

DICRANUM AFONINAE (DICRANACEAE, BRYOPHYTA), A NEW SPECIES
WITH THE FLAGELLIFORM BRANCHLETS FROM ASIA

DICRANUM AFONINAE (DICRANACEAE, BRYOPHYTA), НОВЫЙ ВИД
С ФЛАГЕЛЛОВИДНЫМИ ВЕТОЧКАМИ ИЗ АЗИИ

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Abstract

A morphological and molecular phylogenetic study of the genus *Dicranum* Hedw. from Asian Russia revealed a new species with flagelliform branchlets, *Dicranum afoninae* sp. nova. This species differs from other flagellate species of the genus in having smooth peristome teeth on the outer surface, acuminate and slightly recurved leaflets of the flagelliform branchlets, subquadrate to transverse-rectangular cells in upper part of the leaf, crispate leaves when dry, and capsules cylindrical, pale, slightly ribbed when dry. A comparison of the new species with other flagellate species of the genus is provided. *Dicranum afoninae* is widespread in the Russia (south parts of East Siberia and Far East) and Mongolia. It grows on rock outcrops, on the bases of tree trunks, and on rotten wood. Key to identification of *Dicranum* species with flagelliform branchlets occurring in Russia is given.

Резюме

Морфологическое и молекулярно-филогенетическое исследование рода *Dicranum* Hedw. из азиатской России выявило новый вид с флагелловидными веточками, *Dicranum afoninae* sp. nova. Этот вид отличается от других флагеллоносных видов рода гладкими зубцами перистома на внешней поверхности, острыми, слегка отогнутыми листочками флагелловидных веточек, квадратными и поперечно прямоугольными клетками верхней части листа, курчавыми листьями в сухом состоянии, а также прямыми светлыми коробочками, слегка морщинистыми или слабо ребристыми в сухом состоянии. Приводится сравнение с другими флагеллоносными видами рода. *Dicranum afoninae* распространен в России (юг Восточной Сибири и Дальнего Востока) и в Монголии. Он растет на выходах горных пород, основаниях стволов деревьев и гнилой древесине. Приводится ключ для определения видов *Dicranum* с флагелловидными веточками, распространенных в России.

KEYWORDS: moss flora, Buryatia, rps4, trnL-F, ITS1-2

INTRODUCTION

Dicranum is one of the most multi-species and wide-spread genera within the Dicranaceae in northern hemisphere. Over 1800 taxa in the genus *Dicranum* have been described for more than two centuries since 1801. Most of them are synonymized with species of other genera and within *Dicranum*, many names are recognized as invalid, illegitimate. Currently, about 100 species of the genus are known in the world (<https://tropicos.org/name/Search>, Accessed data 22 April 2016), and 41 occur in Russia (*Dicranum*, 2016; Tubanova, 2016; Tubanova & Dugarova, 2023). However, it is still insufficiently studied, and species new to science are still described, e.g. *D. hengduanensis* W.Z.Huang & R.L.Zhu from China (Huang *et al.*, 2023) and *D. baicalense* Tubanova from Russia (Tubanova & Dugarova, 2022).

During the study of the moss flora of Buryatia we found several enigmatic specimens of *Dicranum* with flagelliform branchlets. These specimens were previously identified as *D. flagellare* Hedw. and *D. mayrii* Broth., but they possessed a peculiar combination of morphological characters which did not fit well any of these species.

They had crisped and curled leaves in dry condition vs falcate-secund leaves of *D. flagellare*, short laminal cells vs short rectangular cells of *D. flagellare*; costae without adaxial epidermis vs with fragmentary to complete adaxial epidermis of *D. mayrii*; leaflets of flagelliform branchlets with acute apices which are slightly recurved when wet vs with obtuse apices which incurved when wet of *D. flagellare* and *D. mayrii*; and peristome teeth with smooth outer surface vs longitudinally stri-

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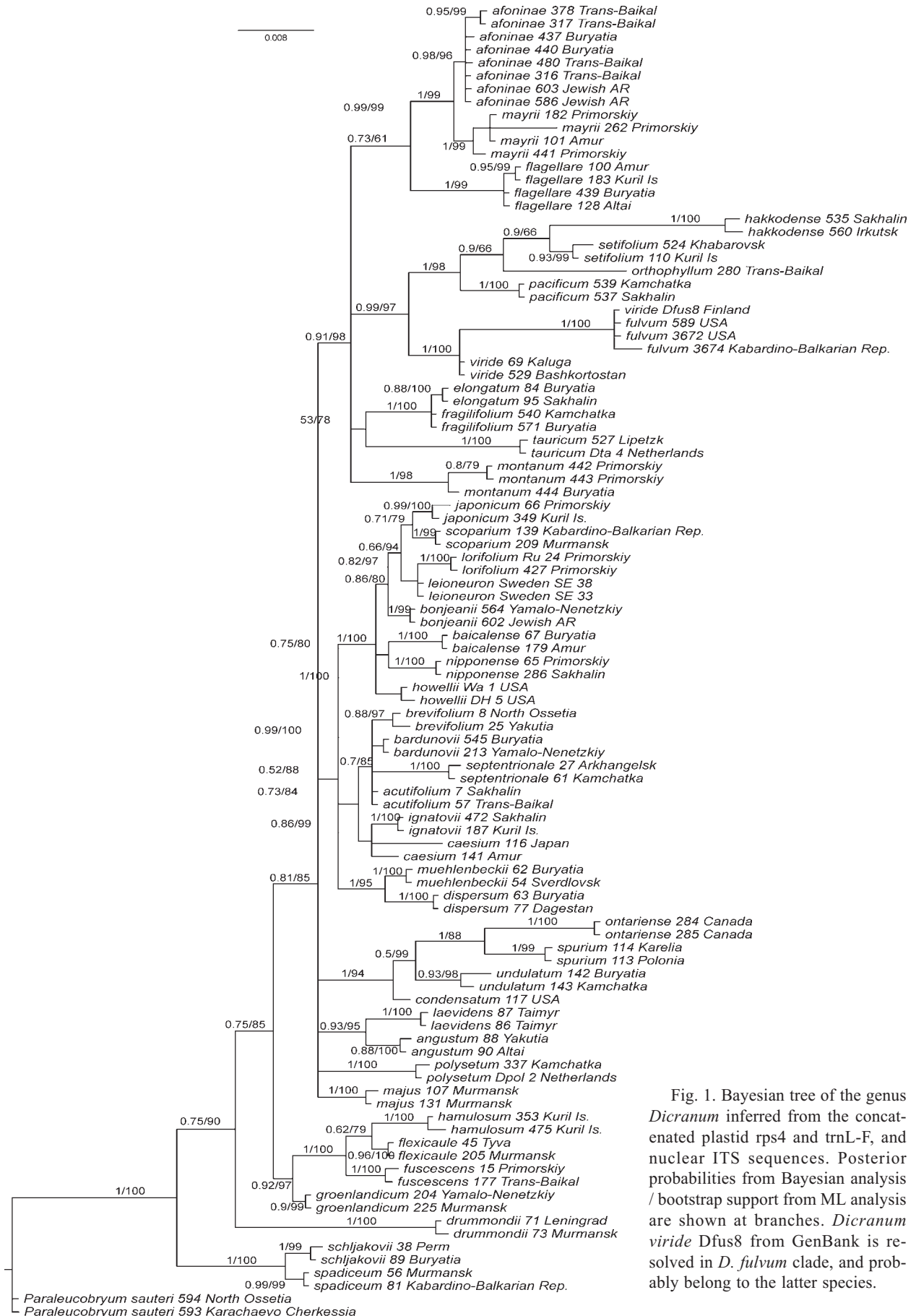


