cryptogamie
Bryologie
2020 • 41 • 4

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Shuvadeep MAJUMDAR & David LONG

art. 41 (4) — Published on 11 March 2020
www.cryptogamie.com/bryologie

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diff.pub@mnhn.fr / http://sciencepress.mnhn.fr

ISSN (imprimé / *print*) : 1290-0796 / ISSN (électronique / *electronic*) : 1776-0992

Two new synonyms and extended distribution of *Anastrophyllum ellipticum* Inoue (Anastrophyllaceae: Marchantiophyta)

Shuvadeep MAJUMDAR
Central National Herbarium, Botanical Survey of India,
Shibpur, Howrah, 711103 (India)

David LONG
Royal Botanic Garden Edinburgh EH3 5LR (United Kingdom)
d.long@rbge.ac.uk (corresponding author)

Submitted on 28 November 2018 | Accepted on 19 April 2019 | Published on 11 March 2020

Majumdar S. & Long D. 2020. — Two new synonyms and extended distribution of *Anastrophyllum ellipticum* Inoue (Anastrophyllaceae: Marchantiophyta). *Cryptogamie, Bryologie* 41 (4): 49-53. https://doi.org/10.5252/cryptogamie-bryologie2020v41a4. http://cryptogamie.com/bryologie/41/4

ABSTRACT
The Sino-Himalayan *Anastrophyllum lignicola* D.B.Schill & D.G.Long and *A. minutum* (Schreb.) R.M.Schust. var. *himalayanum* S.Srivast., S.C.Srivast. & K.K.Rawat are newly designated as synonyms of the Japanese *A. ellipticum* Inoue. The similarities between these taxa are summarised to support this new synonymy, and the current known distribution now ranges from the NW Himalaya of India, through Bhutan, Arunachal Pradesh in NE India, Yunnan and Sichuan in China, Altai in Russia to Japan. Photomicrographs of the distinctive gemmae of *A. ellipticum* are provided.

KEY WORDS
Anastrophyllaceae,
East Asia,
new synonymy.

RÉSUMÉ
Deux synonymes nouveaux et une distribution étendue pour Anastrophyllum ellipticum *Inoue (Anastrophyllaceae: Marchantiophyta).*
Anastrophyllum lignicola D.B.Schill & D.G.Long et *A. minutum* (Schreb.) R.M.Schust. var. *himalayanum* S.Srivast., S.C.Srivast. & K.K.Rawat décrits de la partie chinoise de l'Himalaya sont mis en synonymie d'*A. ellipticum* Inoue, décrit du Japon. Les ressemblances entre ces taxons sont résumées pour confirmer cette nouvelle synonymie ; ainsi, la distribution connue d'*A. ellipticum* s'étend maintenant de l'Himalaya NW au Japon en passant par le Bhutan, l'Arunachal Pradesh dans l'Inde NE, par le Yunnan et le Sichuan en Chine et par l'Altai en Russie. Les gemmules distinctes d'*A. ellipticum* ont été photomicrographiées.

MOTS CLÉS
Anastrophyllaceae,
Asie de l'est,
synonymes nouveaux.

