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ON THE TAXONOMY OF MYURELLA–PLATYDICTYA COMPLEX (PLAGIOTHECIACEAE, BRYOPHYTA)

К ТАКСОНОМИИ КОМПЛЕКСА MYURELLA–PLATYDICTYA (PLAGIOTHECIACEAE, BRYOPHYTA)

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Abstract

Recently collected specimens of poorly known Siberian taxa of Plagiotheciaceae were studied for DNA sequence data, nuclear ITS1-2 and chloroplastic *trn*L-F, and morphology. This study has revealed that *Bardunovia baicalensis* and *Myurella acuminata* belong to one species which is better to classify in the genus *Platydictya*, as *P. acuminata* (Lindb. & Arnell) Ignatov, comb. nov. The Yakutian plants of *Platydictya jungermannioides* are also discussed and illustrated.

Резюме

Проведено изучение морфологии и молекулярных маркеров, ядерных ITS1-2 и хлоропластного *trn*L-F, у недавно собранных образцов, представляющих недостаточно изученные сибирские таксоны Plagiotheciaceae. Показано, что *Bardunovia baicalensis* и *Myurella acuminata* принадлежат к одному виду, который лучше относить к роду *Platydictya*, под названием *P. acuminata* (Lindb. & Arnell) Ignatov, comb. nov. Якутские образцы *Platydictya jungermannioides* также обсуждаются и иллюстрируются.

KEYWORDS: mosses, taxonomy, Plagiotheciaceae, *Myurella*, *Platydictya*, Siberia, nrITS, *trn*L-F

INTRODUCTION

Recent literature provides two different circumscriptions of the family Plagiotheciaceae. One of them confines the family volume to the genus *Plagiothecium* only (Buck & Goffinet, 2000; Goffinet et al., 2009), while *Myurella* is placed in Pterigynandraceae and *Platydictya* in Hypnaceae. Other authors include in Plagiotheciaceae also a number of genera characterized by axillary rhizoids, including *Platydictya* and *Myurella* (cf. Hedenäs, 1987). Molecular phylogenetic analysis of Pedersen & Hedenäs (2002) demonstrated the close relationship of two latter genera to *Plagiothecium* and principally the same result has been found in some other analyses, e.g., by Ignatov et al. (2007).

However, some classification problems at the species level remain, and the present paper deals with a group of taxa referred to *Myurella, Platydictya,* and *Bardunovia*.

Platydictya was described in the middle of XIX century; however the name was out of use for a long time because *Platydictya sprucei* (Bruch) Berk., the type of the genus, was treated as a member of *Amblystegium* or *Amblystegiella.* The genus *Platydictya* was resurrected in 1964 when it was turn out that *Amblystegiella* is an illegetimate name, and all its widespread American species were transferred to *Platydictya* (Crum, 1964).

Hedenäs (1987) showed that *P. jungermannioides* (Brid.) H.A. Crum (syn. *P. sprucei*), is distinct from other widespread Holarctic species,

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P. subtilis (Hedw.) H.A. Crum and *P. confervoides* (Brid.) H.A. Crum, and two latter species were transferred to *Serpoleskea* (Söderström et al., 1992) or returned to *Amblystegium* (e.g., Hill et al., 2006).

This approach left in *Platydictya* one widespread species, *P. jungermannioides*, and a number of poorly known species with a limited distribution and apparently rare, e.g., *Platydictya minutissima* (Sull. & Lesq.) H.A. Crum in U.S.A. (Crum & Anderson, 1981), *P. fauriei* (Cardot) Z. Iwats. & Nog. in Japan (Noguchi, 1992), etc. Seems these species need a placement in other genera, but a revision and likely a molecular analysis will be necessary to solve this problem.

The genus ***Myurella*** was established in 'Bryologia Europaea' (Bruch et al., 1853) for one species, *Myurella julacea* (Schwägr.) Bruch et al. It was almost invariably used for this widespread species, and two additional widespread holarctic species, *M. tenerrima* (Brid.) Lindb. and *M. sibirica* (Müll. Hal.) Reimers were added to it in the end of XIX century. Lindberg & Arnell (1890) described also the fourth species, *M. acuminata* Lindb. & Arnell, that remained little known until recent progress of study of the flora of Asiatic Russia. It was discussed by Ignatov & Ochyra (1995) and then found by Krivoshapkin and published with expanded description by Afonina & Krivoshapkin (1998). Among others, they noted a great similarity between *M. acuminata* and *Bardunovia baicalensis* Ignatov & Ochyra.

