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Taxonomic Notes on Asian Species of *Cladonia* (*Cladoniaceae*, *Ascomycota*)

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Three species of the lichen genus *Cladonia* are described as new: *Cladonia fragosa* Ahti & Sohrabi (type from Prov. Jilin, China), *C. sinoaltaica* Ahti & Davydov (type from Xinjiang, China), and *C. sumatrana* Ahti (type from Sumatra, Indonesia). In addition, the recent records of *C. awasthiana* Ahti & Upreti from outside the Himalayas are referred to *C. rei* Schaer., and *C. tixieri* Abbayes (type from Vietnam) is reduced to synonymy of *C. cartilaginea* Müll. Arg.

Key words: Caucasia, China, lichen, new records, new synonyms, new taxa, Sumatra, Thailand, Vietnam.

Species of the lichen family *Cladoniaceae* have been studied intensively in many parts of the world, in recent times increasingly with molecular methods.

The Asian species are fairly well studied largely thanks to the Japanese master lichenologist and phytochemist Yasuhiko Asahina and his pupils and followers. However, the species in parts of Asia and especially Southeast Asia are still very insufficiently known. Some species groups are poorly understood throughout the world. Recent progress in molecular taxonomy has clarified some of the problems (e.g., Stenroos et al. 2002, 2015), but also created new, sometimes unexpected problems.

Our recent (unpubl.) phylogenetic analyses of the *Cladoniaceae* using DNA sequence data have included material from little known areas. Some specimens have turned out to represent unnamed species. Some new Asian taxa, overlooked or misidentified by earlier authors, are described below. They all have morphological and chemical characters, which can allow their identification without molecular analyses. Some other species are treated because of changes discovered in their taxonomic status or known distribution.

Material and Methods

Collections from the herbaria ALTB, BAK, G, H, L, RAMK, REN, TBI, and TUR were studied. The specimens were examined under stereomicroscope and photographed with a Nikon D800 camera and an AF-S VR Micro-Nikkor 105 mm f/2.8G IF-ED lens.

The secondary metabolites were analyzed by thin layer chromatography (TLC) according to standardized procedures (Orange et al. 2001) using the solvents A and B.

Results

1) ***Cladonia awasthiana*** Ahti & Upreti and ***C. rei*** Schaer.

Ahti et al. (2002) described *C. awasthiana* from the Himalayas (type from Himachal Pradesh). Since then Ahti and Sohrabi (2007) reported it from Iran and Yazici and Aslan (2006) from Turkey, both based on determinations by T. Ahti (these records also repeated in Rai et al. 2014). However, when Ahti recently (Aug 2015) travelled in Georgia and studied extensive material in the herbarium TBI in Tbilisi, it became clear that the Caucasian material resembling *C. awasthiana* must be placed into *C. rei*, a widespread but often overlooked species. Then *C. awasthiana* is only known from India. It is more whitish, slender, branched and almost always ascyphous compared to *C. rei.* Both produce homosekikaic acid, but fumaprotocetraric acid is constant only in *C. awasthiana*, while in *C. rei* it is frequently absent, especially in the Caucasian region. *C. rei* is not reported in the recent list of lichens of Azerbaijan (Alverdieva and Novruzov 2014), so that it is a new lichen for that country. It is known from the surrounding areas, but the reports are few (often confused with *C. ramulosa* (With.) J. R. Laundon, which seems to be absent from the area).

Representative specimens of *C. rei* from the Caucasian region examined: **AZERBAIJAN**. Balakan Dist., Solban, 1939, S. O. Barkhalov (BAK, H). **GEORGIA**. Adjara Rep., Kobuleti S, Tsikhisdziri, 1927, V. Pakhunova (H, TBI). Prov. Mstskheta-Mtianeti, Dusheti Mun., Kistani, 2050 m, 2015, T. Ahti 75043 et al. (H). Prov. Samegrelo-Zemo Svaneti, Mestia Mun., Chuberi, 850 m, 1976, T. Inashvili (H, TBI). **IRAN**. Prov. Mazandaran, Nour, Kodjur, 2000 m, 2002, M. Sohrabi & M. Mofid 356, 362 (H). **TURKEY**. Prov. Ordu, Çambasi road, 1760 m, 2014, T. Ahti 74801 et al. (H), 1275 m, 2014, R. Pino Bodas et al. (H). Prov. Trabzon, Akcaabat, Kemaliye, 2005, K. Yazici (H). Prov. Zonguldak, Beycuma, Cayköy, 100 m, 2005, K. Yazici (H).

