Arctoa (2010) **19**: *1-30*

THE GENUS BRACHYTHECIUM (BRACHYTHECIACEAE, MUSCI) IN RUSSIA: COMMENTS ON SPECIES AND KEY FOR IDENTIFICATION

РОД BRACHYTHECIUM (BRACHYTHECIACEAE, MUSCI) В РОССИИ: ОБСУЖДЕНИЕ ВИДОВ И КЛЮЧ ДЛЯ ОПРЕДЕЛЕНИЯ

M.S. IGNATOV[1] & I.A. MILYUTINA[2]

М.С. ИГНАТОВ[1], И.А. МИЛЮТИНА[2]

Abstract

A comparison of molecular phylogenetic analysis (maximum parsimony and haplotype networks) with a morphological approach to species taxonomy is given, revealing a probable rapid speciation in the terminal *Brachythecium salebrosum*-clade. Within the latter, there are rather clearly morphologically delimited taxa with identical ITS, the most variable of the widely used molecular markers. Three new species are described basing on morphology. A key for the species identification in Russia is given, and species delimiting characters are discussed as well. *Brachythecium laetum* is confirmed for Russia and *B. helminthocladum* is reported it its flora for the first time.

Резюме

Дано сравнение результатов молекулярно-филогенетического анализа (методом максимальной экономии и методом сетей гаплотипов) с данными морфологического анализа. На нескольких примерах показано, что быстрая эволюция в терминальной кладе приводит к образованию видов, достаточно четко оформленных морфологически, но при этом имеющих идентичные последовательности даже наиболее вариабельных участков ДНК, nrITS. Описано 3 новых для науки вида. Дан ключ для определения видов рода в России, обсуждаются диагностические признаки сложных для определения таксонов. Подтверждена встречаемость в России *Brachythecium laetum,* а *B. helminthocladum* впервые найден на территории страны.

KEYWORDS: Bryophyta, Brachytheciaceae, *Brachythecium*, molecular phylogenetic, new species, Russia, taxonomy

INTRODUCTION

This paper presents our further results on the Brachytheciaceae based on combined molecular and morphological data. The previous phylogenetic analysis of Huttunen & Ignatov (2004) found in *Brachythecium* the basal group around *B. rivulare* and a terminal clade formed by species of *B. salebrosum*-group. The next analysis (Ignatov et al., 2008) allowed the recognition of three new species of the genus from Asiatic Russia, while a number of specimens, especially around *B. salebrosum,* remained poorly resolved. In this paper we concentrated mostly on the latter complex of species in North Asia.

MATERIAL AND METHODS

Collections from MHA, MW, LE, SASY, S, and partially other herbaria were revised.

Molecular analysis

A considerable part of specimens involved in the present analysis were the same as in the previous one, although in *B. rivulare* and *B. mildeanum* groups many specimens were omitted, while the

[1] – Main Botanical Garden of Russian Academy of Sciences, Botanicheskaya, 4, Moscow 127276 Russia – Россия 127276 Москва, Ботаническая, 4, Главный ботанический сад им. Н.В.Цицина РАН; misha_ignatov@list ru

[2] – A.N.Belozersky' Research Institute of Physico-Chemical Biology, Moscow State University, Moscow 119991 Russia – Россия 119991 Москва, МГУ, НИИ Физико-химической биологии им. А.Н. Белозерского; iramilyutina@yandex.ru

