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DICRANUM BAICALENSE (DICRANACEAE, BRYOPHYTA), A NEW SPECIES FROM RUSSIA

DICRANUM BAICALENSE (DICRANACEAE, BRYOPHYTA) – НОВЫЙ ВИД ИЗ РОССИИ

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Absract

A morphological and molecular phylogenetic study of *Dicranum* with elongate, porose distal laminal cells and costa with ridges on dorsal surface (sect. *Dicranum*) from Asian Russia revealed an unknown species. It is described as *Dicranum baicalense* sp. nova. It differs from the other species of the section *Dicranum* by having straight, homomallous leaves with two ridges on the dorsal side of costa, long and narrow upper laminal cells, and arcuate-cylindric, smooth capsules. A comparison of the new species with the representatives of the section *Dicranum* is provided. *Dicranum baicalense* occurs in southern Siberia (Republic of Buryatia and Zabaikalsky Territory) and the southern Russian Far East (Amur Province and Primorsky Territory). Morphological distinctions and distribution of *D. japonicum* Mitt. in Russia are also discussed.

Резюме

Морфологическое и молекулярно-филогенетическое изучение *Dicranum* с длинными пористыми клетками в верхней части листа и жилкой с продольными гребнями на дорсальной поверхности (sect. *Dicranum*) из азиатской России выявило новый вид, *Dicranum baicalense* sp. nova. Этот вид отличается от других видов секции *Dicranum* прямыми, односторонне обращенными листьями, которые имеют два продольных гребня на дорсальной стороне жилки и длинные, узкие клетки в верхней части листа, а также цилиндрическими, дуговидно согнутыми, гладкими в сухом состоянии коробочками. Дано сравнение *Dicranum baicalense* с видами секции *Dicranum*. *Dicranum baicalense* известен с юга Сибири (из Бурятии и Забайкальского края) и с юга российского Дальнего Востока (из Амурской области и Приморского края). Кроме того, обсуждаются морфологические отличия *D. japonicum* Mitt. и его распространение в России.

KEYWORDS: Bryophyta, *Dicranum*, ITS1-2, *trn*L-F, *rps*4, new species, Asian Russia.

INTRODUCTION

In 2010, we collected specimens of *Dicranum* in the southern areas of Buryatia (southern Siberia) and preliminary identified them as *D. japonicum* Mitt. Most morphological charaters of these specimens were in a well agreement with the species description and illustrations (Takaki, 1964; Savich-Lyubitskaya & Smirnova, 1970); they had keeled leaves with 2–3 lamellae on the dorsal side of costa, long, irregularly mammillose distal laminal cells, and 2-layered alar cells. However, these specimens had straight, homomallous leaves, somewhat similar to *D. scoparium* Hedw., whereas the specimens of *D. japonicum* from the Russian Far East and Japan had spreading, patulous leaves, which made them somewhat similar to *D. polysetum* Sw., though their leaves were not undulate. Subsequently, the plants similar to the specimens from Buryatia were collected in Zabaikalsky Territory, Amur Province, and Primorsky Territory and found in herbarium collections from Primorsky Territory.

A comparison with the type of *D. japonicum* (the high resolution scans in NY and isosyntype specimens from PC) found that *D. japonicum* is a markedly larger plant, having variosly spreading leaves which are never the case in the Buryatian '*D. japonicum*'. The identity of the latter thus remained dubious. The aim of the present study was to clarify it. We applied a moleculat phylogenetic approach, which already helped in solving taxonomic problems in *Dicranum* from Asian Russia (Tubanova & Ignatova, 2011; Tubanova *et al*., 2010, 2016).

MATERIALS AND METHODS

Morphological observation

Specimens from southern Siberia and the Russian Far East were revised. The type material of *Dicranum japonicum* from Paris (PC) was studied. Microscopic examinations and measurements were made by light microscope Carl Zeiss Axiostar plus. The habit and some morphological details were illustrated. Photos of the plant habits were obtained using a Sony α5000 digital camera.

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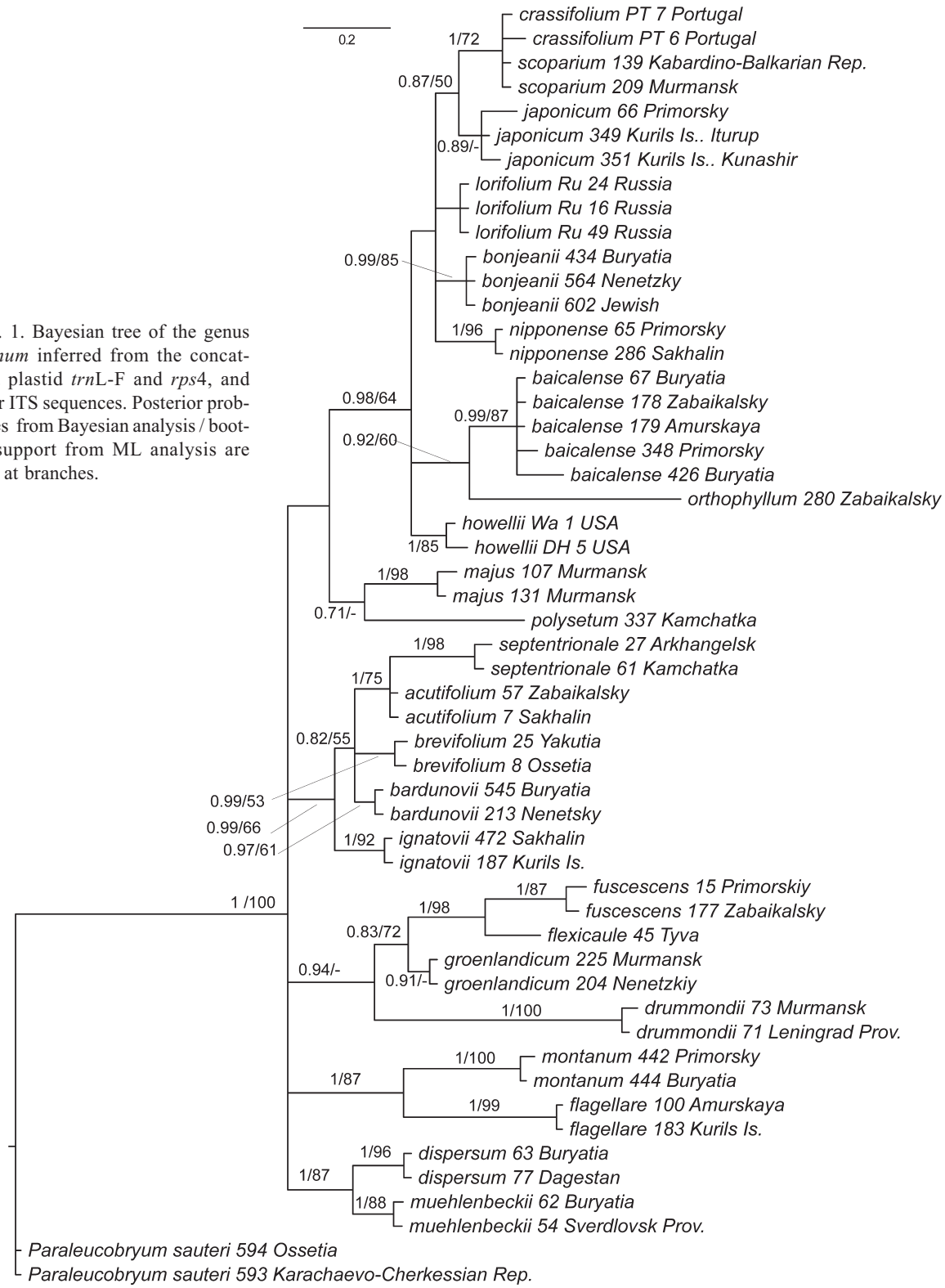