The analysis of Pedersen & Hedenäs (2002) found *M. acuminata* in a basal position in clade of *Platydictya*, not with other *Myurella* species, although a support for this position was low, so no taxonomic decisions were made.

Bardunovia *baicalensis* was descibed by one poor specimen from Baikal region of South Siberia. In the original description, it was compared with *Myurella acuminata*, as a morphologically closest species. The analysis of Pedersen & Hedenäs (2002) found this taxon in a highly supported clade with *Platydctya jungermannioides*, thus the genus was synonymized with *Platydictya* and the single species of *Bardunovia* was transferred to *Platydictya*, as *P. baicalensis* (Hedenäs & Pedersen, 2002). Note, however, that they used for their analysis the specimen of *Bardunovia* from Yakutia, far from the type locality of *B. baicalensis*.

Recent years have yielded in a number of new collections of *Myurella acuminata* from Yakutia, which allow better understanding of this still very rare species. Present paper deals with taxonomy of this group, involving, in addition to morphology, also molecular markers of nuclear ITS and chloroplastic *trn*L-F.

MATERIAL AND METHODS

Laboratory protocol was essentially the same as in some of our previous analyses (e.g., Gardiner et al., 2005). Maximum parsimony analysis and jackknifing was performed in Nona (Goloboff, 1994) under Winclada shell (Nixon, 1999). The specimen details and GenBank accession numbers are given in Appendix 1.

The trees was rooted on *Hookeria lucens* and include representatives of all northern genera of Plagiotheciaceae and also *Fabronia* that sometimes appeared to be closely related to Plagiotheciaceae in molecular analyses (Ignatov et al., 2007). It also includes the sequences from the holotype of *Bardunovia baicalensis* (shown in trees as *Myurella acuminata* Irkutsk).

One *trn*L-F short inversion region of 3 nucleotides exhibits strong variation (CCT – AGG), so it was omitted in the analysis according to the suggestion of Quandt & Stech (2005).

RESULTS

Strict consensus tree of *trn*L-F (Fig. 1) has a polytomy with clades representing *Myurella (M. tenerrima, M. julacea, M. sibirica), Orthothecium (O. chryseon* (Schwägr.) Bruch et al. *, O. intricatum* (Hartm.) Bruch et al.*, O. rufescens* (Dicks. ex Brid.) Bruch et al.*, O. strictum* Lorentz*)*, *Isopterygiopsis* (*I. alpicola* (Lindb. & Arnell) Hedenäs, *I. pulchella* (Hedw.) Z. Iwats.), *Platydictya* (3 of 5 specimens of *P. jungermannioides*) and *Struckia+Plagiothecium.* However two specimens of *Isopterygiopsis muelleriana* (Schimp.) Z.Iwats. form a separate clade, while one of two specimens of *I. pulchella* was found in unresolved polytomy, not with another specimens of *I. pulchella* and *I. alpicola*. The unresolved polytomy includes *Platydictya jungermannioides* (2 of 5 specimens used in analysis)*, Myurella acuminata,* species of *Herzogiella, Pseudotaxiphyllum*, and *Fabronia.*

ITS is more variable in this group and it gives the better resolved strict consensus tree (Fig. 2A)