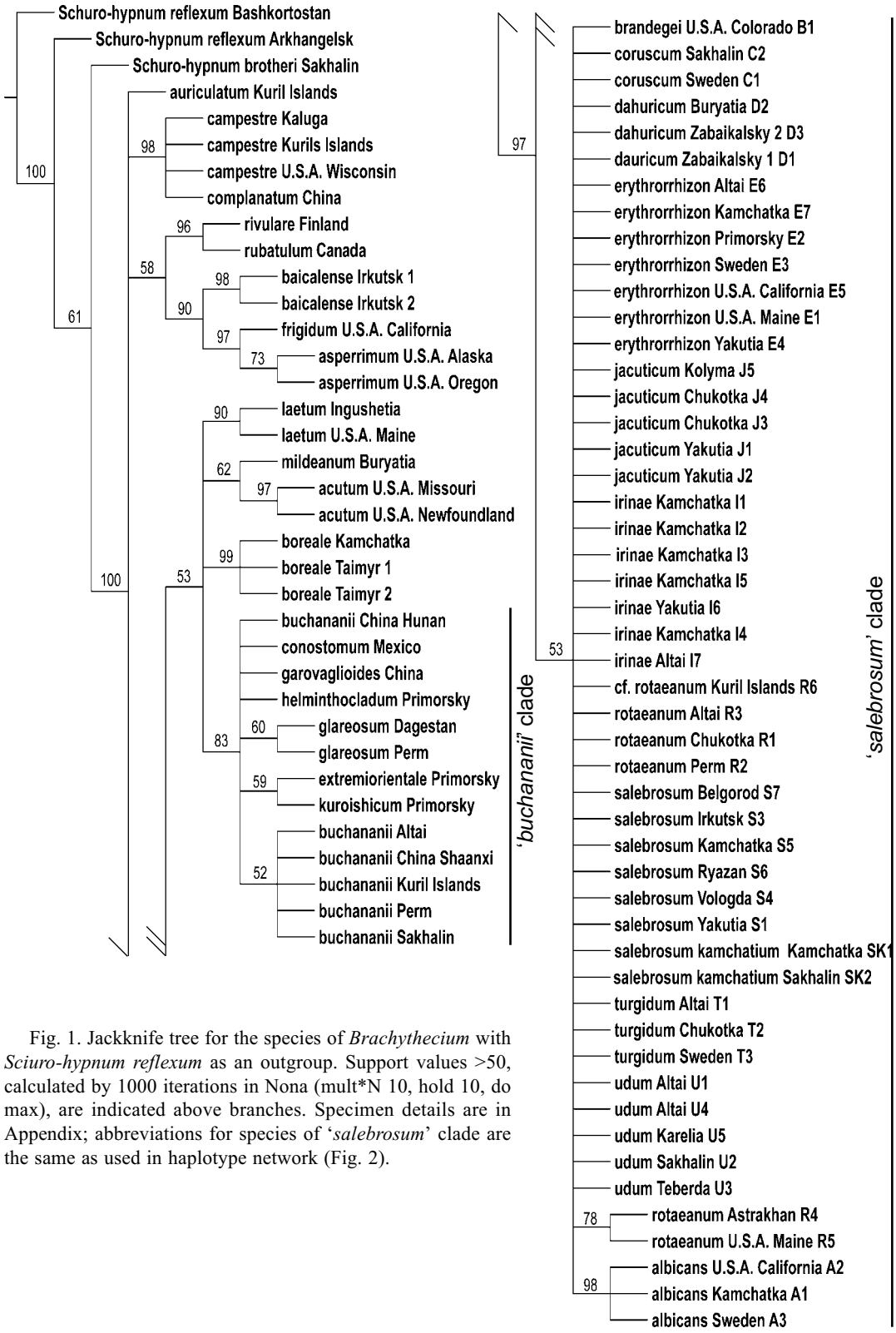


Fig. 1. Jackknife tree for the species of *Brachythecium* with *Sciuro-hypnum reflexum* as an outgroup. Support values >50, calculated by 1000 iterations in Nona (mult*N 10, hold 10, do max), are indicated above branches. Specimen details are in Appendix; abbreviations for species of '*salebrosum*' clade are the same as used in haplotype network (Fig. 2).

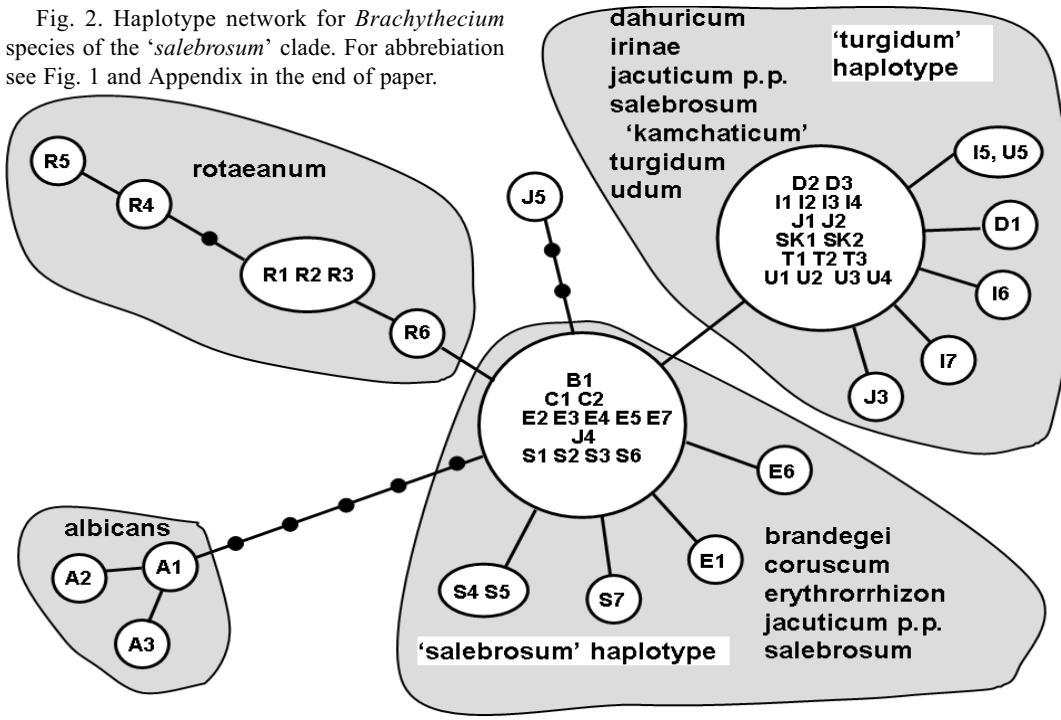


Fig. 2. Haplotype network for *Brachythecium* species of the '*salebrosum*' clade. For abbrebiation see Fig. 1 and Appendix in the end of paper.

specimens of *B. salebrosum, B. turgidum*, *B. rotaeanum,* etc. were added. Specimens for sequencing included 'typical' representatives of the known species and specimens with controversial characters, besides, after a preliminary analysis, an additional samples of putatively new species were added.