Fig. 1. Bayesian tree of the genus *Dicranum* inferred from the concatenated plastid *trn*L-F and *rps*4, and nuclear ITS sequences. Posterior probabilities from Bayesian analysis / bootstrap support from ML analysis are shown at branches.

Molecular phylogenetic analysis

The laboratory protocol of DNA extraction, amplification and sequencing was the same as described in Gardiner *et al*. (2005). The plastid *trn*L-F and *rps*4 regions and nuclear ITS1-2 region were used for the molecular phylogenetic study; some sequences from our previous studies of *Dicranum* (Tubanova *et al*., 2010, 2016, 2018; Tubanova & Ignatova, 2011; Ignatova *et al*., 2015) were included in the analyses. 89 new accesssions from 42 specimens (28 of *trn*L-F, 36 of *rps*4, and 25 of ITS1-2) were obtained (see Appendix). Sequences were aligned manually in BioEdit (Hall, 1999). Bayesian analyses were performed in MrBayes 3.2.6 (Ronquist *et al.*, 2012) in each case with three runs, five chains, 5,000,000 gener-

Table 1. A comparison of *Dicranum* species.

Character	Leaf length, mm	Leaf position	Leaf distally	Distal leaf cells, μm	Alar cells layers	Costa width	Costa ridges	Costa ridge cell rows
D. baicalense	5.5–7.5	homomallous or spreading	Keeled to canaliculate	70–100	2	1/11–1/9	2–3	1–3
D. bonjeanii	(4–)7–9	erectopatent, appressed or homomallois	Keeled	30–80	2	**1/20–**1/10	2	1
D. crassifolium	4–8	falcate-secund	Keeled to canaliculate	20–60	2	1/10–1/6	**4–6**	1–4
D. howelii	8–10	erectopatent homomallous or secund	Tubulose	50–90	1(2)	1/10–1/6	2	1
D. japonicum	8–9(–11)	patent straight	Keeled	80–110	2**–4**	1/11–1/9	2–3(–4)	1–2(–3)
D. leioneuron	5.5–7	erectopatent rarely appresed	Keeled	35–100	2	**1/20–**1/10	2	1
D. nipponense	3–7	falcate-secund rarely appresed	Keeled	50–80	2	1/10–1/5	2–3	1(–2)
D. orthophyllum	7–8(–9)	erectopatent straight or appresed	Keeled	90–140	2	1/11–1/8	**2–4**	1–2(–3)
D. polysetum	6–8	erect pendent	Keeled	40–120	**2–3(–4)**	1/15–1/10	2	1–3
D. scoparium	7–10	falcate-secund	Keeled	25–50	2	1/10–1/5	**(3)4(6)**	1–3
D. transsylvanicum	6–9	straight, falcate erectopatent or spreading	Canaliculate	20–40(–50)	2	1/13–1/10	**4–6**	1–4

ations, 25% burnin, chain temperature 0.015, and GTR+G model. Maximum Likelihood method was implemented also with GTR+G model in MEGA X (Kumar *et al.*, 2018).

Results

Molecular phylogenetic trees inferred from the nrITS and two plastid markers are similar to many previously published trees, where the clades of species with short distal laminal cells form a basal paraphyletic group, whereas the species with elongate distal laminal cells form a terminal, though unsupported clade. This terminal clade includes two subclades: (1) low-supported *D. majus*+*D. polysetum* clade, and (2) high / moderately supported (PP=0.98 BS=64) clade with all other species with elongate distal cells. The latter clase is further subdivided into three subclades:

(1) *D. howelii* (1 species / 2 samples) [PP=1 BS=85];

(2) *D. orthophyllum* + the specimens from southern Siberia tentatively named as '*D. japonicum*' [mutual clade PP=0.92 BS=60, '*D. japonicum*' clade PP=0.99 BS=87].

(3) a polytomy of single species clades of *D. nipponense* (1/2, PP=1 BS=96)*, D. bonjeanii* (1/3, PP=0.99 BS=85)*, D. lorifolium* (1/3, no support), and low supported clade of three species (PP=0.87 BS=50), composed of *D. japonicum* (1/3, PP=0.89 BS–), while another clade (2/4, PP=1 BS=72) combines two samples of *D. scoparium* and two samples of *D. crassifolium* – two closely related species that have no genetic distinctions in the studied gene regions.