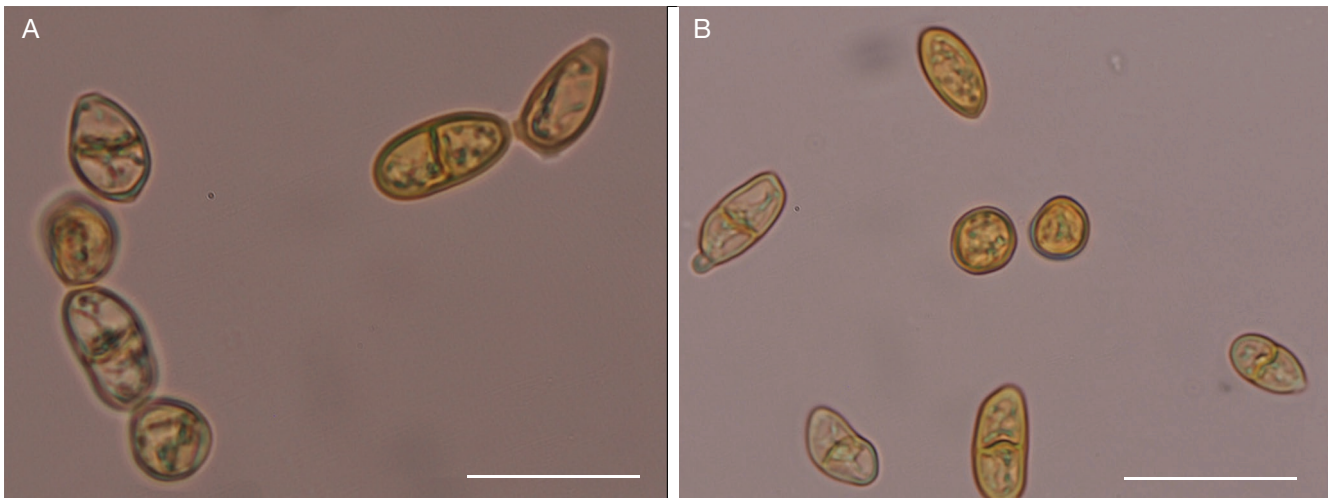

Fig. 1. — Gemmae of *Anastrophyllum ellipticum* Inoue, from TNS-42220, (holotype TNS). Scale bars: 30 µm.

INTRODUCTION

The family Anastrophyllaceae Söderström *et al.* (2010) is currently represented by 20 genera worldwide (Söderström *et al.* 2016) and its type genus *Anastrophyllum* (Spruce) Steph. by 17 species, viz. *A. alpinum* Steph., *A. assimile* (Mitt.) Steph., *A. auritum* (Lehm.) Steph., *A. ciliatum* Steph., *A. donnianum* (Hook.) Steph., *A. ellipticum* Inoue, *A. esenbeckii* (Mont.) Steph., *A. fissum* Steph., *A. joergensenii* Schiffn., *A. lignicola* D.B.Schill & D.G.Long, *A. michauxii* (F.Weber) H.Buch, *A. nigrescens* (Mitt.) Steph., *A. obtusum* Herzog, *A. piligerum* (Nees) Steph., *A. squarrosum* Herzog, *A. stellatum* R.M.Schust. and *A. tubulosum* (Nees) Grolle (Söderström *et al.* 2016). *Jungermannia minuta* Schreb. ex D.Crantz was established in the year 1770 based in material from Greenland; since that date it has been transferred to several other genera including *Anastrophyllum*; currently it is recognised under *Sphenolobus* as *S. minutus* (Schreb. ex D.Crantz) Berggr. (Söderström *et al*. 2016). Molecular support for segregating *Sphenolobus* (Lindb.) Berggr. is given by de Roo *et al.* (2007).

Amongst the species of *Anastrophyllum* and *Sphenolobus* recognised in the past from East Asia, three taxa formerly accepted as distinct were noted by us and the late Jiri Váňa (*in litt*.) as morphologically very similar and worthy of close scrutiny: *A. ellipticum* Inoue (Inoue 1978), *A. lignicola* D.B.Schill & D.G.Long (Schill & Long 2002) and *A. minutum* (Schreb. ex D.Crantz) R.M.Schust. var. *himalayanum* S.Srivast., S.C.Srivast. & K.K.Rawat (Srivastava *et al*. 2013). Only recently has it become possible to study the type specimens of all three taxa, which has facilitated the present study. Since the description of *A. ellipticum* from Japan (Inoue 1978) and *A. lignicola* from Bhutan and Yunnan (Schill & Long 2002) further records of the latter have been published from Sichuan by Schill & Long (2003) and from Arunachal Pradesh by Majumdar & Singh (2017). More recently, Mamontov & Vilnet (2013) reported *A. ellipticum* from the Altai Mountains of Russia, pointing out its close similarity to *A. lignicola*, but concluding, on the basis of both morphological and molecular evidence, that they should be maintained as distinct from each other. We wish to reconsider this distinctness on the basis of a much wider sample range than was available previously.

MATERIAL AND METHODS

This study is based on a review of literature and light microscope study of relevant type material and other specimens listed below.