Fig. 1. Bayesian tree of the genus *Dicranum* inferred from the concatenated plastid rps4 and trnL-F, and nuclear ITS sequences. Posterior probabilities from Bayesian analysis / bootstrap support from ML analysis are shown at branches. *Dicranum viride* Dfus8 from GenBank is resolved in *D. fulvum* clade, and probably belong to the latter species.

olate of *D. flagellare* and *D. mayrii*. In order to estimate the affinity of these plants, we decided to apply chloroplast (*rps4* and *trnL-F*) and nuclear (ITS1-2) DNA markers in addition to morphological study.

MATERIALS AND METHODS

Morphological study

Microscopic examinations and measurements were made by light microscope Carl Zeiss Axiostar plus and stereomicroscope LOMO MSP-2. The habit and some morphological details were illustrated. Photos of the plant habit were obtained using a Sony á5000 digital camera and microscopic images were captured by Levenhuk M500 BASE Camera attached to the microscope. Morphological studies were based on herbarium collections from IRK, LE, MHA, and UUH.

DNA extraction and amplification

Eight specimens of the presumably new species and 11 specimens of the other *Dicranum* species with the flagelliform branchlets were selected to the DNA studies de novo. DNA extractions, amplification and overall laboratory protocols were essentially the same as in, e.g., Gardiner *et al.* (2005) and Fedosov *et al.* (2016). The plastid *rps4* and *trnL-F* regions and nuclear ITS1-2 region widely applied in moss phylogenetic studies were used; 146 sequences were taken from our previous studies of *Dicranum* (Tubanov *et al.*, 2010, 2016, 2018; Tubanova & Ignatova, 2011; Ignatova *et al.*, 2015; Tubanova & Dugarova, 2022) and 24 accessions of 7 *Dicranum* species were downloaded from GenBank. 114 new accessions from 49 specimens (43 of *rps4*, 36 of *trnL-F*, and 35 of ITS1-2) were obtained de-novo (see Appendix 1). Sequences were aligned manually in BioEdit version 7.2.5 (Hall, 1999). The alignment comprised 2009 positions, corresponding to *rps4* (1st–624th positions), *trnL-F* (625th–1112th positions), ITS1 (1113th–1451th positions), 5.8S rRNA gene (1452th–1609th positions) and ITS2 (1610th–2009th positions), considered as unlinked partitions.

Molecular phylogenetic analysis

In total, 101 specimens of 44 species of *Dicranum* were used in the analysis and 2 specimens of *Paraleucobryum sauteri* were selected as outgroups. A list of taxa with collection localities, vouchers, and GenBank accession numbers is shown in Appendix 1.

Phylogenetic reconstructions under Bayesian inference (BI) were performed using MrBayes v.3.2.7 (Ronquist *et al.*, 2012), with the GTR+G model, and run with 5 000 000 generations (reaching all PSRF equal to 1.000, and ESS>1000). Partitioning followed the initially suggested partitions, nruns=4, nchain=6, temp=0.02.

Evolutionary analysis by Maximum Likelihood was performed using IQtree (Trifinopoulos *et al.*, 2016) with GTR+G+I model. Robustness of the nodes was assessed using 1000 pseudoreplications of the ultrafast bootstrapping algorithm as implemented in IQtree. Trees were rooted on *Paraleucobryum sauteri* and visualized using FigTree 1.4.3.

RESULTS

In the phylogenetic reconstruction obtained from the concatenated plastid *rps4* and *trnL-F*, and nuclear ITS sequences (Fig. 1), a fully supported clade of *D. spadiceum* J.E. Zetterst. plus *D. schljakovii* Ignatova & Tubanova branches off first, it is followed by a fully supported clade of *D. drummondii*. The next nodes of polytomy comprise a highly supported clades of (1) *D. groenlandicum*, *D. hamulosum*, *D. flexicaule*, *D. fuscescens* (PP=0.92, BS=97); (2) *D. condensatum*, *D. undulatum*, *D. ontariense*, *D. spurium* (PP=1, BS=94), (3) *D. laevigens* plus *D. angustum* (PP=0.93, BS=95), (4) *D. majus* (PP=1, BS=100), (5) *D. polysetum* (PP=1, BS=100), (6) a moderately supported (PP=0.52, BS=88) clade of 16 species mainly with keeled leaves in upper part plus *D. muehlenbeckii*; (7) a highly supported (PP=0.91, BS=98) clade of 13 species mainly with the tubulose leaves in upper part plus *D. orthophyllum*. The species with flagelliform branchlets are not resolved in one clade. However, three morphologically most similar species are assembled in a moderately supported clade (PP=0.71, BS=61) which consists of five accessions of *D. flagellare* (PP=1, BS=99), three of *D. mayrii* (PP=1, BS=99), and eight accessions of a putatively new species (PP=0.98, BS=96). Such topology in combination with a unique morphological features provides a support for a separate taxonomic status of these specimens in question. They are described below as a species new for science.

TAXONOMY

Dicranum afoninae Tubanova sp. nov. Figs. 2–4.

Type: RUSSIA, Southern Siberia, Trans-Baikal Territory, Kalar District. Yuzhno-Muysky Range, Koyra Creek (56°13'59.5" N, 115°52' 59.5" E, alt. 589-600 m). Rocks covered by mosses near creek, on rotten wood, 07.VIII.2012, coll. O.M. Afonina #8312. Isolate 378 [Holotype UUH! Isotype LE!].