No existing names were found for the specimens of '*D. japonicum*' from Buryatia; therefore, we describe it below as a new species.

Taxonomy

Dicranum baicalense Tubanova, sp. nov. Figs. 2–3.

Type. Russian Federation, Republic of Buryatia, Kyakhta District, vicinity of Naushki Settlement, "Botyiskaya Yama" Gully, Mel'nichnaya Stream, 50°23'34.3"N, 106°11'37.9"E, 685 alt., grassy willow and birch thicket, on soil and rotten wood, 18.VII.2010, coll. D.Ya. Tubanova # Kyakh-06/1042 [holotype UUH].

***Diagnosis*:** *Dicranum baicalense* is similar to *D. scoparium* Hedw. in habit of plants, sharing secund leaves with elongate, porose distal laminal cells and ridges on the dorsal side of costae in distal leaf portions. It differs from this species in having straight, homomallous vs. falcate-secund leaves; costae with 2(3) vs. (3)4 ridges on dorsal side; and longer distal laminal cells: 70–100 μm long vs. 25–50 μm long. The differences of *D. baicalense* from *D. japonicum* Mitt., which also has 2(3) ridges on dorsal side of costa, include shorter leaves: 5.5–7.5 mm vs. 8–9(–11) mm long; and shorter laminal cells: 70–100 μm long vs. 80–110 μm long. *Dicranum baicalense* is also similar to *D. orthophyllum* Broth. in having

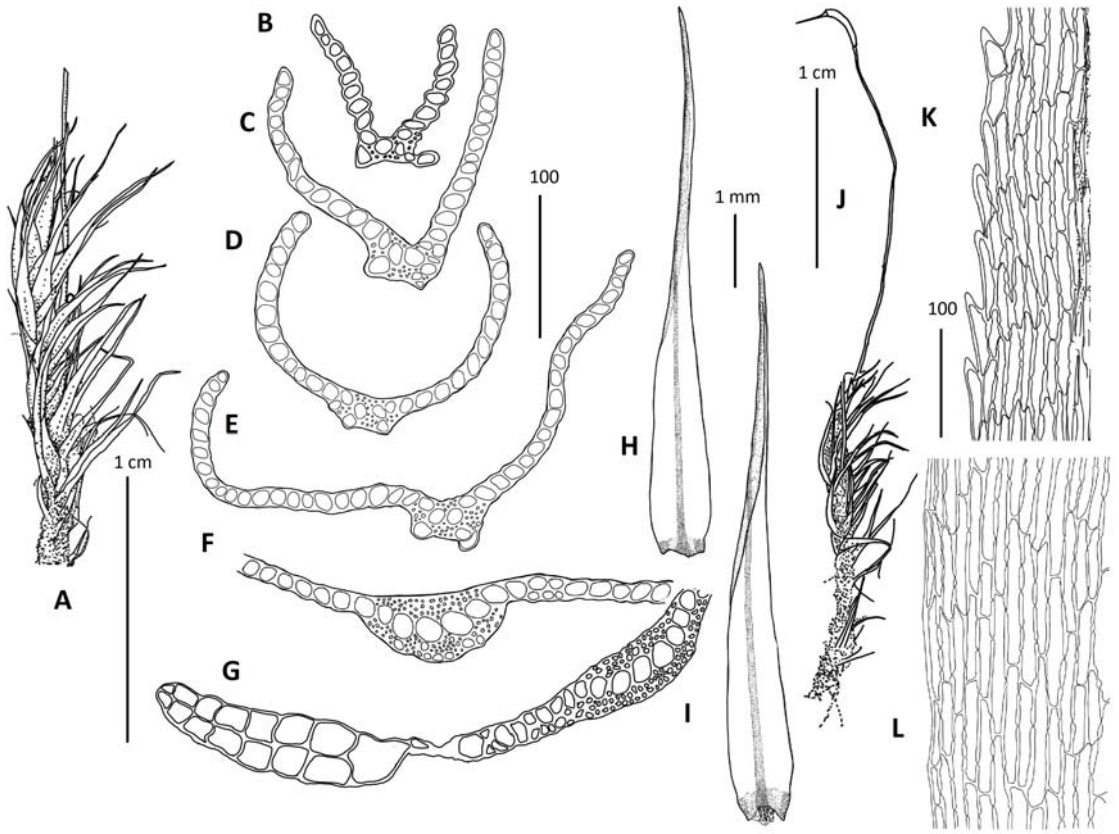

Fig. 2. *Dicranum baicalense* (from holotype): A: habit, wet; B–G: leaf transverse sections; H–I: leaves; J: plant with sporophyte, dry; K: upper laminal cells; L: basal laminal cells. Scale bars: 1 cm for A, J; 1 mm for H, I; 100 μm for B–G, K–L.

straight leaves and costae with 2(3) ridges, but the latter species has erect to appressed, not homomallous leaves and straight capsules.

***Etymology*.** The species epithed 'baicalense' refers to the vicinity of the Lake Baikal, where from the first collection of the species originates.

***Description*.** *Plants* medium-sized, in loose tufts, glossy, yellowish to light green. *Stems* 6–8 cm, more or less densely foliate, moderately to densely tomentose, tomentum whitish in upper part of stems and brownish below. *Leaves* homomallous, straight-secund to slightly flexuose-secund when dry, straight-secund when wet, lanceolate, (5–)5.5–7.5×0.6–0.9 mm, from lanceolate or ovate-lanceolate base gradually long acuminate, concave proximally, keeled or slightly canaliculate distally; margins plane or slightly incurved, serrate distally, unistratose; *costa* 1/11–1/9 of leaf width at base, percurrent or ending below apex, in upper part on abaxial surface with 2–3 serrate ridges 1–2 cells high, in transverse sections with one row of guide cells, two stereid bands, adaxial and abaxial epidermal layers of cells not differentiated; lamina 1-stratose, cells irregularly mammillose, often oblique in leaf transverse sections; distal laminal cells elongate rectangular to linear, (55–)70–105(–142)×(9–)10–12.5(–14.5) μm, moderately thick-walled, porose; basal laminal cells (69–)82–124(–159)×(9–)11–15(–18) μm, moderately thick-walled, porose; alar cells well-differentiated, 2-stratose, brownish, not reaching the costa. *Phyllodioicous*. Male plants dwarfed, on rhizoidal tomentum of female plants. Inner *perichaetial leaves* abruptly long-acuminate, convolute-sheathing. *Setae* 2.5–3 cm. *Capsules* cylindrical, arcuate, urns 2.5 mm long, brown, smooth when dry. *Annuli* not seen. *Operculum* with long, straight beak. *Spores* 13–24 μm, papillose.