RESULTS AND DISCUSSION

During the present study, the authors examined the holotype of *A. ellipticum,* the holotype, isotype and paratypes of *A. lignicola* and the holotype of *Anstrophyllum minutum* var. *himalayanum*. We found that the types of all three taxa are extremely similar to each other. Comparison of the protologues (Table 1) supports their very close similarity though some differences were indicated: var. *himalayanum* was described as being of smaller stature than the other two, although it is only known from a single population; it was also described as having frequent branching in contrast to the other two with no or little branching, and having slightly decurrent leaves. Differences in the gemmae of the three taxa were also reported in the protologues: *A. ellipticum* and *A. minutum* var. *himalayanum* having exclusively 2-celled gemmae, whereas in *A. lignicola* the gemmae were described as mostly 2-celled with some 1-celled. However, study of the types of both *A. ellipticum* and var. *himalayanum* revealed some 1-celled gemmae amongst the majority of 2-celled ones. Hence this difference is not substantiated by us, and those of stature and branching are not considered significant due to the limited material used in the description of two of the three taxa. The gemmae of *A. ellipticum* are photomicrographed in Fig. 1.

TABLE 1. — Comparison of protologues of *Anastrophyllum ellipticum* Inoue, *A. lignicola* D.B.Schill & D.G.Long and *A. minutum* var. *himalayanum* S. Srivast., S.C. Srivast. & K.K. Rawat with observations on the type of var. *himalayanum*.

Characters	***Anastrophyllum ellipticum* (Protologue)**	***Anastrophyllum lignicola* (Protologue)**	***Anastrophyllum minutum* var. *himalayanum* (Protologue)**	***Anastrophyllum minutum* var. *himalayanum***
Shoots	8-15 mm long and 0.6-0.8 mm wide	Up to 14 mm long and 1.4 mm wide	4-8 mm long, 0.6-1.1 mm wide (with leaves)	5-8 mm long, 0.6-1.0 mm wide (with leaves)
Branching	Usually without	Little; terminal, lateral and often postical intercalary	Frequent, terminal or lateral intercalary	Terminal or lateral intercalary
Stem	100-130 µm in diam., 6-8(-9) cells across	(90-) 120-180 (-200) µm	0.09-0.1 mm wide vertically, 0.15-0.17 mm wide laterally, 6-8 cells wide vertically, 10-12 cells wide laterally	7-11 cells across
Cortical cells	1-2 layers with deep brown and thickened walls	1-2 layers, very thick walled	1(-2) layers, thick walled	1(-2) layers, thick walled
Leaves	Remote to contiguous (sometimes weakly imbricate), erect to obliquely spreading	obliquely spreading	distant imbricate to contiguous, insertion transverse	Distant, imbricate to contiguous, obliquely spreading
Decurrency	Not on both ends	Not or only slightly decurrent	Slightly decurrent	Slightly decurrent
Shape	Ovate to ovate-oblong when flattened (350) 380-420 µm wide, 400-450 µm long, usually 1-1.2 times as long as wide	Ovate to subquadrate, (280-) 400-500 (-790) µm wide, (320-) 400-550 (-820) µm long	Broadly ovate, subquadrate to rectangulate, 0.51-0.66 mm long, 0.48-0.60 mm wide	Ovate, broadly ovate to subquadrate
Bilobing	Subsymmetrically to about ½ of the length; lobes triangular, sometimes the dorsal lobe a little smaller than the ventral	Lobes equal to subequal, leaf insertion postically oblique	Lobes divergent 1/3-1/2 of the leaf length, dorsal lobe slightly smaller and folded over ventral	Lobes equal to subequal, 1/3-1/2 of the leaf length, dorsal lobe slightly smaller than ventral lobe
Apex	Acute to narrowly rounded	Predominantly apiculate or rounded, subacute, acuminate	–	Narrow or broadly acute
Surface	Smooth	–	Verrucose under SEM	–
Trigones	Indistinct, triangular	–	With distinct and confluent trigones	Trigones present
Oil bodies	(3) 4-8 (12) per leaf cells, small, globose, 2-4 µm, nearly homogeneous or rarely with few very indistinct granules	–	–	–
Asexual reproduction	Gemmae, brownish or sometimes pale purplish clusters at tips of shoot	Gemmae always present and generally abundant on ascending to erect gemmiferous shoots	Gemmae present at the margins of apical leaf lobe	Gemmae present at the margins of apical leaf lobe
Gemmae	2-celled, elliptical or sometimes fusiform in outline, without any angulation, 8-10 µm wide 20-28 µm long	Mostly 2-celled, ellipsoid; 1-celled rounded, red to purplish	strictly 2-celled, elliptical to spindle-shaped with tapering ends, 18-30 × 9-15 µm	Mostly 2-celled, ellipsoid; 1-celled rounded, reddish; not fusiform
Sexuality	Dioicous (female not seen)	Dioicous	Dioicous ?	Dioicous ?
Androecia	Intercalary	Sometimes on gemmiferous shoots	Male plants not seen	Male plants not seen
Bracts	3-6 pairs, similar to leaves	2-8 pairs per stem, bracts bulging	–	–
Margin	Without any denticulation	–	–	–
Antheridia	1 per bract	1 (-2) per bract	–	–