The protocol of DNA extraction, PCR and sequencing was the same as described by Gardiner et al. (2005). Sequences were aligned manually in Bioedit (Hall, 1999). Parsimony analysis was completed with Nona (Goloboff, 1994) within the Winclada shell (Nixon, 1999a). Jackknifing with 1000 replications was performed with Nona within the Winclada shell.

Haplotype network analysis was performed in TCS 1.21 (Clement et al., 2000), with gaps coding as a single event irrespective to their length with a connection limit at 9 steps (95%).

Results

The jackknife tree (Fig. 1) resolved most of species involved in the analysis in the same way as earlier (Huttunen et al., 2007; Ignatov et al., 2008), finding the basal polytomy and one clade (jackknife support 97), composed of two clades with very low jackknife support (Fig.1). However, these two subclades are constantly present in strict consensus analyses (not shown) and rather well correspond to the infrageneric units, suggested on the morphological basis (e.g. McFarland, 1988). The basal polytomy includes species with rough setae (*B. rivulare, B. rutabulum, B. frigidum, B. asperrimum, B. campeste, B. complanatum, B. auriculatum*), and as an exception *B. baicalense* with a smooth seta (note that *B. campestre* sometimes also has a smooth seta). The terminal clade includes all the species with smooth setae. It is composed of two clades, but both receiving low jackknife support. The first of them includes a polytomy of *B. mildeanum, B. acutum, B. laetum, B. boreale*, and a moderately (83) supported clade of southern species around *B. buchananii.*

The second subclade includes species of *B. salebrosum* group, forming mostly unresolved polytomy in a jackknife tree. Only two small clades occur whithin it: one formed by two specimens of *B. rotaeanum*, most species of which are in polytomy, and another one formed by three specimens of *B. albicans*, the latter with a high support of 98.

The TCS analysis (Fig. 2) was applied to the *Brachythecium salebrosum*-clade only, allowing the delimitation of several groups:

1) *Brachythecium albicans* is fairly distinct from all other representatives of this clade: no less than 5 haplotypes are missing between this species and other specimens included in the analysis;

2) *Brachythecium rotaeanum* was found to be represented by a number of haplotypes, despite its rather clear morphological delimitation;

3) All other haplotypes were found in two main groups, differentiated by just one transition, G versus A, in the beginning of ITS2. About 3/4, 30 out of 42 specimens belong to two core haplotypes, and a number of specimens with singular mutational events were found associated with one of two core haplotypes, except for one specimen (J5).

These two main haplotypes will be called below as "*salebrosum*-" [with G in 497 position of alignment] and "*turgidum*-" [with A in 497 position of alignment] haplotypes, by the better known species. Specimens differing from those core haplotypes in one mutational event will be discussed also under the same haplotype names (cf. Fig. 2).

DISCUSSION

The position of *Brachythecium helminthocladum* and *B. conostomum* in the '*buchananii*-group' (Sect. Stereopoma McFarland, inedit) is in agreement with the previous ideas on their affinity (cf. Takaki, 1955; McFarland, 1988).

In the *B. salebrosum* group, the two main haplotypes, '*salebrosum*' and '*turgidum*', rather definitely correspond to several morphotypes, allowing their better segregation. The '*salebrosum*' haplotype includes all the studied plants of *B. salebrosum* (except for two specimens from Kamchatka that will be discussed below), *B. erythrorrhizon*, *B. coruscum,* and *B. brandegei*. There is only one exception of *B. jacuticum* (J4), a species mostly found to have '*turgidum*' haplotype. At the same time, the '*turgidum*' haplotype includes in addition to *B. turgidum* also plants identified as *B. udum*, a little known species, often considered as a variety of *B. mildeanum*, and a number of specimens, mostly from North Asia, representing three contrasting morphotypes that will be described below as new species: *B. jacuticum, B. dahuricum* and *B. irinae*. These morphotypes were segregated in the course of morphological study of collections, mainly from East Siberia and Kamchatka; they were previously identified in herbaria mostly as *B. salebrosum* (*B. jacuticum*), *B. glareosum* (*B. dahuricum*) and *B. mildeanum* (*B. irinae*). In addition '*turgidum*' haplotype includes also two plants of *B. salebrosum* from Kamchatka (see discussion for *B. salebrosum* '*kamchaticum*').

The description and discussion on new species are given below, together with other species known from Russia.

KEY FOR IDENTIFICATION OF *BRACHYTHECIUM* IN RUSSIA

The key is composed for specimens with sporophytes. Assuming that this is reducing its usefulness greatly, we however have no other choice, considering the great variation of species. For identification of sterile material the polytomic table-key is suggested (Table 1), as well as pairwise species comparison in comments to species. It is strongly recommended to consider geographical range of species, which allows to leave outside of consideration many superficially similar plants from faraway territories.