Distribution and habitats. *Dicranum baicalense* is known from southern Siberia (Republic of Buryatia and Zabaikalsky Territory) and the southern part of the Russian Far East (Amur Province and Primorsky Territory). It grows on rotten wood, bases of trees, soil and litter in various types of forests. It was also collected from granite outcrops covered with humus.

Distinctions. *Dicranum baicalense* is similar to the species of the section *Dicranum* (Hoggets *et al.*, 2020) in having leaves with elongate, porose distal cells and costa with dorsal lamellae (ridges). The comparison with species from this section occurring in Russia and nearby areas is presented in Table 1. Our observation on the studied material is supplemented by published data (Savicz-Ljubitzkaja & Smirnova, 1970; Gao *et al*., 1999; Ignatov & Ignatova, 2003; Hedenäs & Bisang, 2004; Ireland, 2007; Lang & Stech, 2014; Lüth, 2002; Noguchi & Iwatsuki, 1987; Otnyukova, 2001; Price & Maier, 2013; Sérgio *at al.*, 1995; Tubanova & Afonina, 2016).

Fig. 3. Habit of *Dicranum baicalense*: A, from holotype; B, from Amur Province, *Bezgodov 261*, DNA 179; C, from Zabaikal'skiy Territory, *Afonina 7912b*, DNA 178; D, from Primorskiy Territory, *Tubanova Pr1508/02*, DNA348; E, from Republic of Buryatia, *Tubanova O1517/01*, DNA426.

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Dicranum baicalense looks rather similar to *D. scoparium* in plant size and secund leaves, although in the latter species leaves are usually falcate, whereas in *D. baicalense* they are almost straight and homomallous. Distal laminal cells in Siberian populations of *D. scoparium* are 25–50(–60) µm long vs. 70–100 µm long in *D. baicalense.* The leaf transverse sections of *D. scoparium* show (3)4 lamellae or large cells on the dorsal side of costa, while in *D. baicalense* such cells or lamellae are two, rarely three.

Dicranum baicalense is similar to *D. orthophyllum* Broth. in having straight leaves; however, in *D. baicalense* leaves are always homomallous, while in *D. orthophyllum* they are erectopatent. Distal laminal cells are longer in *D. orthophyllum*: 90–140 µm vs. 70–100 µm. There is also a distinction in sporophyte characters between these species: capsules of *D. baicalense* are arcuate, while they are straight in *D. orthophyllum*.

The differences between *Dicranum baicalense* and *D. japonicum* include homomallous vs. often spreading to all sides leaves; distal laminal cells 70–100 µm vs. 80–110 µm long; alar cells 2-layered vs. 2–4-layered; and capsules smooth vs. striate when dry.

Dicranum nipponense, which is fairly easy to recognize in nature, is distinguished by dark green color of plants; its leaves are quite short, mostly straight and more or less blunt. One of the main microscopic characteristics that separates it from the other species of this group is the presence of short cells above the alar cells, extending upwards along the leaf margins. *Dicranum polysetum* is recognized by spreading, transversely undulate leaves, and typically several sporophytes from perichaetium. These characters separate both these species from *D. baicalense*, which is characterized by yellowish-green color of plants; long, homomallous, not undulate leaves; and one sporophyte from perichaetium.

There are contradictory descriptions of morphology for *Dicranum lorifolium*, a species recently reported for the Russian moss flora (Lang & Stech, 2014). Among other diagnostic characters, straight capsules are mentioned (Mitten, 1859, p. 15), whereas in *D. baicalense* capsules are arcuate.

Additional specimens examined: RUSSIA: **Republic of Buryatia**: (1) Bichursky District, Malkhansky Ridge, vicinity of Maly Kunaley Village, Bol'shoy Kunaley Stream, E slope ~30°, 50°32'48.0"N, 107°47'39.1"E, 725 alt., sparse grass-birch

