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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, *trn*L-F, ITS1-2

Introduction

Dicranum is one of the most multi-species and widespread 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 *trn*L-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* (Tubanova *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 *trn*L-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 GRT+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 *trn*L-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. laevidens* 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

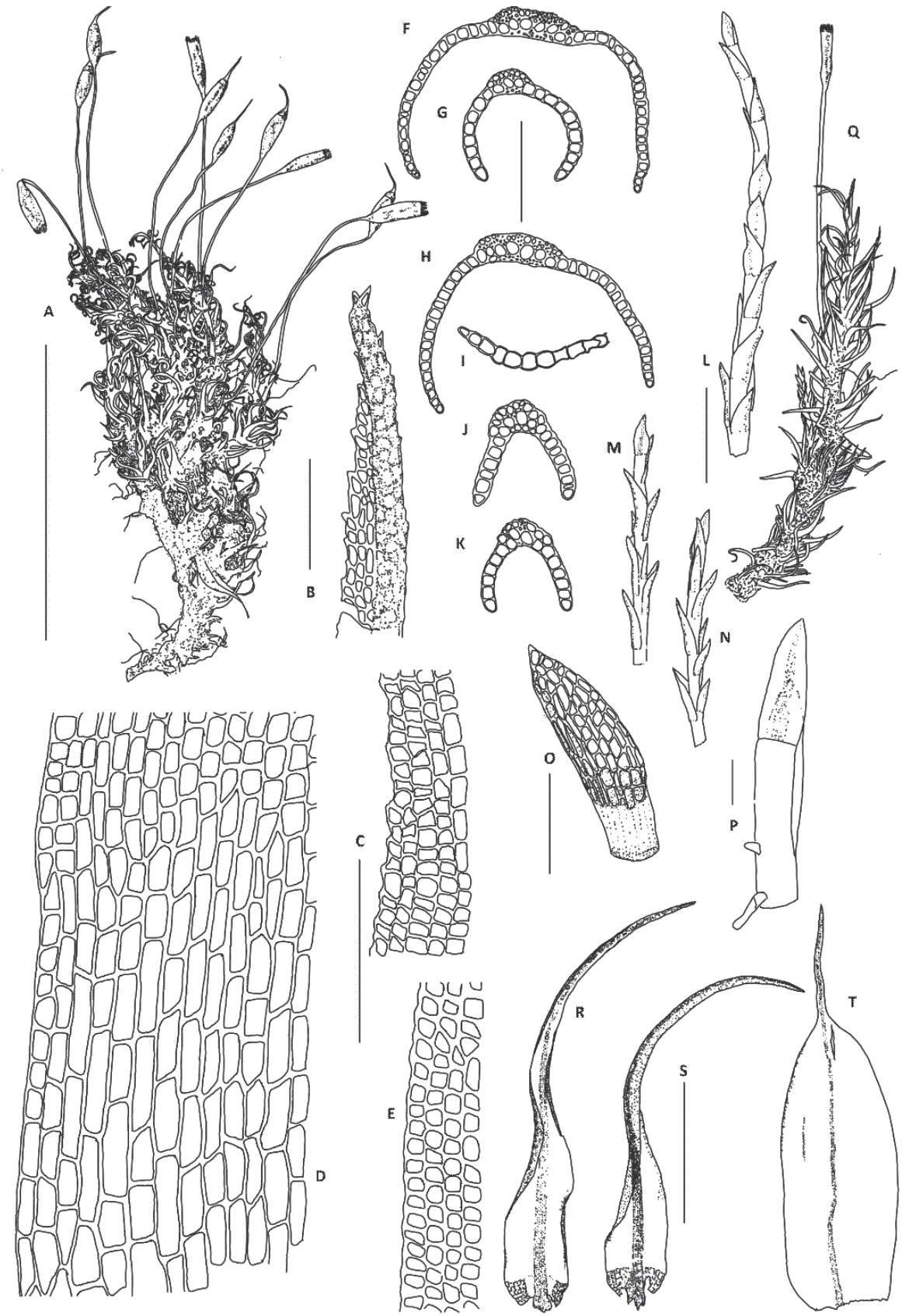

Fig. 2. *Dicranum afoninae* (from holotype): A: habit, dry; B: apex of leaf; C, E: upper leaf cells; D: basal laminal cells; F–H, J–K: leaves transverse section; I; alar cells transverse section; L–N: flagelliform branchlets, wet; O–P: leaflets of flagelliform branchlets; Q: habit, wet; R–S: stem leaves;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

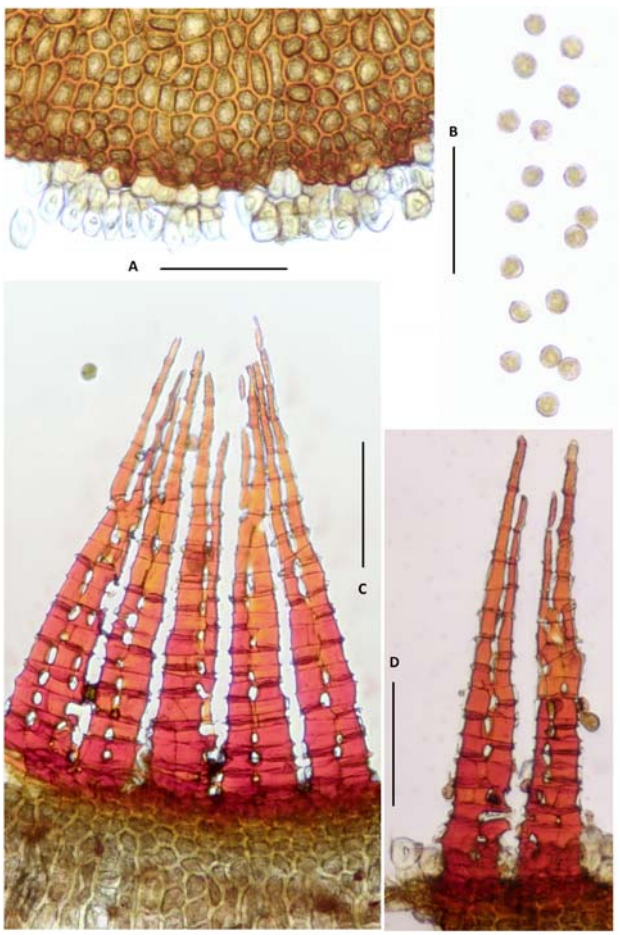

Fig. 3. *Dicranum afoninae* (from holotype): A: annulus on operculum; B: spore; C: peristome, outer view; D: peristome, inner view. Scale bars: 100 μm for A–D.

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)×(7.5–)10–15(–17) μm, with thin walls, not porose; proximal lamina cells short to elongate rectangular, (14–) 24–46(–79)×(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, cylindric, 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 denudated. 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-