1. Seta rough 2
— Seta smooth 10
2. Alar cells enlarged and thin-walled, forming translucent group; mostly hygrophytes or mesophytes 3
— Alar cells not enlarged, more or less thick-walled, in a rather opaque group; mostly mesophytes or xerophytes, rarely hygrophytes .. 5
3. Leaves long-triangular, strongly longitudinally plicate, at base auriculate; dioicous; Far East ..... *B. frigidum*
— Leaves ovate to triangular, not or weakly plicate, at base not auricualte; autoicous or dioicous; widespread 4
4. Dioicous; alar cells abruptly differentiated in extensive alar group of pellucid cells which fill alar region and decurrency up to margin; hygrophyte ..... *B. rivulare*
— Autoicous; alar cells more or less differentiated in alar group which does not reach leaf margin; mesophyte ..... *B. rutabulum*

5(2). Leaves abruptly contracted to piliferous acumen, strongly concave 6
— Leaves acute to rather gradually acuminate, moderately concave (sometimes strongly concave in *B. complanatum*) 7

6. Plants usually pale-yellowish; shoots julaceous with leaves more or less appressed, leaves broadest at 1/2–1/3 of leaf length, broadly rounded and then very abruptly contracted to piliferous acumen; arctic-alpine ..... *B. cirrosum*
— Plants intense green; leaves erect to somewhat spreading, broadest at 1/3–1/6 of leaf length, rather gradulaly tapered and then fairly suddenly contracted to acumen; rare calciphilous moss in forest zone of European Russia ..... *B. tommasinii*

7. Leaves rigid, with strong longitudinal plication; plants intense green to yellowish or brownish green 8
— Leaves rather soft, weakly to moderately longitudinally plicate or crumplingly plicate in various directions; plants rather pale, often stramineous to whitish 9

8. Costa reaching 0.8-0.95 leaf length; plants irregularly pinnate; leaves straight, more of less appressed, slightly to moderately serrulate; Caucasus and South Urals .... *B. geheebii*
— Costa reaching 0.7-0.8 leaf length; plants regularly pinnate; leaves falcate-secund, strongly serrate; Far East ... *B. auriculatum*

9. Alar group more or less delimited, alar cells small and quadrate; autoicous; seta with low and small mamillae; calyptra smooth; widespread ..... *B. campestre*
— Alar cells weakly differentiated from neighboring cells, not forming apparent alar group; dioicous; calyptra with scattered hairs; seta with coarse large mamillae; South Siberia and Far East ..... *B. complanatum*

10(1). Leaves 1.1-1.8 mm wide, from broadly ovate basal part abruptly contracted to narrow acumen; alar cells quadrate, gradually transiting to laminal cells with a broad zone of rhombic cells; robust dark green plants; rare in southern Far East ..... *B. helminthocladum*
— Leaves 0.5-1.3 (-1.7) mm wide, from ovate or lanceolate basal part gradually or more or less abruptly contracted into acumen; alar cells usually not transiting to laminal cells with a broad zone of rhombic cells, or if they do, then leaf is smaller or not abruptly acuminate; widespread 11

11. Autoicous or rarely polyoicous; leaf margins from entire to distinctly and sharply serrulate 12
— Dioicous, leaf margins from entire to weakly serrulate (in *B. laetum* teeth can be rather distinct, but blunt) 23

12. Alar cells thin-walled and form rather pellucid alar group or cells more or less evenly enlarged across leaf base 13
— Alar cells moderately to strongly thick-walled and form opaque or 'not opaque, not pellucid' alar group 18

13. Leaf margins entire to weakly serrulate . 14
— Leaf margins serrulate to serrate 16

14. Leaves suddenly contracted to filiform acumen; Far East ..... *B. kuroishicum*
— Leaves gradually tapered to narrow, but not filiform acumen; widespread 15

15. Shoots usually procumbent, more or less pinnately branched; plants green; broad basal cells gradually transiting to thin-walled laminal cells; Kamchatka, Yakutia and South Siberia ..... *B. irinae*
— Shoots usually ascending to erect; plants yellowish to brownish green; broad basal leaf cells rather rapidly transiting to moderately thin-walled laminal cells; widespread .... *B. mildeanum*

16(13). Large cells even across leaf base; leaves erect, straight, rigid; plants strongly glossy, often with bronze tint; southern part of Russian Far East ..... *B. extremiorientale*
— Large cells mostly in alar region; leaves erect to patent or homomallous; plants moderately glossy, yellow-green; East Siberia and Far East, from Arctic to Primorsky Territory . 17

17. Leaves ovate to ovate-lanceolate, short acuminate; alar group rather compact; marginal teeth sharp but rather small; foliage rather dense ..... *B. boreale*
— Leaves ovate-lanceolate to lanceolate, acuminate; alar group in well developed leaves rather extensive; marginal teeth sharp and medium to large-sized for the genus; foliage often very loose ..... *B. baicalense*

18(12). Leaf margin entire or indistinctly serrulate throughout 19
— Leaf margin serrate, at least at places 20

19. Robust plants; intense yellowish to brownish green; leaves plicate; laminal cells distinctly thick-walled; basal cell strongly porose; alar cells usually in a small group, sometimes hidden due to recurved margin; arctic and alpine ..... *B. turgidum*
— Medium-sized plants, usually pale stramineous or whitish; leaves not or weakly plicate; laminal cells moderately thick-walled; basal cell porose; alar cells usually in a small group of 3-5 × 3-4 cells; NE Asia ..... *B. jacuticum*
– – Plants medium-sized to robust; yellowish to brownish green; leaves plicate; laminal cells moderately thin-walled; basal cell not or weakly porose; alar cells usually in a conspicuous group of 4-7 × 4-6 cells; Europe and western part of Asiatic Russia ..... *B. salebrosum* p.p.
20. Alar cells not clearly delimited from other basal cells; juxtacostal basal cells rather lax; leaves straight, subjulaceous; plants usually green; capsule curved and horizontal to often only slightly inclined and suberect ..... *B. rotaeanum*
— Alar cells forming more or less clearly delimited group; juxtacostal basal cells not markedly lax; leaves straight to homomallous and falcate-secund, subjulaceous to more spreading; plants yellow-green, more rarely dark green or whitish 21
21. Leaves 0.5-0.7 mm wide, with length to width ratio >4:1; acumen very long and in many leaves broken ..... *B. dahuricum*
— Leaves 0.6-1.2 mm wide, with length to width ratio <4:1; acumen moderately long, almost never broken 22
22. Leaves with short decurrencies usually not present in detached leaves; leaves usually not broadened above alar group; plication clearly longitudinal; plants yellow-green ..... *B. salebrosum* p.p.
— Leaves with larger decurrencies usually present in detached leaves; leaves more or less broadened above alar group; plication in longitudinal and oblique directions; plants green to somewhat whitish .... *B. campestre*