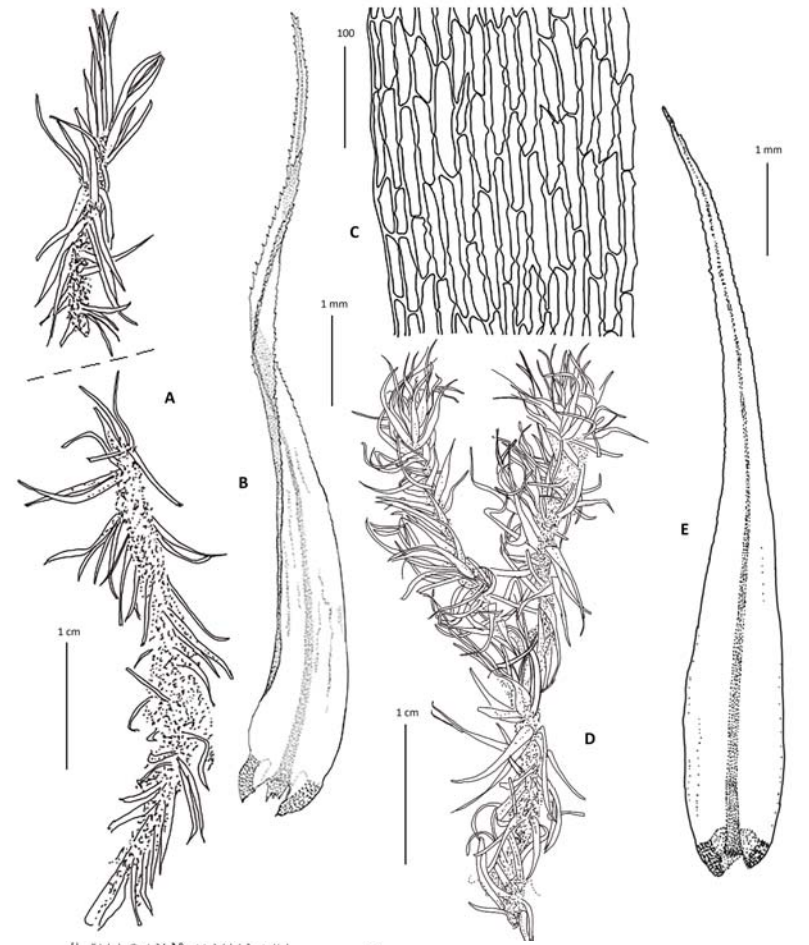

Fig. 4. *Dicranum japonicum* (A, from isosyntype PC0128670; C–F, from isosyntype PC0128669; D–E, from Kunashir Island, *Koroteeva 15-9/3-3*, DNA351). A, D: habit; B, E: leaves; C: basal leaf cells. Scale bars: 1 cm for A, D; 1 mm for B, E; 100 μm for C.

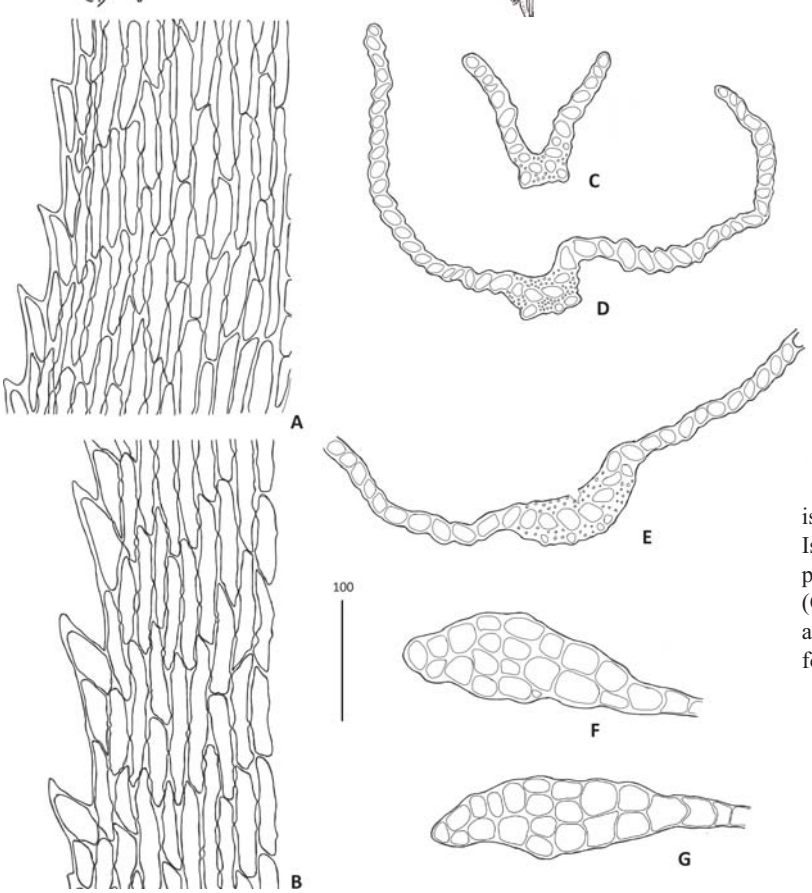

Fig. 5. *Dicranum japonicum* (A, C–F, from isosyntype PC0128669; B, G, from Kunashir Island, *Koroteeva 15-9/3-3*, DNA351). A, B: upper leaf cells; C–E: leaves transverse section (C: mid-leaf, D: upper leaf, E: basal leaf); F–G: alar cells transverse section. Scale bars: 100 μm for A–G.

Fig. 6. Habit of *Dicranum japonicum:* A, from isosyntype PC0128669, F, from isosyntype PC0128670, photo by Tubanova; B, from Kunashir Island, *Koroteeva 15-9/3-3*, DNA351; C, from Primorskiy Territory, *Bardunov et al*.; D, from Primorskiy Territory, *Ignatov 07-373*, DNA66; E, from Iturup Island, *Koroteeva 15-15/2-1*, DNA349.

