52044
Cladonia merochlorophaea	1965	9063.3	Vend vidék: Szakonyfalu, Szakonyfalvi patak völgye mentén, földön, erdő tisztáson vagy út mentén.	BP 52048
Cladonia merochlorophaea	1966	9063.4	Vend vidék: Farkasfa elágazástól kb. 1 km-re tölgy elegyes fenyvesben földön.	BP 52693
Cladonia merochlorophaea	1966	9063.4	Vend vidék: Farkasfa elágazástól kb. 1 km-re tölgy elegyes fenyvesben földön.	BP 52696
Cladonia merochlorophaea	1966	9063.4	Vend vidék: Farkasfa elágazástól kb. 1 km-re tölgy elegyes fenyvesben, földön.	BP 52700
Cladonia merochlorophaea	1966	9063.3	Vendvidék: Kétvölgy és Szakonyfalu között, a Szakonyfalvi patak mentén, hegyoldalban, fenyvesben; alt. *c*. 200 m.	BP 52778

Appendix 1. — Continuation.

Name	Year	CES code	Locality	Herb. ID
Cladonia merochlorophaea	1966	9063.3	Vend vidék: Kétvölgy és Szakonyfalu között, a Szakonyfalvi patak mentén, hegyoldalban, fenyvesben; alt. *c*. 200 m.	BP 52783
Cladonia merochlorophaea	1964	9163.1	Vend vidék: Kétvölgy községtől északra, völgyárok szélén, napos, de nyirkos mohos helyen; alt. *c*. 300 m.	BP 52871
Cladonia merochlorophaea	1964	9163.1	Vend vidék: Kétvölgy községtől északra völgyárok szélén, napos, de nyirkos mohos helyen; alt. *c*. 300 m.	BP 52885
Cladonia merochlorophaea	1964	9163.1	Vend vidék: Kétvölgy községtől lévő völgyben és fenyvesben.	BP 52977
Cladonia merochlorophaea	1942	8089.1	Montium Bükk: Cserépfalu, sub rad. m. Odorvár, substr.: terra muscosa; alt. 300 m.	BP 64165
Cladonia merochlorophaea	1927	7889.4	Bükk: Lillafüred, in decl. m. Szent Istvánhegy, substr.: saxa porf. musc.; alt. 400 m.	BP 65176
Cladonia merochlorophaea	1923	7990.1	Montium Bükk: Diósgyőr. in decl. m. Várhegy, substr.: terra muscosa; alt. 300 m.	BP 65201
Cladonia merochlorophaea	1954	7988.2	Bükk: Ómassa, Nagymező: reservatio, substr.: saxa calcarea musc.; alt. 760 m.	BP 65213
Cladonia merochlorophaea	1960	7494.2	Hollóháza: circa László tanya, substr.: terra muscosa; alt. 650 m.	BP 65216
Cladonia merochlorophaea	1983	8365.1	County Győr-Sopron. Mts Soproni-hegység, “Lővérek”, Sopron, Récényi út, at the quarry.	VBI 375
Cladonia novochlorophaea	1964	8872.3	Mt. Bakony: in decl. montis pr. Szentgál, ad terram.	BP 69400
Cladonia novochlorophaea	1913	9171.3	Kisörsihegyen Calluna közt.	BP 9314
Cladonia novochlorophaea	1984	8279.3	Pilis. Mts “Visegrádi-hegység” W of the Mt. “Kakas-hegy” near the road NW of Pilisszentkereszt at the spring “Kinizsi-forrás”; alt. 450 m.	VBI 343