Diagnosis. The species is similar to *Dicranum flagellare* and *D. mayrii* in having cylindrical, straight capsules, flagelliform branchlets and short cells of upper part of leaves, but differs from them in having leaflets of flagelliform branchlets with the acute, slightly recurved apices and slightly serrulate margins; shorter, mostly transverse-rectangular distal lamina cells; and peristome teeth with smooth outer surface.

Etymology. The new species is named in honor of the collector of the type specimen, famous Russian bryologist, Dr. Olga M. Afonina.

Description. Plants in dense, compact tufts, light to bright green, not glossy. Stems 1–2 cm, branched, moderately to densely tomentose. Leaves lanceolate, gradually narrowed towards apex, acuminate, canaliculate or keeled distally, straight or slightly curved when wet, (1.5–) 2–3(–4)×0.4–0.6 mm, crisped and curled when dry; margins plane, entire or slightly serrulate distally, unistratose; costa 60–100 µm wide, occupying 1/5–1/7 of leaf

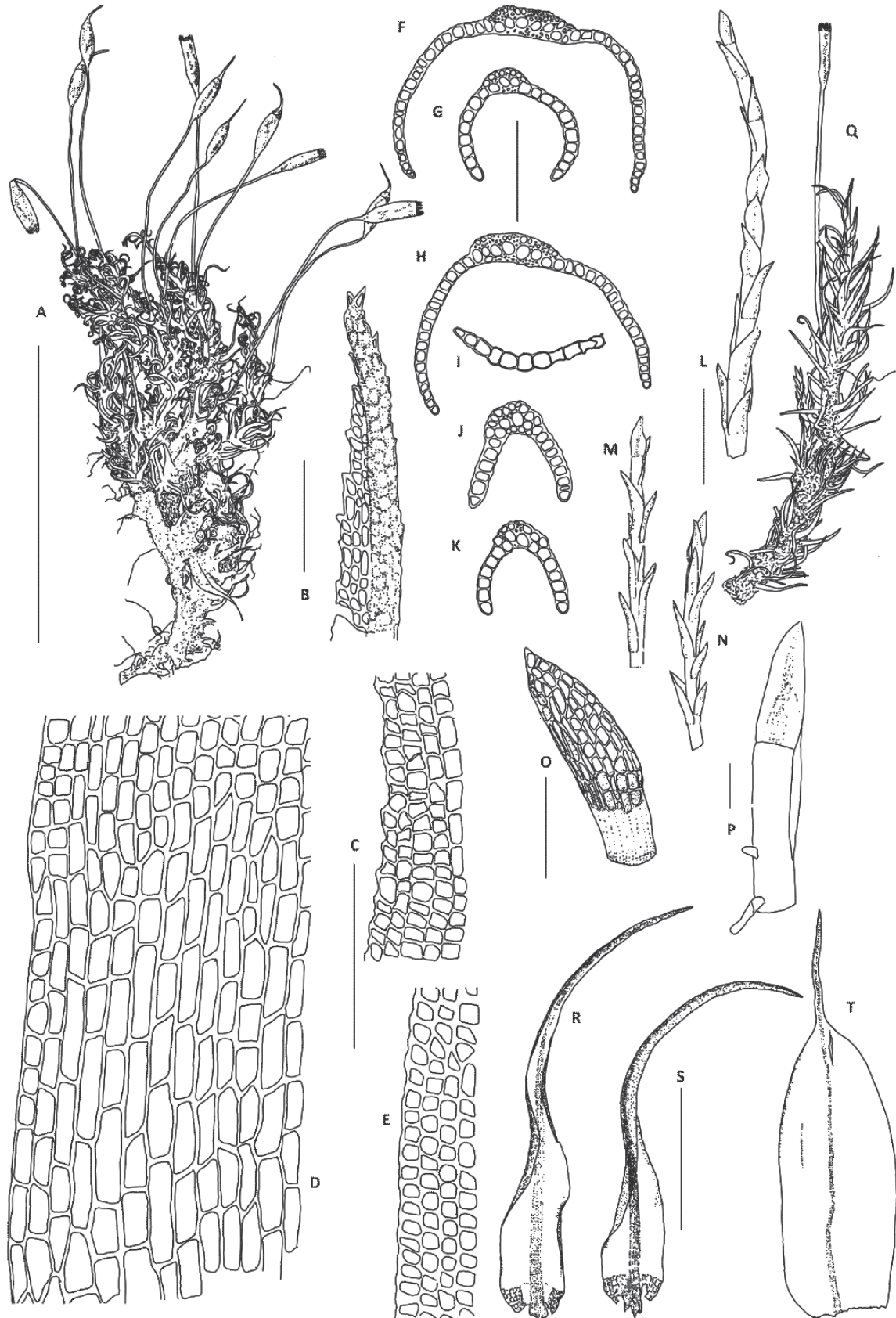


Fig. 2. *Dicranum afoninae* (from holotype): A: habit, dry; B: apex of leaf; C, E: upper leaf cells; D: basal laminal cells; F-H, J-K: leaves transverse section; I: alar cells transverse section; L-N: flagelliform branchlets, wet; O-P: leaflets of flagelliform branchlets; Q: habit, wet; R-S: stem leaves; T: inner perichaetial leaf. Scale bars: 1 cm for A, Q; 1 mm for L-N, R-T; 100 μ m for B-K, O-P.

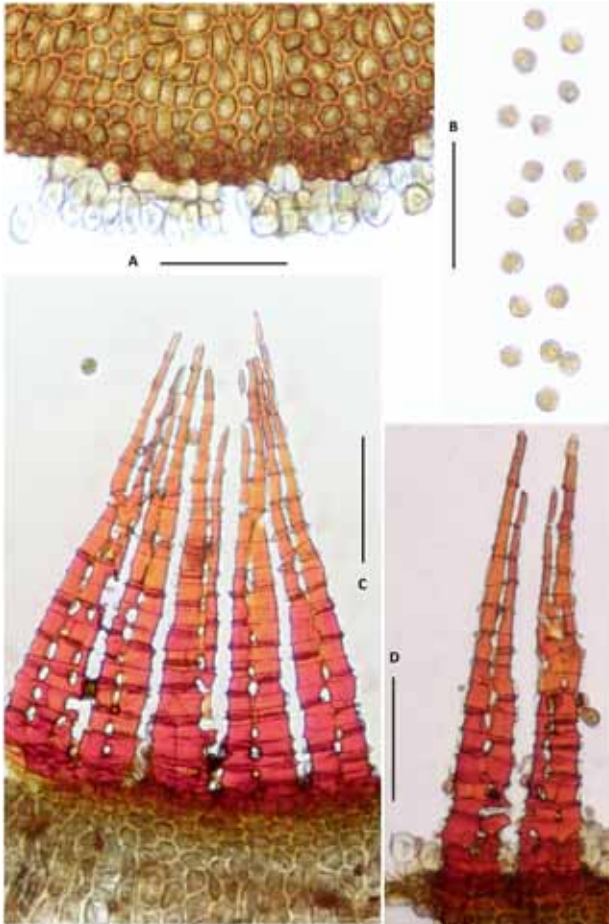


Fig. 3. *Dicranum afoninae* (from holotype): A: annulus on operculum; B: spore; C: peristome, outer view; D: peristome, inner view. Scale bars: 100 μm for A–D.