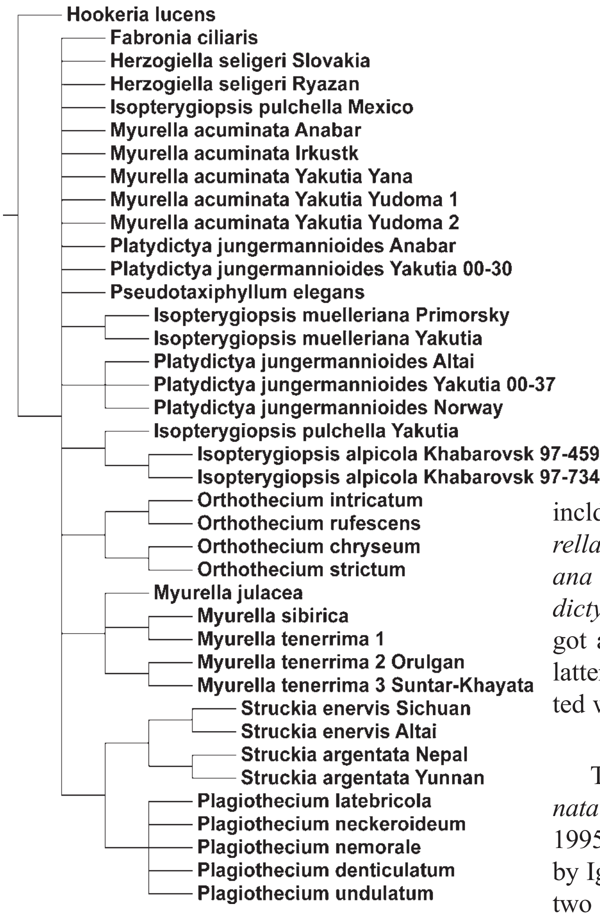


Fig. 1. Maximum parsimony strict consensus tree of 236 shortest trees (L=101, CI=0.58, RI=0.68) obtained in analysis of *trn*L-F chloroplastic region.

and some clades get a statistical support (Fig. 2B), although mostly quite low.

The basal grade in the strict consensus tree (Fig. 2A) includes *Fabronia, Pseudotaxiphyllum* and *Orthothecium* clade.

The terminal clade includes two subclades. One is formed by *Herzogiella spp*., *Isopterygiopsis muelleriana, Platydictya* and *Myurella acuminata*, while another one by *Plagiothecium + Struckia*, *Isopterygiopsis alpicola + I. pulchella*, and *Myurella* (including three widespread species, but excluding *M. acuminata*).

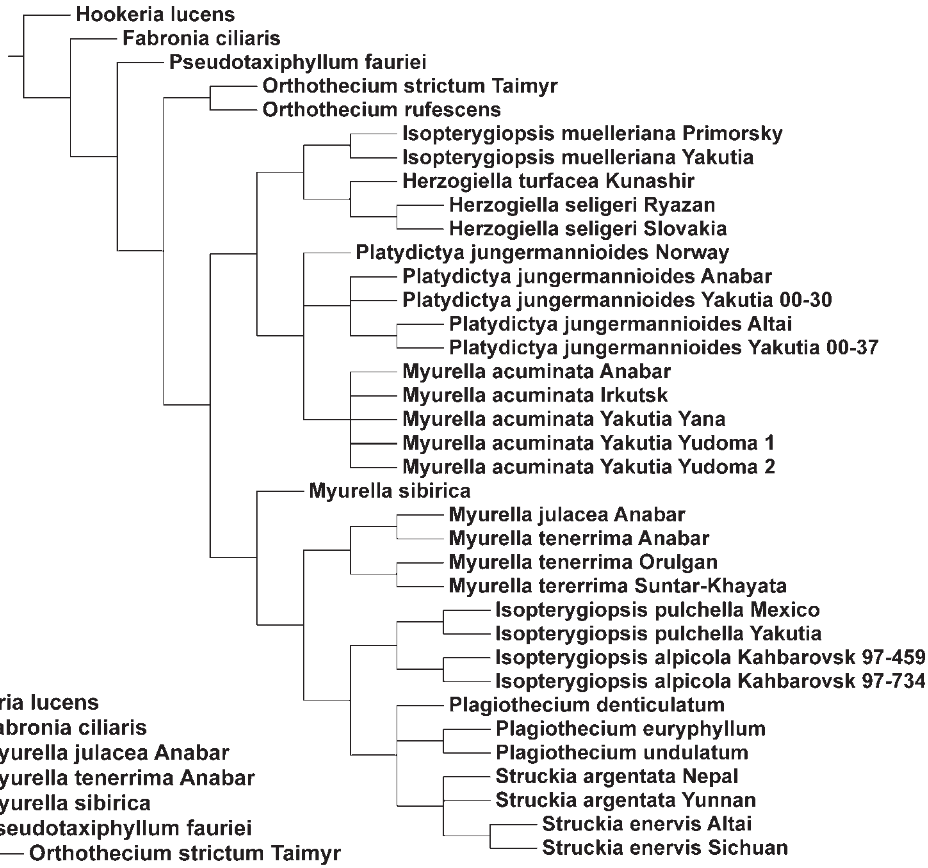
The strict consensus supports the monophyly of *Plagiothecium + Struckia*, *Isopterygiopsis alpicola + I. pulchella*, *Myurella julacea + M. tenerrima, Herzogiella turfacea* (Lindb.) Z. Iwats.+ *H. seligeri* (Brid.) Z. Iwats.