2) ***Cladonia fragosa*** Ahti & Sohrabi, **sp. nov.** [Fig. 1]

MycoBank No.: MB 815558.

Type: **CHINA**. Jilin. Mt. Changbaisan, Erdaobaihe Co., ca. 1 km SW of Erdaocun town, 42.399753°N, 128.100131°E, alt. 735 m, 2011, M. Sohrabi 16504 & Y. C. Dai (H–holotype; Herb. Sohrabi–isotype).

Diagnosis: Podetia ca. 2 cm tall, stoutish, grey, narrowly scyphose, surface esorediate, very rough, granulose and microsquamulose. Contains fumarprotocetraric acid.

Primary thallus persistent, consisting of up to 0.5 cm long, bullate squamules, which form a subcontinuous crust. Podetia 1.5–2 cm tall and 0.5–2 mm thick, erect, stoutish, unbranched, of determinate growth, ash-grey, in patches slightly brown, at base pale, not blackening; terminated by a single scyphus, 1–4 mm wide. Podetial surface appearing very rough, essentially ecorticate but densely covered by corticate granules and flat microsquamules, which easily erode revealing the whitish medulla in patches. Podetial wall 300–320 µm, medulla ca. 50 µm, stereome 250–270 µm, hard cartilagineous, surface of central canal slightly grooved. Conidiomata common, terminal, shortly cylindrical, internal jelly hyaline but conidia not observed. Apothecia dark brown, abundant, subglobose, 0.5–1 mm diam, on short stipes along scyphus margins, spores simple, oblong, 8–14 × 2–3 µm, hyaline.

Chemistry: PD+ red, K−, UV−; fumarprotocetraric acid and traces of protocetraric acid plus minor unknowns (TLC).

Distribution: Only known from the type locality in Prov. Jilin, China. On bare mineral soil. It must be uncommon because was not seen among the numerous collections from Northeast China and adjacent areas examined in many herbaria.

Cladonia fragosa is characterized by its very rough, non-sorediate surface, which is unlike

Fig. 1. Holotype of *Cladonia fragosa* (China, Jilin, M. Sohrabi 16504 & Y. C. Dai, H). Bar: 1 cm.

in any other species of *Cladonia*. It has some resemblance to *Cladonia rei* Schaer., which is clearly sorediate in part, brownish in colour, with narrower scyphi, and containing homosekikaic acid.

In a molecular analysis (Stenroos et al. in prep.) *C. fragosa* is nested in a clade with *C. rei*, but is distinct from that species.

3) ***Cladonia sinoaltaica*** Ahti & Davydov, **sp. nov.** [Fig. 2A]

MycoBank No.: MB 815560.

Type: **CHINA**. Xinjiang Uygur Autonomous Region. Mongolian Altai, W part of Korumtytau Mts., valley of right tributary (Duntsa-Khe) of Yeltgol from the mountain at 5 km of Barytumsuktau peak to the mouth, 47°56′15″N, 88°58′03″E, alt. 1550 m, on sand over rocks, 24 July 2007, E. A. Davydov 6636 (LE–holotype; ALTB, H–isotype).

Diagnosis: Resembles *Cladonia acuminata*, but differs in being more brownish, branched, and coarsely granulose, and containing atranorin and fumarprotocetraric acid.

Primary thallus inconspicuous, disappearing, squamules ca. 1 mm across. Podetia erect, brownish grey, somewhat blackening at base, 2–2.5 cm tall, very slender, 0.5–1 mm thick, much branched in upper parts; tips acute or bluntish, ascyphose. Podetial surface very rough, almost ecorticate, but having corticate granules and microsquamules, which are easily disintegrating, leaving a bare, softish medulla exposed. Podetial wall 200–250 µm thick, medulla ca. 50 µm, stereome 150–200 µm, cartilaginous; with some longitudinal cracks. Conidiomata ampullaceous, constricted at base, at tips of podetia, conidia not observed. Apothecia brown, not seen in mature state. Chemistry: PD+ red, K+ yellow, contains fumarprotocetraric acid complex and atranorin (TLC).