forest, at the birch base, 23 August 2011, *Tubanova* Bi-1/1141 (UUH); (2) Dzhidinsky District, Baikalsky Reserve, valley of Abiduy River, middle course, pine-birch mixed-grass forest with abies, on pine rotten wood, 27 July 1991, *Kazanovsky 1721* (IRK, UUH); (3) Kabansky District, Khamar-Daban Ridge, Levaya Mysovka River, Bushalay, 51°32’49.5"N, 105°50’23.8"Ĺ; 1227 alt., reforestation of fir with blueberries and mosses, on soil and rotten wood, 03 July 2013, *Tubanova Ka-02/1312* (UUH); (4) Okinsky District, Tunkinsky Ridge, Natural Park “Shumak”, left bank of Shumak River, vicinity of hot spring, 51°58’11.5"N,101°52’03.0"E, 1507 alt., larch-spruce cowberry-moss forest, on soil, 26 July 2016, *Tubanova Tu-161115* (UUH) with sporophytes; (5) Tunkinsky District, Tunkinsky Ridge, about 5 km to N from camp site ‘Sukhoy Ruchey”, 51.75935°N, 101.61678°E, 1072 alt., birch grass forest, on soil and rotten wood, 22 July 2016, *Tubanova Tu-160105, Tu-160106* (UUH) with sporophytes; (6) *same place, Tubanova Tu-160106* (UUH) with sporophytes; (7) Tunkinsky District, about 10 km to the SW from Zhemchug Village, Khongor-Uul mineral source, 51°36’25.8"N,102°21’50.0"E, 812 alt., mixed forest with grasses, on soil, 14 September 2017, *Tubanova Tu170109* (UUH); (8) *loc. cit., Tubanova Tu170110* (UUH); (9) *same place,* 51°35’45,0"N, 102°20’48,0"E, 857 alt., birch-larch forest with grasses, on soil, 14 September 2017 *Tubanova Tu170207* (UUH); (10) *same place, Tubanova Tu170212* (UUH); (11) *same place, Tubanova Tu170208* (UUH); (12) Zakamensky District, Vicinity of Ust’ Burgaltay Village, 50.48767°N, 104.06935°E, 1075 alt., birch-grass-sedge forest, on soil, 10 August 2018, *Anenkhonov Op. Zk-3/18* (UUH) with the sporophytes. **Zabaikal’skiy Territory**: Kalarsky District, Yuzhno-Muysky Range, Koira Creek, 56°13’59.5"N, 115°52’59.5"E, 589-600 alt., mixed forest along creek, on dead-wood. 07 August, *Afonina 7912b* (LE, UUH) with sporophytes. **Amur Province**: (1) Selemdzhinsky District, Ust’-Norskaya Sopka, S slope of 306.5-elevation, 52°25’30"N, 129°55’30" E, 200 alt., granite outcrops, 18 July 2011, *Bezgodov 261* (MHA); (2) *same place,* on humus, 23 July 2011, *Bezgodov 409* (PPU, UUH); (3) *same place,* on soil, 20 July 2011, *Bezgodov 357* (PPU, UUH); (4) *same place,* on a humus-covered rock ledge, 20 July 2011, *Bezgodov 286* (PPU, UUH); (5) Selemdzhinsky District, “Norsky” Reserve, left bank of Selemdzha River, the channel Aleksandrovskaya, 52°25’N, 130°14’E, 220 alt., granite outcrops, on covered with humus rotten wood, 11 July 2011, *Bezgodov 138* (PPU, UUH); (6) *same place,* valley of Selemdzha River, 0.8–1 km from cordon “Dvadtzatikha”, 52°25’30"N, 130°12’E, 220 alt., fir forest with grasses, on the soil and litter, 10 July 2011, *Bezgodov 89* (PPU, UUH); (7) Selemdzhinsky District, right slope of Nora River valley, in the lower reaches, Mal’tzevskaya Sopka, 52°30’N, 129°49’E, 220 alt., granite outcrops, on the shady steep walls, 08 June 2011, *Bezgodov 57* (PPU, UUH). **Primorsky Territory** (1) Partizansky District, Ol’khovaya Mountain, S slope, 43°19’37.4"N, 133°39’57.5"E, 1230 alt., dark coniferous forest with alder and maple, on soil, 22 September 2015 *Tumurova Vl-833* (UUH) with sporophytes; *same place, Tumurova Vl-834* (UUH) with sporophytes.

Dicranum japonicum Mitt., Trans. Linn. Soc. Bot. ser. 2, 3: 155. 1891. Figs. 4–6.

Type: ‘Challenger’ Exp.; Oyama and Fujisan, barren, Bisset.

NY herbarium has two syntypes: the putative lectotype “J. Bisset 26 Oyama” (NY 1093852; scans at https://sweetgum.nybg.org/science/vh/specimen-details/?irn=1238206) and ‘Challenger’ Exp. (NY 1093851; scans at https://sweetgum.nybg.org/science/vh/specimen-details/?irn=1238204).

PC herbarium has two isosyntypes: (1)'Challenger' Exp. (PC0128669); (2) Oyama and Fujisan, Bisset. (PC0128670). Scans: https://science.mnhn.fr/institution/mnhn/collection/pc/item/pc0128669.

Plants medium-sized to large, in loose tufts, glossy, yellowish-green. *Stems* 4–5(–12) cm, densely or loosely foliate, with dense, whitish to brownish tomentum throughout. *Leaves* straight, patent to patulous when wet and dry, sometimes slightly flexuose-secund, 8–9(–11) ×0.9–1.1 mm, from ovate-lanceolate base gradually narrowed into long, narrow acumina, concave proximally, keeled distally; margins plane, serrate distally, unistratose; *costa* 1/9–1/11 of leaf width at base, percurrent or ending before apex, in distal part on abaxial surface with 2–3(–4) serrate ridges 1–2(–3) cells high, in transverse sections with one row of guide cells, two stereid bands, adaxial epidermal layer of cells not differentiated, in the basal parts of leaves the abaxial stereid layer interrupted by several enlarged cells; lamina unistratose, cells irregularly mammillose, often oblique in leaf transverse sections; distal laminal cells linear, (68–)80–112(–136) ×(11.5–)12.5–15.5(–18) µm, thick-walled, porose; proximal laminal cells (75–)82–130(–173)×(14–)16–19(–20) µm, moderately thick-walled, porose; alar cells well-differentiated, brownish, 2–4 stratose, not reaching the costa. *Phyllodioicous*. Male plants dwarfed, on rhizoidal tomentum of female plants. Inner *perichaetial leaves* abruptly long-acuminate, convolute-sheathing. *Setae* solitary, 4–5(–6) cm. *Capsules* inclined, asymmetrical, urns 2.5–3(–4.5) mm long, slightly curved, furrowed when dry. *Spores* 13–24 µm, papillose.

Distribution and habitats. *Dicranum japonicum* was reported from Japan, China, and Korea (Takaki, 1964; Gao *et al.*, 1999). In Russia this species is rare; it occurs in monsoon climate of the Far East: in Kamchatka Peninsula, Kuril Islands and Primorsky Territory. It grows on soil, rocks covered with humus and forest litter, in open sites and in mixed forests. In Japan "this species most frequently grows on humus-rich soil in moderately moist and shaded places where this species forms sometimes wide pure carpets as does *D. scoparium*" (Takaki, 1964, p. 117).

Variation. There is a slight variation in size of distal laminal cells in specimens from the Russian Far East in comparison with the type specimen. For example, the cells in Kunashir specimens of *D. japonicum* are (63–)88–128(–143)×13–17(–20) µm and in specimens from Primorsky Territory (47–)72–112(–143) ×(14–)15.5–20(–24) µm. These cells are wider then in the type specimen. Alar cells in the upper young leaves often are only 2-stratose. In the Moss flora of Japan (Noguchi & Iwatsuki, 1987) upper laminal cells are described as 45–80 µm long. We also studied few specimens of Mosses of Japan Exsiccati (№1252, Fasc. XXXI (2010), №6, Fasc. 1. (1987)) and duplicates of *D. japonicum* specimens from Japan. They had upper laminal cells 50–75 µm long and 2-stratose alar cells. Only one studied specimen from Japan (№1311) had longer laminal cells and 2–4-stratose alar regions.