A high value of Jackknife support has been found for *Plagiothecium+Struckia*-clade (97), *Orthothecium-clade* (82) and *Herzogiella*-clade (79). Other clades got only a moderate support, inclding those formed by a single species: *Myurella tenerrima* (57); *Isopterygiopsis muelleriana* (69), *I. pulchella* (68). The clade of *Platydictya jungermannioides + Myurella acuminata* got a support of 67, and five specimens of the latter species formed a clade with support 64 nested within *Platydictya* polytomy.

DISCUSSION

The previous descriptions of *Myurella acuminata* (Lindberg & Arnell, 1890; Ignatov & Ochyra, 1995) and description of *Bardunovia baicalensis* by Ignatov & Ochyra (1995) were based on only two and one specimens respectively, which does not allow fully understand the variation of these taxa. It seems that small plant size, variable foliage and leaf shape in different shoots, growth in a small quantity, and also quite fragile plants have led to one misintrerpretation for the latter species. The heterophylly was considered as an important character of *Bardunovia*; however, some larger leaves (0.7 mm long) illustrated in Figs. 28-3, 28-4 and 29-1 by Ignatov & Ochyra (1995) were taken likely from slender shoots of *Campylidium sommerfeltii* entangled with the type material of *Bardunovia*. A total re-study of the type collection of *Bardunovia baicalensis* indicates the absense of leaves longer than 0.5 mm in plants that have axillary rhizoids and axillary gemmae, a characteristic of *Bardunovia*.

Another problem concerns the analysis of Pedersen & Hedenäs (2002). The sampling for molecular analysis has been done among specimens labeled by Ignatov as *Bardunovia baicalensis*. However Siberian phenotypes of *Platydictya*



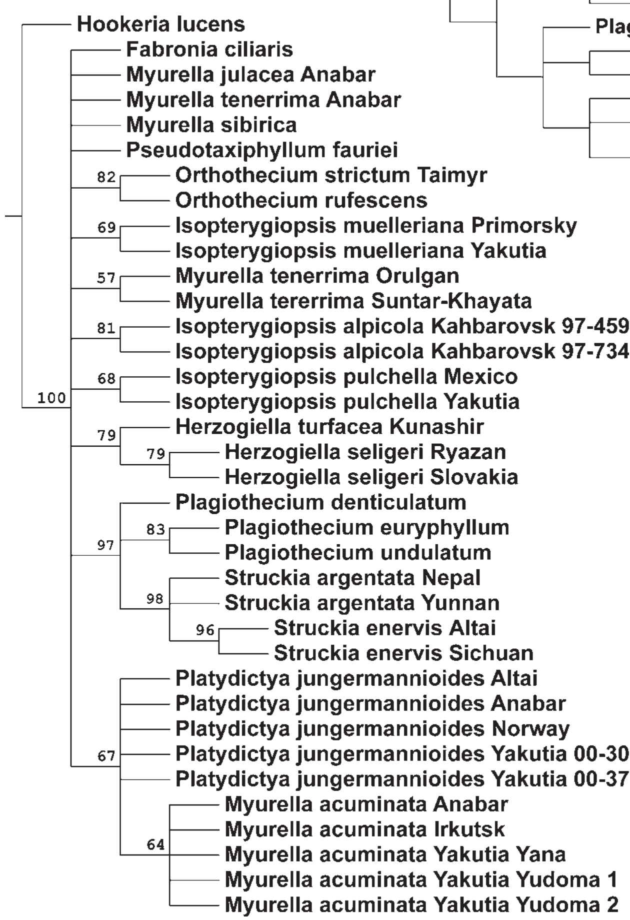


Fig. 2. Maximum parsimony trees based on nrITS sequences:

A (upper, right) – strict consensus tree of 12 shortest trees (L=298, CI=0.75, RI=0.72) obtained in analysis of ITS1-2 nuclear region.