23(11). Leaves falcate (and usually secund) .. 24

— Leaves at best only slightly curved 25
24. Leaf basal part concave and symmetric, rather abrubtly contracted into long narrow acumen; foliage julaceous; plants pale stramineous, often somewhat whitish ..... *B. albicans* p.p.
— Leaf somewhat curved to falcate, asymmetric from basal part, rather gradually tapered into acumen; foliage not julaceous; plants purely green to yellowish green ..... *B. erythrorrhizon*
25. Plants small, rarely medium-sized; plants pale stramineous; leaves with ovate concave basal part more or less abruptly tapered into acumen; basal areolation lax thoughout in smaller leaves, while in larger ones alar group has quadrate, but not especially thick-walled cells; upper leaf areolation however quite dense and narrow. ..... *B. buchananii*
— Plants medium-sized to large; without so markedly differentiated areolation in proximal and distal leaf 26
26. Basal cells small across leaf base, forming opaque zone; rare xerophyte in the eastern part of Caucasus and south Urals ..... *B. laetum*
— Basal cells at least partly medium-sized to large, not forming opaque zone across leaf base; some species widespread 27
27. Leaves longly and broadly decurrent, long acuminate; plants whitish, never with intense green or golden color; temperate to boreal, occasionally arctic ..... *B. albicans* p.p.
— Leaves shortly decurrent, long to short acuminate; plants yellow to green, usually rich in color, rarely pale 28
29. Leaves with long acumen >1/3 of leaf length; calciphyte of southern and boreal regions of European Russia, Urals and Caucasus ..... *B. glareosum*
— Leaves with acumen 1/4 of leaf length; arctic, subarctic and rarely alpine species ... 30
30. Alar cells small, numerous, forming large alar group; leaves usually strongly plicate . ..... *B. coruscum*
— Alar cells moderately large, rather indisctinctly delimited from basal cells; leaves usually eplicate ..... *B. udum*

Table 1
Character/distribution of *Brachythecium* species in Russia: 0 – never, 1 – rare, 2 – often, 3 – almost always (or frequent), ? – unknown. [ ] – based on literature data only.