Although *Anastrophyllum minutum* var. *himalayanum* was described under the genus *Anastrophyllum* (Srivastava *et al.* 2013) the species to which it was assigned (*A. minutum*) is now considered to belong to a distinct genus, *Sphenolobus* (de Roo *et al.* 2007; Söderström *et al.* 2016). Indeed, Katagiri & Furuki (2012) also considered that *Anastrophyllum ellipticum* should also be included under *Sphenolobus*, and consequently made the new combination of *Sphenolobus ellipticus* (Inoue) T.Katag. & Furuki. However, the molecular study by Mamontov & Vilnet (2013) has shown that *A. ellipticum* nests with other *Anastrophyllum* species and not with *Sphenolobus minutus* (Schreb. ex D.Crantz) Berggr. or *Crossocalyx hellerianus* (Nees ex Lindenb.) Meyl.

Anastrophyllum ellipticum, including *A. lignicola*, has been described and illustrated in detail by Inoue (1978), Schill & Long (2002, 2003), Mamontov & Vilnet (2013), Srivastava *et al.* (2013) and Majumdar & Singh (2017). Mamontov & Vilnet (2013), however, maintained the two as distinct species, with *A. ellipticum* restricted to Japan and Russia. The morphological evidence presented by Mamontov & Vilnet (2013) for maintaining them as distinct is not strong, as both species can have both horizontal and erect vegetative shoots,

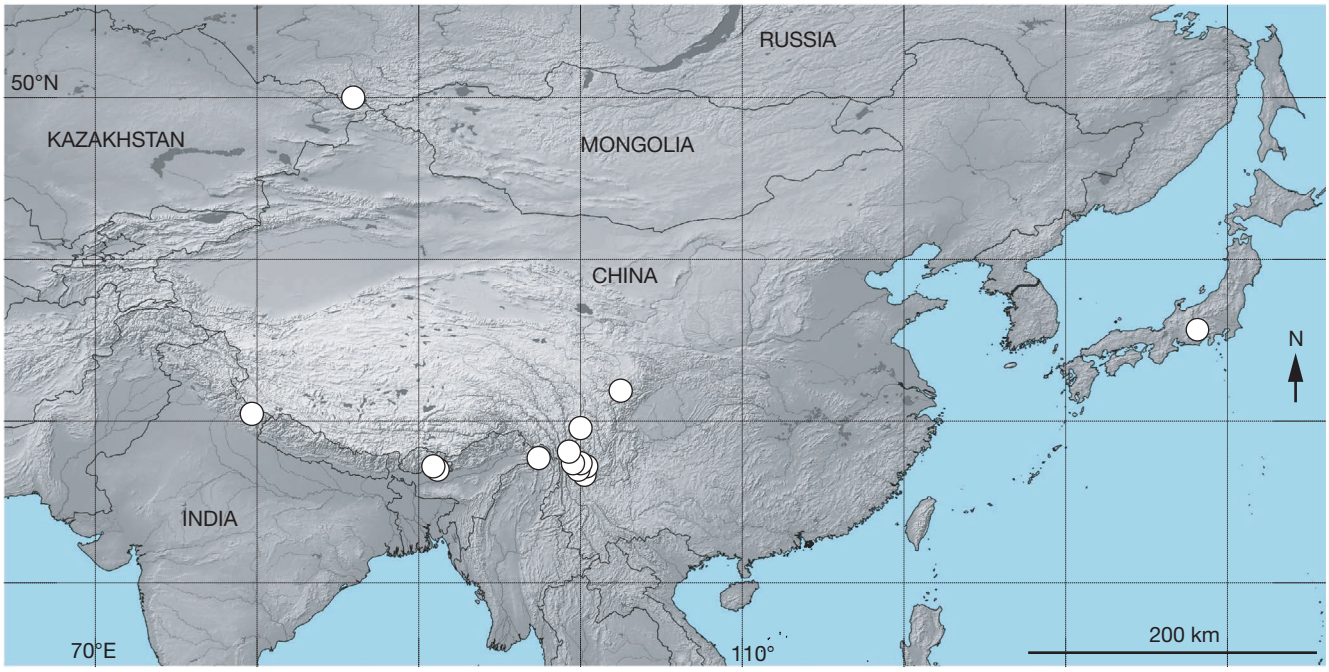

Fig. 2. — Distribution of *Anastrophyllum ellipticum* Inoue, based on herbarium and literature records.