B (lower, left) – jackknife tree for 100 replications.

jungermannioides are sometimes very difficult to separate from *B. baicalensis* (cf. Figs. 3-4). East Siberian specimens of *P. jungermannioides* often have more strongly serrate margin with prominent 'compound' teeth (formed by projection of upper end of cell and lower end of next cell above along margin). This character seems to be strongly overestimated as a diagnostic for *Myurella acuminata* and *Bardunovia baicalensis*, as such teeth are rarely seen in European populations of *P. jungermannioides*, and this caused a number of misidentifications. We resequenced the specimens 'Yakutia 00-37', used for the analysis of Pedersen & Hedenäs (2002) and studied also its ITS. This revealed that the conclusion of the position of *Bardunovia* in *Platydictya* has been based on a specimen different from the type of *Bardunovia* ('*Myurella acuminata* Irkutsk' in Figs. 1-2), but according to present analysis, especially of ITS, belonging to *P. jungermannioides*. At the same time, the type of *B. baicalensis* appears in the clade with four studied specimens of *Myurella acuminata*. This new sorting based on molecular data also agree with morphological characters, however changing the values of characters, increasing, e.g., that of leaf concavity and descering the importance of, e.g., 'compound teeth'.

The results of the phylogenetic analysis (Figs. 1-2) indicate that *Myurella acuminata* does not belong to the genus *Myurella* and has to be placed in *Platydictya,* as a separate species, *P. acuminata,* with *Bardunovia baicalensis* being its synonym. Thus, the suggestion to synonymize the latter genus with *Platydictya* (Hedenäs & Pedersen, 2002) is supported. This however expands the circumscription of *Platydyctya,* including in the genus plants with julaceous foliage (at least at places), strongly concave leaf base, prominent 'compound' marginal teeth, and cells strongly prorate at lower end (cf. SEM photographs in Ignatov & Ochyra, 1995).

The main differences between *Platydictya* and *Myurella* s. str. (i.e. without *M. acuminata*) include a common presence of non-concave leaves in the former, but never in the latter, as well as the papillosity pattern of the laminal cells: smooth or papillose ('prorate') at its lower angle in the former, while with conspicuous papillae either over cell lumen or in the upper cell end in the latter.

Nomenclatural consequence at species level is as follow:

Platydictya acuminata (Lindb. & Arnell), Ignatov comb. nov. – *Myurella acuminata* Lindb. & Arnell, Kongl. Svenska Vetensk. Acad. Handl. 23(10): 141. 1890. Type: Siberia, Nizhnyaya Tunguska, 65°30'N, 14.VII.1876, leg. H.W. Arnell (lectotype S!, isolectotype H-BR!).

Bardunovia baicalensis Ignatov & Ochyra, Actoa 5: 54. f. 22,24,26-29. 1995. Syn. nov. – Type: Russia, Irkutsk Province, western part of Baikal-Amur Railway, Zvezdnyj (east of Ust-Kut and Kazachinskij), on rotten wood in *Larix* forest, 1.VII.1983, L.V. Bardunov (holotype MHA, isotypes IRK, KRAM, S). The locality is about 56°45' N – 106°30' E.

Plants in lax soft mats, light green to yellowish- or brownish-green, very fragile. Stems 5-8 mm long, moderately densely julaceously foliate to remotely arranged, sparsely and irregularly branched, branches almost undifferentiated from stem; central strand absent or indistinct, of solitary smaller cells, outer cell layer almost undifferentiated; rhizoids axillary, purplish, finely papillose. Leaves erect (when foliage is dense) to spreading (especially when foliage is remote), (0.15-)0.25-0.45(-0.55)×(0.05-)0.10-0.20(-0.25) mm wide, ovate to ovate-lanceolate, acuminate, basal part strongly concave; margin serrate at base, mostly with 'compound' teeth (formed by projected upper end of lower cells and lower end of next upper cell), subentire to serrate above (with simple or more rarely 'compound' teeth); costa absent; laminal cells 20-40×7-10 μm, at base shorter, to 15 μm long, in alar region isodiametric, 10-14 μm; lower and middle laminal cells prorate on abaxial side by projections of lower cell ends, cell in upper third of leaf nearly smooth. Dioicous. Perichaetia rather frequent; perichaetial leaves 0.3-0.45×12-0.17 mm, non-plicate, ovate-lanceolate, gradually narrowed into acumen, serrate; cells in the middle of the lamina large and elongate, 40-60×10-15 μm, near margins smaller, 25-40×7-10 μm, in basal leaf corners subisodiametric.