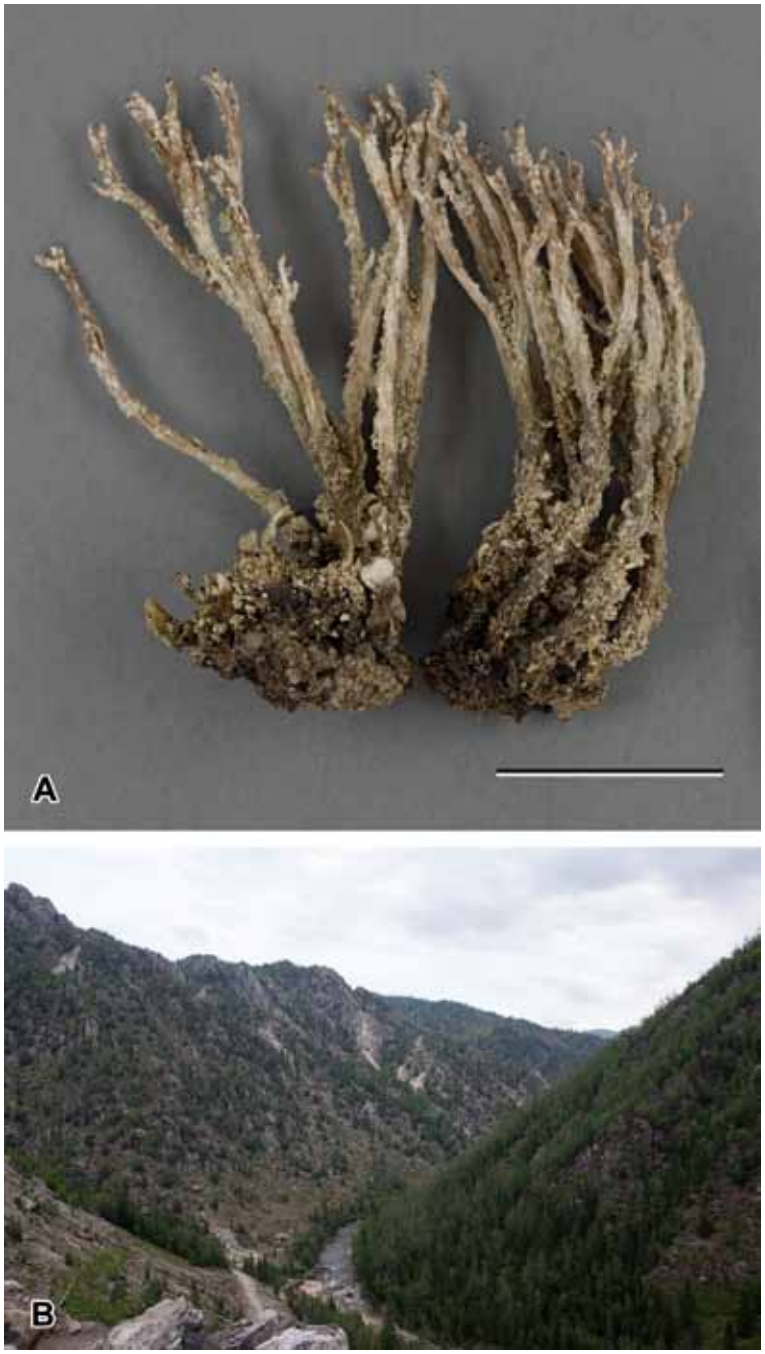

Fig. 2. A. Isotype of *Cladonia sinoaltaica* (China, Xinjiang, E. A. Davydov 6636, H). Bar: 1 cm. B. Habitat of *Cladonia sinoaltaica* along the Duntsa-Khe River, Xinjiang, China. Photo by E. A. Davydov.

Habitats and distribution: A lichen of bare steppe soil over rocks in Mongolian Altai Range in Xinjiang Uygur Autonomous Region, China. Only known from the type locality along the Duntsa-Khe River, where it grows in glades within open *Larix–Picea* forests on rocky slopes (Fig. 2B). Locally abundant.