width at base, slightly scabrous above on abaxial surface, percurrent, with one row of guide cells, two stereid bands, adaxial epidermal layer of cells not differentiated, abaxial layer differentiated or irregular; *lamina* unistratose, in upper part, smooth or slightly scabrous on abaxial surface; distal lamina cells subquadrate, short rectangular or transverse rectangular, (2.5–)8–14 (–20) \times (7.5–)10–15 (–17) μm , with thin walls, not porose; proximal lamina cells short to elongate rectangular, (14–)24–46 (–79) \times (8–)10–14 (–21) μm , with moderately thickened walls, porose, abruptly becoming short in mid-leaf; alar cells light brownish, unistratose, not reaching costa. *Asexual reproduction* by flagelliform branchlets up to 5 mm long, arising in upper leaf axils; leaflets of flagelliform branchlets small, 0.2–0.5 mm long, ovate-lanceolate, acute, with slightly serrulate margins and slightly recurved apices, breaking off in fragments. *Dioicous*. *Inner perichaetial leaves* convolute-sheathing, with strong costa, abruptly narrowed into subulate acumina. *Setae* 6–10 mm, yellowish. *Capsules* erect, straight, cylindrical, urns 1.5–2 mm long, pale to light brown, slightly ribbed when dry. *Annulus* 2(–3)-layered, falling off in fragments. *Peristome* single, consisting of 16 teeth split distally into 2 prongs, with longitudinal perforations in

proximal part, orange to red proximally and colorless or reddish distally, ca. 360 μm long; outer surface smooth below and in the middle and weakly papillose in distal part; inner surface with low trabeculae. *Operculum* conic, with a long, straight beak, 1.5 mm. *Spores* 15–20 μm , slightly papillose.

Differentiation. There are several species in the genus *Dicranum* with flagelliform branchlets occurring in Russia: *D. afoninae*, *D. flagellare*, *D. mayrii*, *D. montanum* Hedw., and *D. ignatovii* Tubanova & Fedosov. Their morphological differences are summarized in Table 1. The specific feature of *D. afoninae* is the smooth outer surface of peristome teeth. This character is also observed in *D. laevidens*, which, however, lacks flagelliform branchlets and is contrastingly different in other morphological features. All other *Dicranum* species, including flagellate ones, have peristome teeth longitudinally striolate proximally and papillose distally on abaxial surface.

The flagelliform branchlets are similar in *Dicranum afoninae*, *D. flagellare* and *D. mayrii*, particularly in the last two species. In *D. afoninae*, leaflets of the flagelliform branchlets are apiculate, slightly serrulate at margins, with slightly recurved apices, whereas in *D. flagellare* and *D. mayrii* they are obtuse, incurved, with entire margins and straight apices. *Dicranum montanum* differs from all other flagellate species by having leaflets of flagelliform branchlets narrow, serrate, crisped when dry and commonly deciduous, often leaving the branches partially denuded. Leaflets of flagelliform branchlets of *Dicranum ignatovii* are similar to those of *D. montanum* in shape, but they are longer, 0.5–1 mm, breaking off with branch pieces (0.3–0.5 mm long, deciduous in *D. montanum*) (Fig. 4).

Dicranum ignatovii differs from all species mentioned above in having bistratose alar groups; stem leaves widely keeled in distal and broadly acute; costa ending before apex. In the molecular phylogenetic tree, it is resolved far from them but within the *D. acutifolium*-group.

Distribution and habitats. *Dicranum afoninae* occurs in Russia (Irkutsk Region, Republic of Buryatia, Trans-Baikal Territory, Amur Region, Jewish Autonomous Region, Khabarovsk Territory, Primorye Territory) and in Mongolia (Khovsgol, Selenge, Tov and Bulgan). It grows on rock outcrops, stones, rotten wood, and on the bases a tree trunks. The list of examined specimens is given.

Additional specimens examined:

RUSSIA. Irkutsk Region: Slyudyanka District, foothill of Khamar-Daban Ridge, 30.VIII.2018, *Tubanova S180124* (UUH). **Republic of Buryatia:** (1) Dzhida District, Maly Hamar-Daban Ridge, 31.VIII.2020, *Tubanova M202211* (UUH); Baikal Nature Reserve, Abidui River, 27.VII.1991, *Kazanovsky ID 1719* (IRK, UUH); (2) Yeravna District, vicinity of “Ozerny GOK”, 04.VIII.2008, *Tubanova ErT-23/0812* (UUH); (3) Zaigraevo District, Kurbinsky Ridge, 25.VII.2017, *Tubanova An-170211* (UUH); (4) Zakamensk District, Dzhidinsky Ridge, 28.VI.2018, *Tubanova Z182504* (UUH); (5) Kurumkan District, Dzhergin-