Specimens examined (other than types): Taimyr Autonomous District, Anabar, 4 July 2009, Fedosov s.n. (MW); Yakutia, Yana River, 10 July 2009, Isakova #82 (MHA ex SASY); Yakutia, Ust-Maya Distr., Yudoma River, Ignatov #00-257 (MHA). (See also Fig. 5).

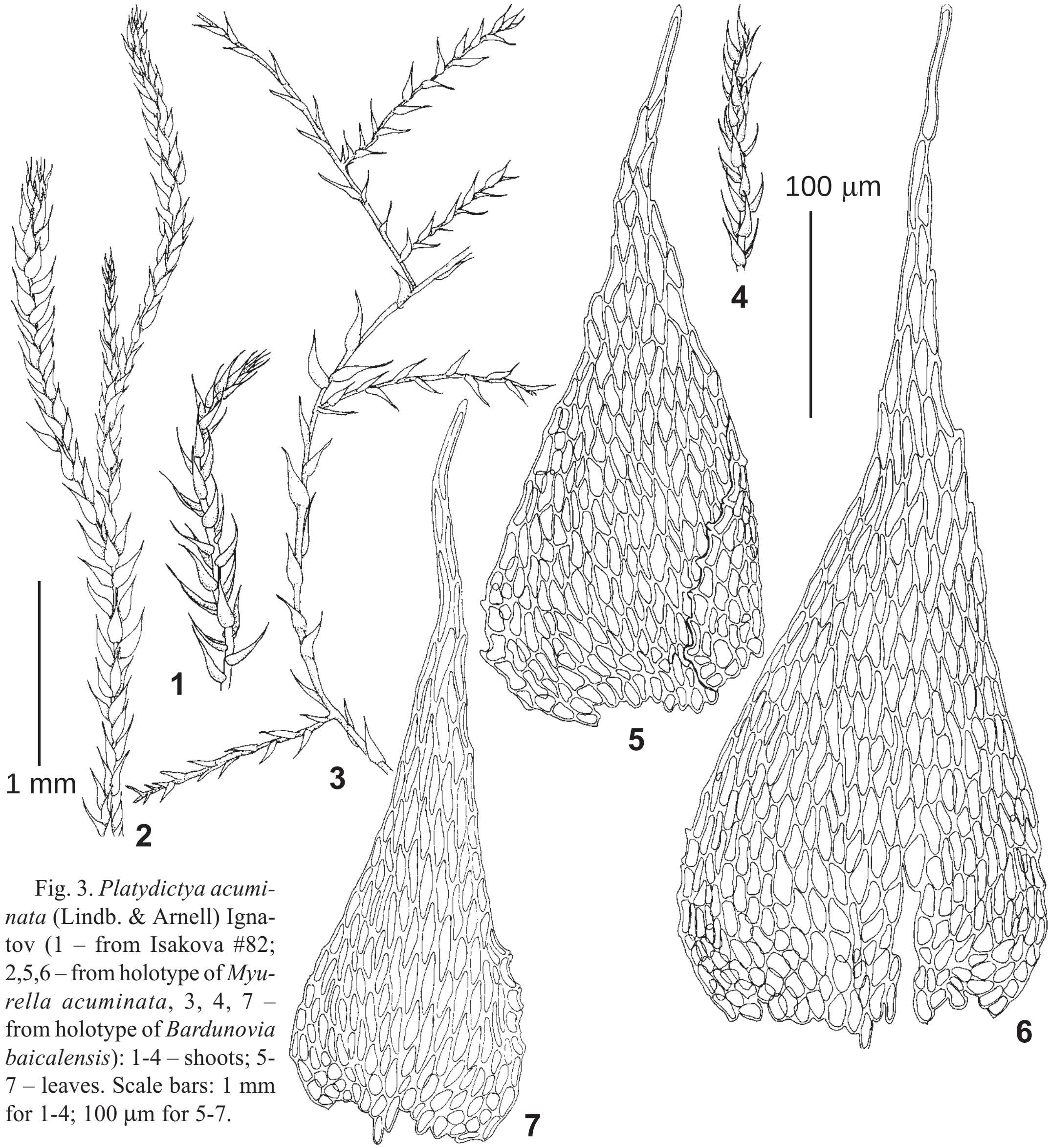


Fig. 3. *Platydictya acuminata* (Lindb. & Arnell) Ignatov (1 – from Isakova #82; 2,5,6 – from holotype of *Myurella acuminata*, 3, 4, 7 – from holotype of *Bardunovia baicalensis*): 1-4 – shoots; 5-7 – leaves. Scale bars: 1 mm for 1-4; 100 μm for 5-7.