Distinctions. *Dicranum japonicum* resembles *D. polysetum* by patent stem foliation; however, its leaves are smooth vs. strongly transversely undulate. Its distal laminal cells are longer, starting from 70 µm vs. from 40 µm in *D. polysetum*. It also has single sporophytes in perichaetia vs. 3–7 in *D. polysetum*. Long upper leaf cells of *D. japonicum* are similar the the upper leaf cells of *D. orthophyllum*; however, they differ in having patent to patulous vs. erectopatent to appresed leaves; 2–4-layered alar cells vs. 2-layered; and inclined, asymmetric, slightly curved vs. cylindrical, straight capsules. Differences between *D. japonicum* and *D. baicalense* are discussed in the comments to this species. The differences of *D. japonicum* from other species of the genus *Dicranum* with ridges on the dorsal surface of the costa are given in Table 1.

Specimens examined: **RUSSIA**: **Kamchatka Territory**, Kamchatka Peninsula, vicinity of Puschino Village, upper Kamchatka River, 54°11'N, 158°02'E, birch-grass forest with rowan on the slope of the hill, 16 September 1978, *Afonina P-7* (LE, UUH) with sporophytes and dwarf male plants. **Primorsky Territory**, Lazovsky District, vicinity of Chistovodnoe Village, N slope of cliff, on rocks, 13 September 1977, *Bardunov et al. s.n.* (IRK, UUH). **Sakhalin Province**: (1) Kuril Islands, Kunashir Island, Mendeleev Volcano, Kisly Sream 44°00'N, 145°46'E, 10 alt., moss coniferous forest, on forest litter, 10 October 2006, *Ignatov 06-3129* (MHA, UUH) with sporophytes and dwarf male plants; (2) *same place,* 43°59'08.4"N, 144°00'03.5"E, 172–452 alt., bamboo spruce forest with an admixture of broad-leaved trees, on soil, 07 August 2014 *Tubanova et al. K14035/87* (UUH). **JAPAN**: Kyushu, Kagoshima-ken, Isl. Yakushima, Hanano-ego, on soil at open site, 1600 alt., 27 September 1975, *Iwatsuki & Suzuki Exsiccatii 1311, Ser. 27* (LE, UUH). **CHINA**: Guizhou Province, Kaijang County, Xiang Zhi Stream, 26°46'59.5"N, 106°54'44.5"E, 1200 alt., broadleaved (mostly evergreen) forest on steep slope to valley of stream, mesic condition clay on slope, in part shade, 19 November 2013, *Bakalin China-51-60-13* (VBGI, UUH).

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Appendix 1. Newly generated accessions are given in bold.

Species	Isolate	nrITS1-2	trnL-F	rps4	Specimen data
Paraleucobryum sauteri	594	**OP957305**	**OP948672**	**OQ0606850**	Russia, Republic of North Ossetia, VII.2013, *Ukrainskaya 15733* (LE, UUH)
P. sauteri	593	**OP957304**	**OP948673**	**OQ060686**	Russia, Karachaevo-Cherkessia, 21.VII.2013, *Ukrainskaya 15798* (LE, UUH)
Dicranum acutifolium	57	**OP939942**	**OP948646**	**OQ060651**	Russia, Zabaikalskiy Territory, 16.VII.2005, *Afonina s.n.* (LE, UUH)
D. acutifolium	7	HQ830322	**OP948647**	**–**	Russia, Sakhalin Island, 20.VIII.2006, *Ignatov, Teleganova 06-18* (MHA, UUH)
D. baicalense	67	**OP939925**	**OP948648**	**OQ060652**	Russia, Republic of Buryatia, 18.VII.2010, *Tubanova Kyakh-6/1042* (UUH)
D. baicalense	426	**OP939927**	**OP948649**	**–**	Russia, Republic of Buryatia, 14.VII.2015, *Tubanova O1517/01* (UUH)
D. baicalense	178	**OP939926**	**OP948650**	**–**	Russia, Zabaikalskiy Territory, 07.VIII.2012, *Afonina 7912b* (LE, UUH)
D. baicalense	179	**OP939929**	**OP948651**	**OQ060653**	Russia, Amur Region, 18.VI.2011, *Bezgodov 261* (PPU, UUH)
D. baicalense	348	**OP939928**	**OP948652**	**–**	Russia, Primorskiy Territory, 23.IX.2015, *Tubanova Pr1508/02* (UUH)
D. bardunovii	213	**OP939941**	**OP948653**	**OQ060654**	Russia, Yamalo-Nenetskiy AD, 29.VII.2013, *Bezgodov 491* (PPU, UUH)
D. bardunovii	545	**OP939940**	**OP948654**	**OQ060655**	Russia, Republic of Buryatia, 26.VII.2016, *Tubanova Tu-161110* (UUH)
D. bonjeanii	434	**OP939935**	**OP948655**	**–**	Russia, Republic of Buryatia, 31.VII.1998, *Anenkhonov Op 98-7-31-9* (UUH)
D. bonjeanii	564	**OP939933**	**OP948656**	**OQ060656**	Russia, Nenetzk AP, 11.VI.2017, *Lavrinenko s.n.* (LE, UUH)
D. bonjeanii	602	**OP939934**	**OP948657**	**OQ060657**	Russia, Jewish AR, 17.VI.2018, *Tubanova E183618* (UUH)
D. brevifolium	8	HQ830343	KJ796589	**OQ060658**	Russia, North Ossetia, 6.IX.2002, *Korotkov s.n.* (MW, UUH)
D. brevifolium	25	HQ830344	**OP948658**	**OQ060659**	Russia, Republic of Sakha, 30.VIII.2000, *Kuznetzova op. 6* (MW, SASY, UUH)
D. crassifolium	PT_6	KM502669	KM502754	**–**	Portugal, Beira Alta
D. crassifolium	PT_7	KM502670	KM502755	**–**	Portugal, Douro Litoral
D. dispersum	63	KT580738	KT580684	**OQ060660**	Russia, Republic of Buryatia, 18.VII.2010, *Tubanova Kaykh-5/1043* (UUH)
D. dispersum	77	KT580740	KT580686	**OQ060661**	Russia, Dagestan, 19.V.2009, *Ignatov, Ignatova 09-189* (MHA, UUH)
D. drummondii	73	KT580744	KT580690	**OQ060662**	Russia, Murmansk Prov., 31.VII.2009, *Kozhin, Leonova M-M-0542* (MW, UUH)