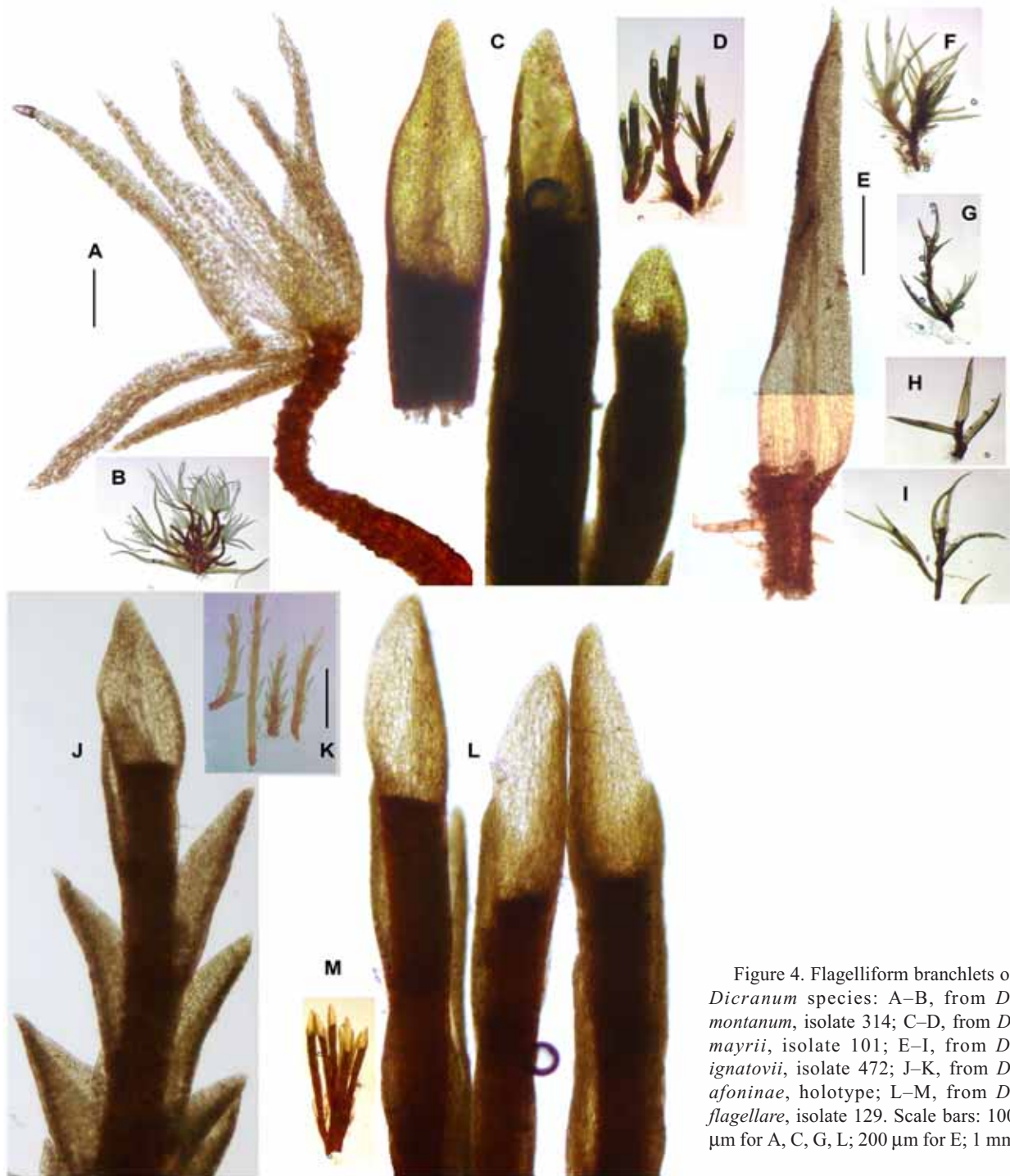


Figure 4. Flagelliform branchlets of *Dicranum* species: A–B, from *D. montanum*, isolate 314; C–D, from *D. mayrii*, isolate 101; E–I, from *D. ignatovii*, isolate 472; J–K, from *D. afoninae*, holotype; L–M, from *D. flagellare*, isolate 129. Scale bars: 100 µm for A, C, G, L; 200 µm for E; 1 mm

sky Nature Reserve, 09.VII.1999, *Tubanova 43(III)* (UUH); (6) Kyakhta District, the vicinity of Naushki Village, 18.VII.2010, *Tubanova Kyah-5/10-4* (UUH); (7) Pribaikalsky District, coast of Baikal Lake, 28.VI.2014, *Tubanova B14012/42, B14012/43* (UUH); (8) Tunka District, vicinity of Turan Village, 16.VI.2022, *Tubanova T220202* (UUH). **Trans-Baikal Territory:** (1) Sokhondinsky Biosphere Reserve, Agutsa River, 12.VII.2013, *Chernyadeva 26-13* (LE, UUH); (2) Alkhana National Park, 21.VII.2005, *Afonina 3405* (LE, UUH). **Amur Region:** Zeysky Reserve, Tukuringra Ridge, 03.VIII.1980, *Stetsura 3(758)* (IRK, UUH). **Jewish Autonomous Region:** Obluchye District, Maly Khingan Ridge, 16.VI.2018, *Tubanova E183007* (UUH). **Kha-**

barovsk Territory: (1) Verkhnebureinsky District, Bureya River 27.VIII.1997, *Ignatov 97-723* (MHA, UUH); (2) Sovetsko-Gavansky District, Botchinsky Nature Reserve, 19. VIII.2013, *Ignatov, Ignatova 13-876* (MHA, UUH). **Primorskiy Territory:** (1) Dalnegorsk District, 5 km to the NW from the Krasnorechenskiy Village, 30.VIII.2013, *Ignatov, Ignatova, 13-1588* (MHA9100587); (2) Ol'khovaya Mt., 04.X.2006, *Cherdantseva s.n.* (VBGI, UUH); (3) Lazo District, the road to Benevsky Waterfalls, 10.IX.2014, *Fedosov 14-2-002* (MW, UUH); (4) Vladivostok, the pass to Lazurnaya Bay, 28.IX.1974, *Bardunov, Cherdantseva, s.n.* (IRK); (5) Verkhne-Ussuriyskiy Statzionar, 20.VII.1980, *Cherdantseva, s.n.* (IRK); (6) Kavalerovo District,