Differentiation: *Platydictya acuminata* differs from *P. jungermannioides* in concave leaves and tendency to julaceous foliage, which is usually apparent in more developed plants at least in some shoots. Also in the former species leaves are usually larger, more strongly serrate at margin and with laminal cells more strongly prorate.

It should be noted however, that *Platydictya jungermannioides* is probably a heterogeneous taxon and additional studies are needed for understanding if it represents one polymorphic species or a complex of cryptic species. Yakutian plants of *P. jungermannioides* (Fig. 4) have rather dense foliage, larger leaves with well developed marginal teeth, i.e. they are variable in characters differentiating the most widespread phenotype of this species from *P. acuminata.* 'Compound' marginal teeth are common in Yakutian *P. jungermannioides* (Fig. 4), while they are at best very rare in European and North American collections, at least they are not illustrated by European (Nyholm, 1965) and American authors (Crum & Anderson, 1981; Lawton, 1971).

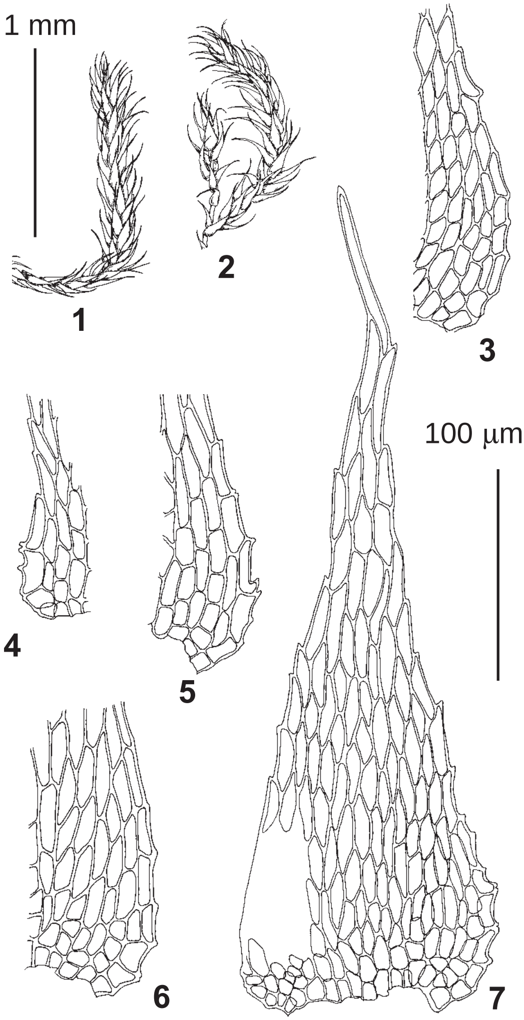
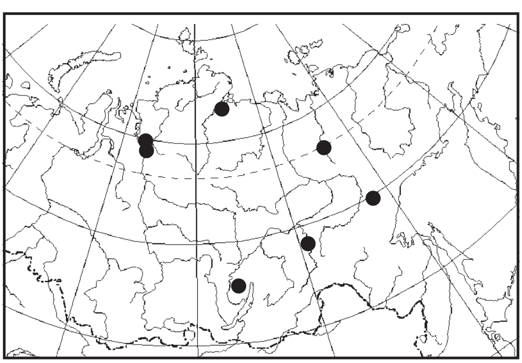


Fig. 4. *Platydictya jungermannioides* (from Yakutia, Ignatov, 00-30): 1-2 – shoots; 3-6 – cells of leaf margin, showing 'compound' teeph; 7 – leaf. Scale bars: 1 mm for 1-2; 100 µm for 3-7.

Fig. 5. Distribution of *Platydictya acuminata.*



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Appendix 1. Studied specimen data and GenBank accessions numbers.