Cladonia sinoaltaica is very distinct in morphology, being characterized by shortish, much branched, at surface very rough, ascyphose podetia, which produce atranorin and fumarprotocetraric acid. It resembles tiny specimens of *C. scabriuscula* (Delise) Nyl., but that species has no atranorin. The new species may actually be closer to *C. acuminata* (Ach.) Norrl., which is paler, with subsorediate surface and normally produces norstictic acid and atranorin. It also has a psoromic acid strain, which was recognized as a distinct species, *C. acuminans* R. C. Harris by Harris (2009) –actually a new name for what was earlier (incorrectly) called *C. norrlinii* Vain. Ahti and Stenroos (2013) synonymized *C. acuminans* (also found in Japan) with *C. acuminata*. However, Stenroos and Ahti (1991) pointed out that in Tierra del Fuego, Argentina, the chemistry of *C. acuminata* is even more variable, also including a rare strain with atranorin and fumarprotocetraric acid. It seems to be different from *C. sinoaltaica* in comparison. We do not have molecular data for this species.

4) ***Cladonia sumatrana*** Ahti, **sp. nov.** [Fig. 3]

MycoBank No.: MB 815561.

Type: **INDONESIA**. Sumatra. Aceh: Gunung Leuser Nature Reserve, Gunung Bandahara (Descent Camp 5 to 4), ca. 12 km NE of kampong Seldok (Alas Valley), ca. 25 km N of Kutatjane, alt. 2500–2600 m, terrestrial cushions in montane scrub, 28 February, 1975 W. J. J. O. de Wilde & B. E. E. de Wilde-Duyfjes 15309 (L–holotype; H–isotype).

Diagnosis: Podetia erect, forming very densely branched, erect, tall (up to more than 15 cm) cushions, corticate, branchlets thin, greyish yellow except for the strongly brown top parts. Contains usnic and thamnolic acids.

Primary thallus unknown, podetial growth apparently of indefinite type. Podetia erect, to more than 15 cm, yellowish grey to strongly brown in upper parts, basal parts not blackening, forming extremely dense cushions, branchlets thin (0.5–1 mm), dichotomously branched (with occasional trichotomy), axils closed, rarely open. Surface of podetia generally very smooth, areolate, but the areolae not usually elevated, but sometimes causing slight scabrosity; no podetial squamules seen. Podetial wall ca. 150 μm. cortex very thin (corticoid), 50 μm, stereome softish, 100 μm; surface of central canal minutely fibrose. Conidiomata at podetial tips, black, at maturity shortly cylindrical, internal jelly purple (not seen definitely), conidia not observed. Apothecia not seen. Chemistry: PD+ yellow, K+ yellow, contains usnic and thamnolic acids (TLC).

Habitat and distribution. On soil in open, high-mountain rain forests in northern Sumatra.

Additional specimen studied: **INDONESIA**. Sumatra. Aceh: Gunung Leuser Nature Reserve, Gunung Mamas (Camp 4-2), 14–18 km SW of the mouth of Lau Ketambe, ca. 30 km NW of Kutatjane, alt. 1700 m, terrestrial cushion in montane rain forest, in open elfin forest, 16 May, 1975, W. J. J. O. de Wilde and B. E. E. de Wilde-Duyfjes 16941 (H, L).

In habit *Cladonia sumatrana* much resembles the species of the "reindeer lichens", especially *C. ciliata* Stirt. However, it contains thamnolic acid, not known in that group, and the tips are not strongly deflexed. Another similar species in the area is *C. siamea* Abbayes, described from Thailand by des Abbayes (1956). It is chemically similar, but its branching is not very dense, and the tops are not strongly browned (see a photograph in Stenroos 1986, fig. 2).

Cladonia sumatrana is one of the obviously undescribed species discovered in the Leiden herbarium (L) among the species collected in the wet high-mountain forests or bogs on Sumatra and elsewhere in Indonesia. These high elevation habitats are not easily accessible and their

Fig. 3. Isotype of *Cladonia sumatrana* (Indonesia, Sumatra, W. J. J. O. de Wilde & B. E. E. de Wilde-Duyfjes 15309, H). Bar: 1 cm.

perhaps largely endemic lichen flora is badly known. *Cladonia sumatrana* was associated with several other *Cladonia* species, which could not be identified to any known species. Due to scanty material they are not treated here in detail.