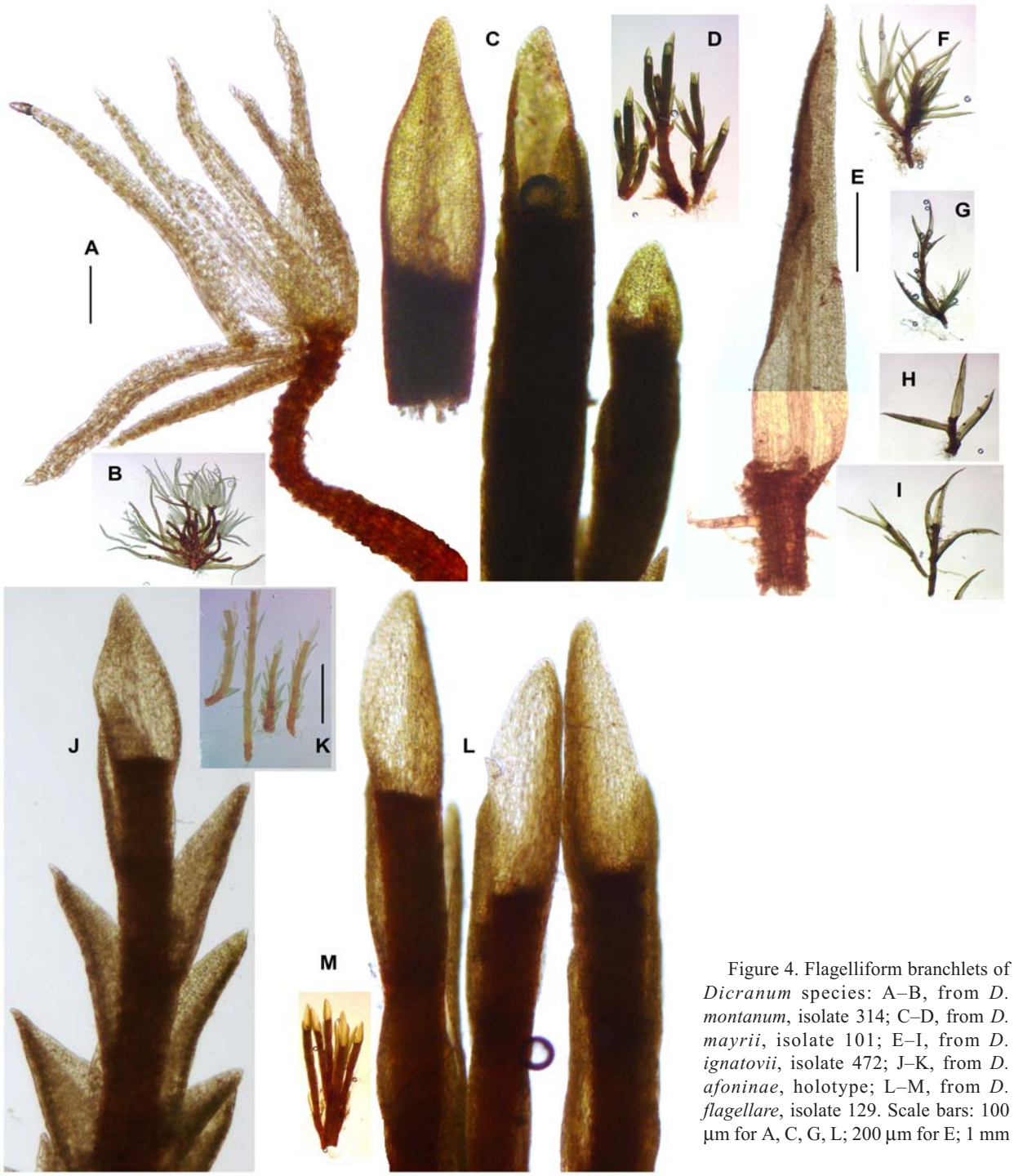

Figure 4. Flagelliform branchlets of *Dicranum* species: A–B, from *D. montanum*, isolate 314; C–D, from *D. mayrii*, isolate 101; E–I, from *D. ignatovii*, isolate 472; J–K, from *D. afoninae*, holotype; L–M, from *D. flagellare*, isolate 129. Scale bars: 100 μm for A, C, G, L; 200 μm for E; 1 mm

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). **Khabarovsk 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-Ussuriysky Statzionar, 20.VII.1980, *Cherdantseva, s.n.* (IRK); (6) Kavalerovo District,

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

Morphological features	***D. afoninae***	***D. mayrii***	***D. flagellare***	***D. montanum***	***D. ignatovii***
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 longitudionally 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-Ull, 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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Supplemntary materials are available at https://kmkjournals.com/upload/PDF/Arctoa/33/Arctoa_33_Dicranum_SM.xlsx

Appendix 1. Genbank accession numbers and voucher data.

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

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