A. ***Newly obtained sequences*** (for some specimens sequeces are old, started not from JQ)

species	specimen	trnL-F	ITS
Isopterygiopsis alpicola Khabarovsk 97-459	Russia, Khabarovsk, Bureya River, Ignatov #97-459 (MHA)	JQ247743	JQ247726
Isopterygiopsis alpicola Khabarovsk 97-734	Russia, Khabarovsk, Bureya River, Ignatov #97-734 (MHA)	JQ247744	JQ247727
Isopterygiopsis muelleriana	Russia, Primorsky Territory, Ignatov #07-296 (MHA)	JQ247746	JN896318
Isopterygiopsis pulchella Mexico	Plantas de Mexico, Cardenas #3942 (MHA)	JQ247745	JQ247728
Myurella acuminata Anabar	Russia, Taimyr Autonomous District, Anabar, 4 July 2009, Fedosov s.n. (MW)	JQ247747	JQ247729
Myurella acuminata Irkutsk	Russia, Irkutsk Prov., 1 July 1983, Bardunov (MHA)	JQ247748	JQ247730
Myurella acuminata Yakutia Yana	Russia, Yakutia, Yana River, 10 July 2009, Isakova #82 (MHA ex SASY)	JQ247749	JQ247731
Myurella acuminata Yakutia, Yudoma 1	Russia, Yakutia, Ust-Maya Distr., Yudoma River, Ignatov #00-257 (MHA)	JQ247750	JQ247732
Myurella acuminata Yakutia, Yudoma2	Russia, Yakutia, Ust-Maya Distr., Yudoma River, Ignatov #00-257 (MHA) [another extraction of Yudoma1]	JQ247751	JQ247733
Myurella julacea	Russia, Anabar, Fedosov #07-216 (MW)	AF472460	JQ247734
Myurella sibirica	Russia, Sakhalin, Ignatov #06-108 (MHA)	JQ247752	AJ288415/ AJ277227
Myurella tenerrima 2 Orulgan	Russia, Yakutia, Orulgan, Ignatov #11-1001 (MHA)	JQ247753	JQ247736
Myurella tenerrima 3 Suntar-Khayata	Russia, Yakutia, Suntar-Khayata Range, 19 June 1999, Ivanova & Krivoshapkin s.n. (MHA)	JQ247754	JQ247737
Myurella tenerrima 4 Anabar	Russia, Anabar, Fedosov #06-292 (MW)	—	JQ247735
Orthothecium strictum	Russia, Taimyr, 3 Aug 2008, Fedosov s.n. (MW)	JQ247755	JQ247738
Platydictya jungermannioides Altai	Russia, Altai, Ignatov #0/455 (MHA)	JQ247756	JQ247739
Platydictya jungermannioides Anabar	Russia, Anabar, Fedosov #04-15 (MW)	JQ247757	JQ247740
Platydictya jungermannioides Yakutia 00-30	Russia, Yakutia, Lenskie Stolby, Ignatov 00-30 (MHA)	JQ247758	JQ247741
Platydictya jungermannioides Yakutia 00-37	Russia, Yakutia, Lenskie Stolby, Ignatov 00-37 (MHA)	JQ247759	JQ247742

B. ***Previous sequences used in the present analysis*** (trnL-F|||ITS1-2 or ITS1/ITS2)

Fabronia ciliaris AY527128|||AY528883; *Herzogiella seligeri* Ryazan AY683585|||AY695758/AY695764; *Herzogiella seligeri*_Slovakia AF472453|||AY999174; *Herzogiella turfacea* Kunashir —|||JN896315; *Hookeria lucens* AF215906|||JN896317; *Isopterygiopsis muelleriana* Yakutia AY527138|||AY528882; *Isopterygiopsis pulchella* Yakutia AY683568|||AY695751/AY695770; *Myurella tenerrima* 1 AF472461|||—; *Orthothecium chryseum* AF472462|||—; *Orthothecium intricatum* AF472463|||—; *Orthothecium rufescens* AF472464|||AY999177; *Plagiothecium euryphyllum* —|||AJ288577; *Plagiothecium latebricola* AF472468|||—; *Plagiothecium neckeroideum* AF472469|||—; *Plagiothecium nemorale* AF472470|||—; *Plagiothecium denticulatum* AY527131|||AY528892/AY528893; *Plagiothecium undulatum* AF230990|||AF231005; *Platydictya jungermannioides* Nowray AY857568|||AY857610; *Pseudotaxiphyllum fauriei* —|||FM161207; *Pseudotaxiphyllum elegans* AF472473|||—; *Struckia argentata* Nepal DQ836728|||DQ836733; *Struckia argentata* Yunnan DQ836729|||DQ836734; *Struckia enervis* Altai DQ836730|||DQ836735; *Struckia enervis* Sichuan DQ836731|||DQ836736/DQ836737.