Table 1. A comparison of *Dicranum* species with flagelliform branchlets

Morphological features	<i>D. afoinae</i>	<i>D. mayrii</i>	<i>D. flagellare</i>	<i>D. montanum</i>	<i>D. ignatovii</i>
Leaves when dry	Strongly crisped	Strongly crisped	Falcate-secund	Strongly crisped to flexuose-straight	Slightly curved to flexuose
Leaf sizes, mm	(1.5-)2-3(-4) ×0.4-0.6	(2.5-)4-5 ×0.7-0.9	(2-)3-4 ×0.4-0.6	(1.5-)2.5-3.5(-4) × 0.2-0.4	2.5-4.1(-4.9) ×0.6-0.8
Leaves distally	Tubular to slightly keeled	Tubular to slightly keeled	Tubular	Tubular to slightly keeled	Widely keeled with recurved margins
Costa width, µm	60-100	100-150	70-120	40-80	80-130
Costa width relative	1/7-1/5	1/5-1/3	1/4-1/6	1/5-1/4	1/5-1/8
Costa length to leaf width	percurrent to shortly excurrent	percurrent to shortly excurrent	percurrent to shortly excurrent	percurrent to shortly excurrent	ending below apex to percurrent
Costa adaxial epidermis	absent	proximally differentiated to fragmentary	absent	absent	absent
Leaf cells in distal part	Subquadrate to transverse-rectangular	Subquadrate to transverse-rectangular	Quadrate to short rectangular	Subquadrate to transverse-rectangular	Subquadrate to transverse-rectangular
Leaf cells in distal part, µm	(2.5-)8-14(-20) × (7.5-)10-15(-17)	(5.5-)8.5-15(-20) × (5.5-)8-12.5(-13)	(4.5-)8- 20(-41) × (5-)8-12(-16)	(4-)8.5-14(-25) × (6.8-)9.5-13(-17.8)	(6-)9-13(-18) × (6-)11-15(-19)
Proximal leaf cells, µm	(14-)24-46(-79) × (8-)10-14(-21)	(26.5-)38.5-67(-86.6) × (9-)11-15(-17)	(16.5-)27-54(-84) × (5-)9-13(-17.8)	(11.3-)20-42(-72) × (4.8-)8-12(-15.5)	(17-)35-61(-88.5) × (6-)9-12(-14.7)
Flagelliform branchlets	Branched and fragile	Branched and fragile	Branched and fragile	Branched, with caducous leaves	Branched and fragile
Leaflets of flagelliform branchlets	Apiculate, crenulate, with recurved apex	Obtuse, with incurved apex	Obtuse, with incurved apex	Narrow, serrate, crisped	Broadly acute, slightly serrate, straight
Capsule lengths, mm	1.5-2	1.5-2.5	2-2.5	1.5-2.5	1.7-2
Capsule color	pale to light	dark brown, glossy	pale to brown	brown	pale brown
Capsule surface when dry	smooth to slightly wrinkled	smooth	ribbed	furrowed	smooth to slightly wrinkled
Seta length, cm	0.6-1.0	1.2-2.0	1.5-2.5	0.7-1.5	0.6-0.9
Seta color	yellowish to brownish		yellowish	yellowish to reddish	yellowish
Annulus, cell rows	2(-3)	2-3	1-2	1-2	1-2(-3)
Peristome outer surface	smooth and weakly papillose distally	longitudinally striolate and papillose distally	longitudinally striolate and papillose distally	longitudinally striolate and papillose distally	weakly longitudinally striolate to almost smooth below and middle, obliquely striolate and weakly papillose distally
Spores, µm	15-20	13-22	13-22	10-18	14-19
Habitats	Rocks, rotten wood, tree bases	Rotten wood, tree bases	Rotten wood, tree bases	Rotten wood, tree trunks, tree bases	Tree trunks, rotten wood

Vysokogorsk, 10.IX.1977, *Bardunov et al. s.n.* (IRK); (7) Partizansky District, Lazovsky Reserve, 22.IX.1974, *Bardunov et al. s.n.* (IRK); (8) Terney District, Isakov Klyuch, 03.IX.2013, *Ignatov et al. 13-1813* (MHA 9-100589); (9) Chuguev District, Bulyga-Fadeeva, 24.IX.1976, *Bardunov s.n.* (IRK); (10) Khasansky District, "Kedrovaya Pad" Nature Reserve, 1958, *Ardeeva s.n.* (LE, UUH); (11) Khankajskiy District, Sinyaya Mt., 02.IV.2011, *Malashkina Pr-01-11-11* (VBGI, UUH); (12) Shkotovsky District, vicinity of Lukyanovka Village, 20.IX.2015, *Tumurova VL-3-3* (UUH); (13) Ussuriysky Nature Reserve, 23.VII.1974, *Nesterova s.n.* (IRK).

MONGOLIA. **Khovsgol County**, Source of Sharga River, 18.VII.2012, *Enkhjargal 2982* (UBA). **Selenge County**, Darkhan-Uul, 17.VII.2005, *Tsegmed et al. 14048, 14045* (UBA). **Tov County**, Southern slope of Bogdo-Ula Mountain, 26.VII.1995, *Tsegmed 11 893* (UBA). **Bulgan County**: Buteligt Nuruu Ridge, 05.VIII.1995, *Tsedendash 12103* (UBA).

Full label data are available at the supplementary materials, SM: (https://kmkjournals.com/upload/PDF/Arctoa/33/Arctoa_33_Dicranum_SM.docx).

KEY TO IDENTIFICATION OF *DICRANUM* SPECIES WITH THE FLAGELLIFORM BRANCHLETS IN RUSSIA

1. Flagelliform branchlets few, arising terminally on stems; plants medium-sized to large; capsules inclined and curved; growing in bogs, rare on rocks .
..... *D. leioneuron*
- Flagelliform branchlets numerous, arising from axils of upper leaves; plants small to medium-sized; capsules erect, straight, cylindrical; growing on rotten wood, tree trunks and rocks 2
2. Leaves keeled, with recurved margins; epiphyte
..... *D. ignatovii*
- Leaves tubular, with plane margins; growing on rotten wood and rocks, occasionally on tree trunks . 3
3. Flagelliform branchlets not fragile, with deciduous leaflets of flagella (naked parts of branches are visible); dry stem leaves strongly crisped, 0.2–0.4 mm wide *D. montanum*
- Flagelliform branchlets fragile, with leaflets breaking off with pieces of branchlets; dry stem leaves slightly falcate-secund or curled to crisped, 0.4–0.9 mm wide 4
4. Stem leaves straight, patent or slightly falcate-secund when dry (very rarely curled); upper leaf cells short rectangular to quadrate; widespread . *D. flagellare*
- Stem leaves curled to crisped when dry; upper leaf cells quadrate to transversely rectangular; South Siberia and Russian Far East 5
5. Costa with adaxial epidermis (occasionally fragmentary); leaflets of flagelliform branchlets with obtuse, incurved apices *D. mayrii*
- Costa without adaxial epidermis; leaflets of flagelliform branchlets with acute, recurved apices
..... *D. afoninae*

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Appendix 1. Genbank accession numbers and voucher data.