	rutabulum	*rivulare*	*frigidum*	*baicalense*	*auriculatum*	*cirrosum*	*tommasinii*	*campestre*	*complanatum*	*geheebii*	*buchananii*	*extremiorientale*	*glareosum*	*helminthocladum*	*kuroishicum*	*laetum*	*boreale*	*mildeanum*	*albicans*	*rotaeanum*	*turgidum*	*jacuticum*	*irinae*	*udum*	*coruscum*	*erythrorhizon*	*dahuricum*	*salebrosum*
Plants pale stramineous	1	1	1	2	0	2	0	2	2	1	2	0	2	0	1	2	1	1	2	0	0	2	0	1	1	1	2	2
Plants intense green	2	1	1	0	2	0	2	0	0	1	1	1	0	2	2	0	0	1	0	2	1	0	1	0	0	2	0	2
Stem rather regularly pinnate branching	2	2	2	2	3	0	1	2	1	0	2	2	1	1	1	2	1	1	2	1	0	3	3	1	1	3	1	2
Foliage julaceous	1	1	0	0	0	3	2	0	1	2	1	0	0	2	2	0	1	1	3	2	2	1	0	2	2	1	1	1
Leaves homomallous to falcate-secund	0	0	0	2	3	0	0	1	2	0	0	0	0	0	0	1	0	0	2	0	0	1	0	2	2	0	0	0
Stem leaves >3:1	0	0	0	2	0	0	0	1	0	0	1	2	2	0	3	0	0	1	1	1	1	2	0	0	0	0	3	1
Stem leaves >2.5 mm long	2	2	2	2	1	2	1	2	2	1	0	2	2	2	1	1	1	2	1	1	2	1	2	2	1	2	2	2
Stem leaves <0.6 mm wide	0	0	0	1	0	1	0	0	0	0	2	0	0	0	0	2	0	0	1	0	0	1	0	0	0	0	2	1
Leaves acute rather than acuminate	2	2	2	0	1	0	0	1	0	2	0	0	0	0	0	2	0	2	0	2	1	1	2	1	0	1	0	2
Leaves more or less abruptly acuminate	0	0	0	1	0	3	2	1	1	0	2	1	1	2	2	0	1	0	2	1	1	1	0	2	2	0	1	1
Leaves conspicuously decurrent	3	3	3	1	3	1	1	2	0	0	0	0	1	0	1	1	1	1	3	0	0	0	1	0	1	2	0	1
Leaves strongly plicate	1	1	2	0	3	1	1	2	2	3	1	1	1	1	1	3	1	1	1	2	2	1	0	1	3	3	1	2
Margin serrulate to serrate	3	2	3	3	3	2	0	3	3	1	1	3	1	1	1	2	2	1	1	3	1	1	2	1	1	1	3	3
Laminal cells <5:1	0	1	0	0	2	0	0	0	0	2	1	0	0	1	0	2	0	0	1	1	0	0	0	1	2	1	0	0
Laminal cells >10:1	3	3	2	3	1	2	2	3	3	1	2	3	3	2	2	1	3	3	2	2	3	3	3	3	1	2	3	2
Basal juxtacostal cells strongly porose	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	0	1	0	3	2	0	0	2	0	1	1
Basal cells even across leaf base	0	0	0	1	0	0	0	0	2	2	1	2	0	2	1	2	0	2	0	2	1	0	0	2	0	0	0	0
Alar cells numerous in poorly delimited group	0	1	0	1	1	0	1	2	1	3	1	0	2	3	2	2	0	1	2	2	1	0	1	1	3	3	0	1
Alar cells in a delimited group	3	3	2	2	3	2	2	3	1	2	2	1	3	2	2	2	2	1	3	2	3	3	2	1	3	3	3	3
Alar cells enlarged	3	3	3	3	1	1	3	0	1	0	1	2	1	0	3	0	3	2	1	1	0	0	2	2	1	2	0	1
Autoicous	3	0	0	3	0	0	0	3	0	0	0	3	0	[3]	3	0	3	2	1	3	2	3	3	0	0	0	3	3
Seta rough	3	3	3	0	3	3	3	2	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	?	?	0	0	0
Annulus poorly differentiated	0	0	0	0	0	0	0	0	0	0	2	2	2	?	2	2	0	0	0	0	0	0	0	0	0	0	0	0
Arctic and Yakutia	0	1	0	0	0	3	0	1	0	0	1	0	0	0	0	0	2	3	1	1	3	2	1	2	1	2	0	1
Europe (excl. Arctic, incl. Caucasus & Urals)	3	2	0	0	0	1	1	2	0	1	1	0	2	0	0	1	0	3	3	2	2	0	0	1	1	3	0	3
Siberia outside Arctic and Yakitia	1	2	0	1	0	2	0	2	1	0	2	0	0	0	0	1	2	3	2	3	2	2	2	1	1	3	2	3
Far East (excl. Arctic)	1	2	1	1	2	2	0	1	2	0	3	3	0	1	3	0	1	3	1	3	2	1	2	2	1	3	1	2

COMMENTS ON DIFFERENTIATION AND DISTRIBUTION OF SPECIES

This section provides an overview of diagnostic characters that are useful for the *Brachythecium* species identification in Russia. New species are described and illustrated, while the references to previously published descriptions are given for other species.

Brachythecium albicans (Hedw.) Bruch, Schimp. & Gümbel, Bryol. Eur. 6: 23. 1853. — *Hypnum albicans* Hedw., Sp. Musc. Frond. 251. 1801.

Descriptions and illustrations: Ignatov & Ignatova, 2004.

The species can often be recognized just by appearance that includes pale stramineous color of plants, clearly julaceous shoots, concave leaves with falcate-secund attenuate leaf apices. The julaceous foliage of *B. rotaeanum* and *B. campestre* have resulted in a number of misidentifications of them as *B. albicans*. However, they have serrulate leaf margins and autoicous sexual condition in contrast to entire-leaved and dioicous *B. albicans*.

Brachythecium erythrorrhizon is also dioicous and has a conspicuous large alar group, but leaves are falcate from the leaf base, making plants very different in appearance, totally lacking julaceous aspect; in addition, leaves in *B. erythrorrhizon* are commonly strongly plicate, whereas leaves of *B. albiacans* have usually only two submarginal plicae appearing in microscope slides.

In Arctic, *B. albicans* can be confused with *B. coruscum*, as both are dioicous, julaceous and having large alar groups expanded up along the leaf margin. However *B. coruscum* has shortly decurrent and strongly plicate leaves. The golden color of plants of the latter species never occurs in *B. albicans*, although occasionally *B. coruscum* may have whitish plants as well.

Distribution. *Brachythecium albicans* is common in European Russia and neighboring areas in Western Siberia, while further to the east it has an extensive disjunction to the Pacific region, where it occurs in Kamchatka, Chukotka and scattered localities are known in the eastern part of Yakutia.

Selected specimens: Kuril Islands: Paramushir, 4.VIII.1978 *Zavorotny & Cherdantseva* (VLA, MHA); Chukotka: Gilmimliveem Creek, 6.VII.1972 *Serretareva* (LE); Kamchatka: Khodutka 20.VII.2002 *Czernyadjeva* #5 (MHA); Yakutia. Oimyakon Distr., 11.VIII. 1960 *Dobretsova* 112/2 (SASY).

Brachythecium auriculatum A. Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1876—77: 340. 1878.

Descriptions and illustrations: Ignatov et al., 2006.