D. drummondii	71	KT580743	KT580689	**OQ060663**	Russia, Leningrad Province, 11.VIII.2006, *Kurbatova Exs. 211* (UUH)
D. flagellare	183	MG214814	MG214835	**OQ060664**	Russia, Kunashir Island, 5.IX.2006, *Ignatov 06-1082* (MHA, UUH)
D. flagellare	100	MG214815	MG214836	**OQ060665**	Russia, Amur Province, 5.VII.2010, *Bezgodov 197* (PPU, UUH)
D. flexicaule	45	HQ830328	**OP948659**	**OQ060666**	Russia, Republic of Tyva, 23.VII.1995, *Molokova s.n.* (UUH)
D. flexicaule	205	**OP939944**	**OP948660**	**OQ060667**	Russia, Murmansk Province, 28.VII.2003, *Belkina B117-103* (KPABG, UUH)
D. fuscescens	177	**OP939943**	**–**	**OQ060668**	Russia, Zabaikalskiy Territory, 11.VIII.2011, *Czernyadjeva 19-11* (LE, UUH)
D. fuscescens	15	HQ830337	KG796579	**–**	Russia, Primorskiy Territory, 3.IX.2006, *Ignatov et al. 06-2588* (MHA, UUH)
D. japonicum	66	**OP939930**	**OP948661**	**OQ060669**	Russia, Primorskiy Territory, 22.VIII.2007, *Ignatov 07-373* (MW, UUH)
D. japonicum	349	**OP939931**	**OP948662**	**OQ060670**	Russia, Iturup Island, 18.VIII.2015, *Koroteeva 15-15/2-1* (SAK, UUH)
D. japonicum	351	**OP939932**	**OP948663**	**OQ060671**	Russia, Kunashir Island, 12.VIII.2015, *Koroteeva 15-9/3-3* (SAK, 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 Island, 20.VII.2014, *Tubanova et al. S14015/17* (UUH)
D. ignatovii	187	MG214803	MG214826	**–**	Russia, Kunashir Island, 9.IX.2006, *Ignatov 06-3008* (MHA, UUH)
D. groenlandicum	204	KY296852	KY296872	KY296880	Russia, Yamalo-Nenetskiy AD, 31.VII.2013 *Bezgodov 533* (PPU, UUH)
D. groenlandicum	225	KY296853	KY296873	**OQ060672**	Russia, Murmansk Prov., 22.VII.2007, *Belkina B176-1a-07* (KPABG, UUH)
D. lorifolium	24	KF423656	KF424011	**–**	Russia, Primorsky Territory
D. lorifolium	16	KF423655	KF424010	**–**	Russia, Primorsky Territory
D. lorifolium	49	KF423654	KF424009	**–**	Russia, Primorsky Territory
D. majus	107	**OP939938**	**OP948665**	**OQ060674**	Russia, Murmansk Prov., 17.VII.2007, *Belkina B155-1-07* (KPABG, UUH)
D. majus	131	**OP939939**	**OP948666**	**OQ060675**	Russia, Murmansk Prov., 29.VI.2012, *Tubanova KP-4/1206* (UUH)
D. montanum	442	**OP939945**	**OP948667**	**OQ060676**	Russia, Primorskiy Territory, 20.IX.2015, *Tubanova Pr1501/03* (UUH)
D. montanum	444	**OP939946**	**OP948668**	**OQ060677**	Russia, Republic of Buryatia, 25.VI.2014, *Tubanova B14002/03* (UUH)
D. muehlenbeckii	62	KT580752	KT580699	**–**	Russia, Republic of Buryatia, 18.VII.2010, *Tubanova Kyakh-5/1044* (UUH)
D. muehlenbeckii	54	KT580751	KT580698	**OQ060678**	Russia, Sverdlovsk Province, 12.VII.1996, *Nikonova s.n.* (MW, UUH)
D. nipponense	65	**OP939936**	**OP948669**	**OQ060679**	Russia, Primorskiy Territory, 28.IX.2006, *Ignatov 06-2975* (MW, UUH)
D. nipponense	286	**OP939937**	**OP948670**	**OQ060680**	Russia, Sakhalin Island, 24.VII.2014, *Tubanova, Dorzhieva #S1492231* (UUH)
D. orthophyllum	280	**OP939947**	**OP948671**	**–**	Russia, Zabaikalskiy Territory, 7.VIII.2012, *Afonina 7912b* (LE, UUH)
D. polysetum	337	MG214806	MG214832	**–**	Russia, Kamchatka, 11.VIII.2004, *Czernyadjeva 58* (LE, UUH)
D. scoparium	139	MG214807	MG214828	**OQ060681**	Russia, Kabardino-Balkaria, 30.VII.2004, *Ignatov et al. s.n.* (MHA, UUH)
D. scoparium	209	MG214808	MG214829	**OQ060682**	Russia, Murmansk Prov., 10.VI.2007, *Belkina B41-5-07* (KPABG, UUH)
D. septentrionale	27	HQ830339	KJ796586	**OQ060683**	Russia, Arkhangelsk Province, 19.VII.2000, *Churakova 864* (MW, UUH)
D. septentrionale	61	HQ830338	KJ796585	**OQ060684**	Russia, Kamchatskiy Territory, 04.08.2007, *Neshataeva 986* (LE, UUH)

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