Species	Isolate	nrITS1-2	trnL-F	rps4	Geolocation and specimen data for newly generated sequences
<i>Paraleucobryum sauteri</i>	594	OP957305	OP948672	OQ060685	Russia, Republic of North Ossetia
<i>P. sauteri</i>	593	OP957304	OP948673	OQ060686	Russia, Karachaevo-Cherkessia
<i>Dicranum acutifolium</i>	57	OP939942	OP948646	OQ060651	Russia, Trans-Baikal Territory
<i>D. acutifolium</i>	7	HQ830322	OP948647	–	Russia, Sakhalin Island
<i>D. afoninae</i>	378	PP820600	PP818668	PP818704	Russia, Trans-Baikal Territory, 07.VIII.2012, <i>Afonina</i> #8312. (LE)
<i>D. afoninae</i>	603	PP820601	PP818669	–	Russia, Jewish Autonomous Region, 13.VI.2018, <i>Tubanova</i> #E180126 (UUH)
<i>D. afoninae</i>	437	–	PP818670	PP818705	Russia, Republic of Buryatia, 04.VIII.2008, <i>Tubanova</i> #ErT-23/0814 (UUH)
<i>D. afoninae</i>	316	PP820602	PP818671	PP818706	Russia, Trans-Baikal Territory, 31.VII.2012, <i>Afonina</i> #5312 (LE)
<i>D. afoninae</i>	440	PP820603	PP818672	PP818707	Russia, Republic of Buryatia, 27.VI.2014, <i>Tubanova</i> #B14011/10 (UUH)
<i>D. afoninae</i>	317	PP820604	PP818673	PP818708	Russia, Trans-Baikal Territory, 12.VII.2013, <i>Czernyadjeva</i> #26-13 (LE)
<i>D. afoninae</i>	480	PP818645	PP818674	PP818709	Russia, Trans-Baikal Territory, 23.VII.2013, <i>Czernyadjeva</i> #49-11 (LE)
<i>D. afoninae</i>	586	PP820605	PP818675	PP818710	Russia, Jewish Autonomous Region, 13.VI.2018, <i>Tubanova</i> #E180102 (UUH)
<i>D. angustum</i>	88	PP820606	PP818676	PP818711	Russia, Sakha (Yakutia), 23.VIII.2000, <i>Ignatov</i> #00-933 (MHA)
<i>D. angustum</i>	90	PP820607	PP818677	–	Russia, Altai, 01.VIII.1993, <i>Ignatov</i> #36/38 (MHA)
<i>D. baicalense</i>	67	OP939925	OP948648	OQ060652	Russia, Republic of Buryatia
<i>D. baicalense</i>	179	OP939929	OP948651	OQ060653	Russia, Amur Region
<i>D. bardunovii</i>	213	OP939941	OP948653	OQ060654	Russia, Yamalo-Nenetskiy AD
<i>D. bardunovii</i>	545	OP939940	OP948654	OQ060655	Russia, Republic of Buryatia
<i>D. bonjeanii</i>	564	OP939933	OP948656	OQ060656	Russia, Nenetsk AP
<i>D. bonjeanii</i>	602	OP939934	OP948657	OQ060657	Russia, Jewish AR
<i>D. brevifolium</i>	8	HQ830343	KJ796589	OQ060658	Russia, North Ossetia
<i>D. brevifolium</i>	25	HQ830344	OP948658	OQ060659	Russia, Republic of Sakha
<i>D. caesium</i>	116	MG214800	KT580679	PP818712	Japan, Shikoku
<i>D. caesium</i>	141	KT580733	KT580680	PP818713	Russia, Amur Region
<i>D. condensatum</i>	117	PP820608	PP818678	PP818714	USA, Missouri, 02.VI.2007, <i>Atwood</i> 1198 (MO, LE)
<i>D. dispersum</i>	63	KT580738	KT580684	OQ060660	Russia, Republic of Buryatia
<i>D. dispersum</i>	77	KT580740	KT580686	OQ060661	Russia, Republic of Dagestan
<i>D. drummondii</i>	73	KT580744	KT580690	OQ060662	Russia, Murmansk Province
<i>D. drummondii</i>	71	KT580743	KT580689	OQ060663	Russia, Leningrad Province
<i>D. elongatum</i>	84	KY296850	KY296868	–	Russia, Republic of Buryatia
<i>D. elongatum</i>	95	KY296847	KY296866	KY296886	Russia, Sakhalin
<i>D. flagellare</i>	183	MG214814	MG214835	OQ060664	Russia, Kunashir Island
<i>D. flagellare</i>	100	MG214815	MG214836	OQ060665	Russia, Amur Province
<i>D. flagellare</i>	439	PP820609	PP818679	PP818715	Russia, Buryatia, 26.VI.2014, <i>Tubanova</i> B14007/22 (UUH)
<i>D. flagellare</i>	128	MG214813	MG214834	PP818716	Russia, Altai
<i>D. flexicaule</i>	45	HQ830328	OP948659	OQ060666	Russia, Republic of Tyva
<i>D. flexicaule</i>	205	OP939944	OP948660	OQ060667	Russia, Murmansk Province
<i>D. fragilifolium</i>	571	PP820610	PP818680	PP818717	Russia, Buryatia, 27.VII.2017, <i>Tubanova</i> An-171307 (UUH)
<i>D. fragilifolium</i>	540	PP820611	PP818681	PP818718	Russia, Kamchatka, 07.VIII.2006, <i>Czernyadjeva</i> 9 (LE)
<i>D. fulvum (viride)</i>	Dfus8	KM502694	KM502781	KM502619	Finland, Karelia Prov.
<i>D. fulvum</i>	589	PP818643	PP818682	PP818719	USA, Pennsylvania, 26.VII.1994, <i>Schmidt et al.</i> 1510 (MO, LE)
<i>D. fulvum</i>	3672	PP820612	–	–	USA, Virginia, 02.XII.1995, <i>Ignatov s.n.</i> (MHA)
<i>D. fulvum</i>	3674	PP820613	–	–	Russia, Kabardino-Balkaria, 03.VIII.2004, <i>Ignatov et al. s.n.</i> (MHA)
<i>D. fuscescens</i>	177	OP939943	–	OQ060668	Russia, Trans-Baikal Territory
<i>D. fuscescens</i>	15	HQ830337	KG796579	–	Russia, Primorskiy Territory
<i>D. japonicum</i>	66	OP939930	OP948661	OQ060669	Russia, Primorskiy Territory
<i>D. japonicum</i>	349	OP939931	OP948662	OQ060670	Russia, Kuril Islands, Iturup
<i>D. hakkodense</i>	560	PP820614	PP818683	PP818720	Russia, Irkutsk, 30.VIII.2018, <i>Tubanova</i> S180121 (UUH)
<i>D. hakkodense</i>	535	PP820615	PP818684	PP818721	Russia, Sakhalin, 17.VII.2014, <i>Tubanova</i> S14010/04 (UUH)
<i>D. hamulosum</i>	353	PP820616	PP818685	PP818722	Russia, Kuril Islands, Iturup, 18.VIII.2015, <i>Koroteeva</i> 15-14/1-7 (SAK)
<i>D. hamulosum</i>	475	PP820617	PP818686	PP818723	Russia, Kuril Islands, Kunashir, 07.VIII.2014, <i>Tubanova et al.</i> K14036/19 (UUH)
<i>D. howellii</i>	Wa_1	KF423637	KF423991	–	USA, Washington
<i>D. howellii</i>	DH_5	KF423570	KF423929	–	USA, California
<i>D. ignatovii</i>	472	MG214801	OP948664	OQ060673	Russia, Sakhalin
<i>D. ignatovii</i>	187	MG214803	MG214826	–	Russia, Kuril Islands, Kunashir
<i>D. groenlandicum</i>	204	KY296852	KY296872	KY296880	Russia, Yamalo-Nenetskiy AD
<i>D. groenlandicum</i>	225	KY296853	KY296873	OQ060672	Russia, Murmansk Province
<i>D. laevidens</i>	86	KT580747	KT580694	PP818724	Russia, Taimyr
<i>D. laevidens</i>	87	KT580748	KT580695	PP818725	Russia, Taimyr