The species can be recognized in the field by regular pinnate branching, rigidly and uniformly falcate and deeply plicate leaves, and intense green to brownish green color. Under the microscope, relatively short laminal cells, regular margin serration, auriculate leaf base, and quite expanded alar group are conspicuous. Seta is strongly rough in this species.

East Asiatic plants of *B. salebrosum* '*kamchaticum*' (see below) have strongly plicate, falcate leaves, large alar group and often short laminal cells, but differs in not so rigid plants, variable pattern of plication and serration (versus constantly present), and autoicous sexual condition.

Distribution. *Brachythecium auriculatum* grows usually in forest on rotten logs, rocks, litter, tree bases, and inclined trunks. It is common in southern Kuril Islands, while in Sakhalin and mainland Russian Far East it is a rare species.

***Selected specimens*:** Primorsky Territory, Lazo Pass, 800 m, Ignatov 06-2499 (MHA); Sakhalin, Rogatka, 300 m, Ignatov 06-330 (MHA).

Brachythecium baicalense Ignatov, Arctoa 17: 119. 2008.

Description and illustrations: Ignatov et al., 2008.

This species is difficult to recognize in the field, because its habit is really protean: it has aspects of poorly developed *B. salebrosum* or *Sciuro-hypnum starkei* or sometimes *Bryhnia* spp., etc. Its important characters include smooth seta, autoicous sexuality, distinctly serrate leaf margin, and pellucid cells across leaf base (in narrow leaves) or in leaf corners (in larger leaves) or rectangular pellucid cells form decurrencies (in still better developed leaves). Most collections have quite poorly developed plants, recognizable by pellucid cells at base that are somewhat extended along leaf margin upward, sharp teeth along the whole leaf margin, and autoicous sexual condition.

Distribution. Being described from Irkutsk Province, SE Yakutia and Khabarovsk Territory, this species was found in additional localities in SW

Yakutia, and also in Primorsky Territory, so its range reaches ca. 2200 km in West–East direction.

Selected specimens: Primorsky Territory: Lazo Pass, 800 m, Ignatov et al., 06-3301 (MHA); Bulyga-Faddeevo 560 m, near road 21.IX.1976 Bardunov (MHA, VLA).

Brachythecium boreale Ignatov, Arctoa 17: 127. 2008.

Description and illustrations: Ignatov et al., 2008.

Triangular-ovate leaves shortly and rather abruptly rounded to the base, margin serrulate all around with not very large, but sharp teeth of the same size along most of leaf length, narrow cells throughout lamina, small group of enlarged and more or less pellucide alar cells, autoicous sexual condition, and smooth seta is a unique combination characteristic of *B. boreale.* Leaves are spreading in most of collections, which in combination with the pellucid alar cells and serrulate leaf margin had led to identification its of its collections as *Sciuro-hypnum curtum* before *B. boreale* was described. However, *B. boreale* has usually light-green to golden-yellow plants versus deep green in *S. curtum*, and leaves are more densely arranged in most cases, lacking any aspect of complanate foliage that is characterstic of *S. curtum*. Microscopically, the serration is especially distinct, as in *S. curtum* apical part is usually quite coarsely serrate, being stronger than in basal part of leaf, whereas in *B. boreale* teeth look conspicuously even. Fortunately, both species often produce sporophytes, and the smooth versus rough seta excludes a possibility of confusion.

On the other hand, plants from exposed habitats have more appressed leaves, and more abrupt acumen, approaching to *B. cirrosum* habit but differing from the latter in enlarged alar cells, autoicous sexual condition, etc. Also, before *B. boreale* description, some of its collections had been treated as *B. udum* (including specimen in analysis of Huttunen & Ignatov, 2004).

Distribution. Being recently described from Yakutia, Chukotka and SE Taimyr, this species was found later in herbarium collections westward to Yenisey River, southward to the Eastern Sayan Mts., SW from the Baikal Lake, and eastward to Alaska (Ignatov, 2011). The species grows in *Larix* forests (usually rather open), tundra, osier thickets along brooks, etc., among other mosses within moss carpet, as well as on rocks.

Selected specimens: Krasnoyarsk Territory: Jenisej, Nischnaja Tunguska, 65°50'N, 14.VII.1876 Arnell (S, as *B. salebrosum*); Buryatia, East Sayan Mts., Oka River, 52°32'N, 99°55'N, Afonina 6.VII.2008 (LE); Kamchatka, Czernyadjeva 12-8-2004 (LE).

Brachythecium buchananii (Hook.) A. Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1876—77: 341 (Gen. Sp. Musc. 2: 1159). 1878. — *Hypnum buchananii Hook.,* Trans. Linn. Soc. London 9: 320. 28 f. 3. 1808.

Description and illustrations: Ignatov & Koponen, 1996; Ignatov, 1998.

The species is dioicous, has slightly curved capsule (sometimes almost straight) with poorly developed annulus, so the operculum remains on the mature capsules for a long time (many collections in herbaria are operculate, unlike most of other *Brachythecium* species). Superficially sterile plants can in most cases be recognized by small size and pale stramineous color with rather strong luster, and a "variegate" aspect. The latter is formed as follow: leaves are strongly concave at base, so the leaf deviates from stem at quite a broad angle, but upwards it bents to erect; however as leaves are not very dense, the space between leaves is conspicuously darker than leaves itself, resulting in the mentioned variegateness.