5) ***Cladonia tixieri*** Abbayes [Fig. 4]

Type: **VIETNAM**. Dalat: Manline, 1500 m, 1959, P. Tixier s.n. (REN-Abbayes–holotype; TUR 13403–isotype).

This species was described from Vietnam by H. des Abbayes (1964) on the basis of two specimens collected in the same place. The status of this species has never been evaluated by other authors. Both the holotype and isotype were examined and the species is here reduced to synonymy of *Cladonia cartilaginea* Müll. Arg.

Cladonia cartilaginea is a widespread "weedy" species in tropical South and Central America (described from Venezuela). Its presence in Asia it was confirmed by Ahti et al. (2002), who found it to be widespread in India (see a long list of localities in Rai et al. 2014: 63–66). It is also present in Nepal and Thailand.

The type of *C. tixieri* contains fumarprotocetraric acid, but the specimens from Thailand and Vietnam cited below also have homosekikaic acid. Both these strains are also known from the Neotropics (Ahti 2000). The name *C. tixieri* may become useful

Fig. 4. Isotype of *Cladonia tixieri.* Vietnam, Dalat, P. Tixier s.n., TUR 13403). Bar: 1 cm.

later, if a molecular survey of the Neotropical and Paleotropical material will show that all those populations are not uniform. Due to its high variability this species is very difficult to interpret from morphology alone.

Additional specimens of *Cladonia cartilaginea* examined: **NEPAL**. Eastern Region: Mechi, De Yektin, Kunga–Tharpu, 1150 m, 1971, P. Ozenda 33K (G, H), De Ilam by lake Mai Pokhari, 1250 m, 1971, P. Ozenda 28B (G, H). **THAILAND**. Pisanulok Prov.: Phu Hin Longla Natl. Park, 1100 m, 2003 S. Meesim 113 (H, RAMK). **VIETNAM**. Prov. Vinh Phu: Tam Dao Natl. Park, 2001 M. J. Lai 9072202 (H).

Taxonomic notes on Japanese species of *Cladonia*

As to Japanese species of *Cladonia*, most species are well known, but several problems still exist. Among recent novel findings concerning the Japanese species are the resurrection of *Cladonia pseudalcicornis* Asahina, an amphi-Beringian species (Ahti 2009), and the report of *C. diversa* Asperges ex S. Stenroos as new to Japan (Ahti and Stenroos 2012). In addition, *Cladonia pseudostellata* Asahina has been reduced to be a hypothamnolic acid chemotype of *Cladonia uncialis* (L.) F. H. Wigg. subsp. *uncialis* (and also reported from Scotland; Stenroos et al. 2015) on the basis of phylogenetic analyses using DNA sequence data. Another formerly Asian species, *C. corymbescens* Nyl. ex Leight., has been divided so that in Asia it is represented by *C. pseudofissa* (Asahina) Ahti & al. (Ahti et al. 2015).

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T. Ahti[a], M. Sohrabi[b], E. A. Davydov[c], R. Pino-Bodas[a], S. Stenroos[a]**:アジア産ハナゴケ属（ハナゴケ科，子嚢菌門）の分類ノート**

ハナゴケ属の 3 新種を記載した：*Cladonia fragosa* Ahti & Sohrabi（タイプは中国・吉林省），*C. sinoaltaica* Ahti & Davydov（タイプは中国・新疆），*C. sumatrana* Ahti（タイプはインドネシア・スマトラ島）．*C. fragosa* と *C. sinoaltaica* はいずれもホモセッカ酸を含み，日本産のヒメレンゲゴケ *Cladonia ramulosa* (With.) J. R. Laundon やツエハナゴケ *C. rei* Schaer と形態的には酷似するが遺伝子解析では異なるクレードを形成する．*C. sumatrana* は *R. tenuiformis* Ahti に似ているが分枝の叉の孔は稀でタムノール酸を含むので区別できる．また，ヒマラヤ以外から *C. awasthiana* Ahti & Upreti と報告された種は何れも *C. rei* と同定される．ベトナム産の *C. tixieri* Abbayes は *C. cartilaginea* Müll. Arg. の異名となった．

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