Species	Isolate	nrITS1-2	trnL-F	rps4	Geolocation and specimen data for newly generated sequences
<i>D. leioneuron</i>	SE_38	KJ650906	KJ651106	KJ651050	Sweden, Dalsland
<i>D. leioneuron</i>	SE_33	KJ650905	KJ651105	KJ651049	Sweden, Hälsingland
<i>D. lorifolium</i>	Ru_24	KF423656	KF424011	KF423910	Russia, Primorskiy Territory
<i>D. lorifolium</i>	427	PP820618	PP818687	PP818726	Russia, Primorskiy Territory, 20.IX.2015, <i>Tubanova #Pr1502/3</i> (UUH)
<i>D. majus</i>	107	OP939938	OP948665	OQ060674	Russia, Murmansk Province
<i>D. majus</i>	131	OP939939	OP948666	OQ060675	Russia, Murmansk Province
<i>D. mayrii</i>	101	PP820619	PP818688	PP818727	Russia, Amur Region, 16.VII.2010, <i>Bezgodov 477</i> (PPU)
<i>D. mayrii</i>	182	PP820620	PP818689	PP818728	Russia, Primorskiy Territory, 28.IX.2006, <i>Ignatov & Ignatova 06-3394</i> (MHA)
<i>D. mayrii</i>	262	PP820621	PP818690	–	Russia, Primorskiy Territory, 28.IX.2006, <i>Ignatov & Ignatova 06-3400</i> (MHA)
<i>D. mayrii</i>	441	PP820622	PP818691	PP818729	Russia, Primorskiy Territory, 20.IX.2015, <i>Tubanova Pr1501/15</i> (UUH)
<i>D. montanum</i>	442	OP939945	OP948667	OQ060676	Russia, Primorskiy Territory
<i>D. montanum</i>	444	OP939946	OP948668	OQ060677	Russia, Republic of Buryatia
<i>D. montanum</i>	443	PP820623	PP818692	–	Russia, Primorskiy Territory, 20.IX.2015, <i>Tubanova #Pr1501/02</i> (UUH)
<i>D. muehlenbeckii</i>	62	KT580752	KT580699	–	Russia, Republic of Buryatia
<i>D. muehlenbeckii</i>	54	KT580751	KT580698	OQ060678	Russia, Sverdlovsk Province
<i>D. nipponense</i>	65	OP939936	OP948669	OQ060679	Russia, Primorskiy Territory
<i>D. nipponense</i>	286	OP939937	OP948670	OQ060680	Russia, Sakhalin Island
<i>D. ontariense</i>	284	PP820624	PP818693	PP818730	Canada, Ontario, 16.IX.1989, <i>Ireland 24402</i> (CANM, LE)
<i>D. ontariense</i>	285	PP820625	PP818694	PP818731	Canada, Ontario, 13.IX.1989, <i>Ireland 24308</i> (CANM, LE)
<i>D. orthophyllum</i>	280	OP939947	OP948671	–	Russia, Trans-Baikal Territory
<i>D. pacificum</i>	537	FJ952602	PP818695	PP818732	Russia, Sakhalin, 12.VIII.2006, <i>Ignatov & Teleganova 06-301</i> (MHA, MW)
<i>D. pacificum</i>	539	FJ952603	PP818696	PP818733	Russia, Kamchatka, 26.VII.2004, <i>Czernyadjeva 25</i> (LE)
<i>D. polysetum</i>	337	MG214806	MG214832	–	Russia, Kamchatka
<i>D. polysetum</i>	Dpol_2	KM502684	KM502771	KM502610	Netherlands, Gelderland
<i>D. scoparium</i>	139	MG214807	MG214828	OQ060681	Russia, Kabardino-Balkaria
<i>D. scoparium</i>	209	MG214808	MG214829	OQ060682	Russia, Murmansk Province
<i>D. schljakovii</i>	38	KT580758	KT580705	PP818734	Russia, Perm
<i>D. schljakovii</i>	89	KT580761	KT580708	PP818735	Russia, Buryatia
<i>D. septentrionale</i>	27	HQ830339	KJ796586	OQ060683	Russia, Arkhangelsk Province
<i>D. septentrionale</i>	61	HQ830338	KJ796585	OQ060684	Russia, Kamchatskiy Territory
<i>D. setifolium</i>	110	PP820626	PP818697	PP818736	Russia, Shikotan Island, 25.VIII.2007, <i>Bakalin K-42-12-07</i> (VLA)
<i>D. setifolium</i>	524	PP820627	PP818698	PP818737	Russia, Khabarovsk Territory, 03.VIII.2016, <i>Pisarenko 2006704</i> (NSK)
<i>D. spadiceum</i>	81	KT580771	KT580718	PP818738	Russia, Kabardino-Balkariya
<i>D. spadiceum</i>	56	KT580769	KT580716	PP818739	Russia, Murmansk Province
<i>D. spurium</i>	113	PP818644	PP818699	PP818740	Poland, West Pomerania, V.1985, <i>Gos 929</i> (LE)
<i>D. spurium</i>	114	PP820628	PP818700	PP818741	Russia, Karelia, 18.VI.1997, <i>Boichuk s.n.</i> (LE)
<i>D. tauricum</i>	527	PP820629	PP818701	PP818742	Russia, Lipetzk Province, 26.IV.2016, <i>Ukrainskaya s.n.</i> (LE)
<i>D. tauricum</i>	Dta_4	KJ650901	KJ651101	KJ651045	Netherlands, North Brabant
<i>D. undulatum</i>	142	MG214810	MG214823	PP818743	Russia, Buryatia
<i>D. undulatum</i>	143	MG214811	MG214824	PP818744	Russia, Kamchatka
<i>D. viride</i>	69	PP820630	PP818702	PP818745	Russia, Kaluga Province, 01.V.2008, <i>Teleganova 08-221</i> (MHA)
<i>D. viride</i>	529	PP820631	PP818703	PP818746	Russia, Bashkortostan, 17.X.2011, <i>Mežaka a2 B97luba</i> (LE)