the erect shoots often gemmiferous, the plants sometimes more robust and the gemmae proportionately shorter in *A. lignicola*; however, the broader stature range may be due to many more available samples from the Sino-Himalaya than from Japan and Russia. There are no real habitat differences between the two as both can grow on dead, often rotten stumps and logs in shady forests. Surprisingly, Srivastava *et al.* (2013) recorded *A. minutum* var. *himalayanum* as terrestrial on soil-covered rocks in Uttarakhand, NW India.

The molecular evidence given by Mamontov & Vilnet (2013) for maintaining *Anastrophyllum ellipticum* and *A. lignicola* as distinct species is based on sequence data for one sample of each taxon, displaying relatively minor sequence differences between the two when compared to those within three other *Anastrophyllum* species included in their study: *A. assimile* (Mitt.) Steph. (four samples), *A. michauxii* (F.Weber) H.Buch (five samples) and *A. sphenoloboides* R.M.Schust. (three samples). Until a wider molecular study of a much larger sample range of species within *Anastrophyllum* is carried out, we feel that at present the molecular evidence for maintaining the two as distinct on the basis of only two samples is inadequate.

TAXONOMIC SUMMARY

Anastrophyllum ellipticum Inoue

Bulletin of the National Science Museum, Tokyo, B. Botany 4: 13 (1978). — *Sphenolobus ellipticus* (Inoue) T.Katag. & Furuki, *Bryological Research* 10 (7): 206 (2012). — Type: Japan, Gongen Peak, Mts. Yatsu, Nagano Pref., 2300 m, 03.IX.1977, *S. Ono s.n.* (holo-, TNS[TNS-42220]!).

Anastrophyllum lignicola D.B. Schill & D.G. Long, *Annales Botanici Fennici* 39: 130 (2002); **syn. nov.** — Type: China, Yunnan Province, Diqing [Dêqên] Prefecture, Zhongdian [Shangri-La] County, forested ridge above Na Pa Hai, N of Zhongdian, 27°55'N, 99°34'E, 3920 m, 12.VI.1993, *D.G. Long 24249* (holo-, E!; iso- ,H!, JE!, KUN!)

Anastrophyllum minutum var. *himalayanum* S.Srivast., S.C. Srivast. & K.K. Rawat, *Nelumbo* 55: 126 (2013); **syn. nov.** — Type: India, Uttarakhand, Chamoli, Ghangharia, 22.V.1980, *S.C. Srivastava, D. Kumar & D.K. Singh 4325/80* (holo-, LWU!).

Revised Distribution. — Figure 2 illustrates the updated distribution of *Anastrophyllum ellipticum* based on herbarium specimens studied by us with the addition of the literature record from Russia from Mamontov & Vilnet (2013). The following two Chinese specimens are additional to those previously published:
China. Sichuan Province, Litang County, between Lamaya and Zhangna villages, SW of Litang, 62 km post, 29°51'51.6"N, 99°53'35.4"E, *Abies* forest on valley slope, on rotten *Abies* log, 4049 m, 4.IX.2010, *D.G. Long 39864* (E); Yunnan Province, Yulong County, Yulongxue Shan, Xie Ren Ji valley above Mu Zhou Go valley, steep limestone valley with scree and degraded *Abies* forest, on log under *Abies,* 3505 m, 12.X.1990, *D.G. Long 19104* (E).

Acknowledgements
The first author thanks the Director of the Botanical Survey of India for facilities and encouragement, and for financial assistance under the 'Flora of India' project. The authors are also grateful to the curators and staff of the herbaria E, H, JE, KUN, LWU and TNS for loan of specimens for study. The second author thanks Laura Forrest (E) for comments on molecular evidence, Isuru Kariyawasam (E) for preparing the distribution map, and the Regius Keeper, Royal Botanic Garden, Edinburgh for continued support for bryological research in Edinburgh. We also thank the reviewers for their contribution to the improvement of the manuscript.

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Submitted on 28 November 2018;
accepted on 19 April 2019;
published on 11 March 2020.