Alar cells are small and quadrate in larger plants, while in smaller ones they are not conspicuously differentiated. In the areolation, the most common characteristics of this species are the lax cells in the basal part and quite dense narrow cells in the upper part close to acumen.

In smaller plants the conspicuous pattern is observed: costa at base is often overlayered by large and lax laminal cells on the adaxial side forming 'ventral hyalodermis'; this pattern obviously corresponds to quite a broad angle between stem and basal part of costa.

Being less developed, *B. buchananii* is one of the most confusing species. Basal cells are often small across the whole leaf base, so the problem appears to differentiate it from tiny epiphytic phenotype of *Sciuro-hypnum plumosum.*

Leaf margin is usually entire or subentire, but sometimes smaller plants have serrulate leaves and uniform, moderately broader cells throughout lamina.

Distribution. *Brachythecium buchananii* is one of the most common species of the genus in

the southern part of the Russian Far East (Primorsky Territory, south of Khabarovsk Territory, the Sakhalin, the South Kuril Islands), but occasionally occurs in South Siberia east of the Baikal. More scattered localities are known from Kamchatka, Central Yakutia, mountains of South Siberia west of the Baikal Lake and up to the Altai, and finally, an isolated population of the species was found by A. Bezgodov in the Middle Ural Mountains, the latter being the only place where the species is known in Europe. The earliest collection from Russia that we were able to check belongs to H.W. Arnell: Jenisei, Nikulina (Stolba) 60 20'N 1.7.1876 in S, as *B. salebrosum*). The most common habitats of this species are rocks, fallen logs, and tree bases.

Brachythecium campestre (Müll. Hal.) Bruch, Schimp. & Gümbel, Bryol. Eur. 6: 16. 1853. — *Hypnum rutabulum* var. *campestre* Müll. Hal, Syn. Musc. Frond. 2: 368. 1851.

Description and illustrations: Ignatov & Ignatova, 2004; Ignatov et al., 2008; Hedenäs, 1995.

Brachythecium campestre is often considered to be a 'difficult' species, the most difficulty being in its separation from *B. salebrosum.* Both species have similar plant size, leaf shape, serrulate to serrate leaf margin, small quadrate alar cells, autoicous sexual condition. However plants of *B. campestre* have (1) color usually light green to whitish vs. yellowish to brownish green in *B. salebrosum*; (2) leaves are more broad at base resulting sometimes in more or less conspicuous decurrencies vs. with short decurrencies; (3) alar group is somewhat elongate vs. square; (4) seta of *B. campestre* is minutely rough in most collections, although in some collections it is smooth vs. always perfectly smooth.

The whitish plant color, somewhat julaceous foliage, slender and flexuose-piliferous acumina, and elongate group of alar cells resulted in a number of misidentifications in herbaria as *B. albicans*, but the latter species differs in entire to subentire leaf margin and is dioicous.

Distribution. The species is more common in areas where calcareous bedrocks are widespread, ranging from Arctic to southern Russia in the Caucasus and the Baikal area in Siberia, although sometimes it grows in volcanic areas with strongly prevailing acidic substrates, e.g. in the southern Kuril Islands or in the central part of West Siberia.

***Selected specimens*:** Nenetz Autonomous Distr., Bolshezemelskaya Tundra, Gorodkov (LE); Murmansk Prov., Khibiny, 67°39'N, 33°43'E, 31.VIII.1949 Schljakov (KPABG); Ingush Republic, Tersky Range, 600 m, 29.IV.2004 Bersanova (MHA); Tomsk Prov., Bokchary Distr., 24.VII.1966 Kosacheva (IRK, MHA); Kuril Ils., Kunashir, Ignatov 06-1560 (MHA).

Brachythecium cirrosum (Schwägr.) Schimp., Syn. Musc. Frond. 696. 1860. — *Hypnum cirrosum* Schwägr. in Schult., Reise Glockner 365. 1804. — *Cirriphyllum cirrosum* (Schwägr.) Grout, Bull. Torrey Bot. Club 25: 223. 1898.

Description and illustrations: Ignatov, 1998; Ignatov & Ignatova, 2004.

It is usually an unmistakable moss due to soft irregularly branched plants, stramineous color, and strongly 'cirrose' leaves with conspicuously spreading filiform acumina. The difficulties are provided usually by smaller plants that are difficult to refer to this species, because usually it is 'so invariable'. These small-sized plants are rare, usually occurring as an admixture to other mosses, but occasionally form a considerable mats, especially on dry and shady cliff faces.

In high Arctic, *B. cirrosum* is confused sometimes with *B. turgidum*, their differences are discussed under the latter species.

Distribution. The species occurs in Arctic and in mountains both in alpine belt as well as at middle elevations. It grows usually on rocks, especially calcareous, in mesic to wet places, often near waterfalls, etc. East of the Yenisey River, where rocky substrates are relatively common, *B. cirrosum* occurs almost throughout the territory, while it is absent in most parts of European Russia between Karelia and Arkhangelsk Province in the North and the Caucasusin the South. Similarly, in West Siberia it was never found between the Arctic and the Altai Mountains.

Brachythecium complanatum Broth., Rev. Bryol., n. s. 2: 11. 1929.

Description and illustrations: Ignatov, 1998, Ignatov et al., 2006.

The species can be recognized in the field by robust shiny plants. Leaves are strongly plicate, but plicae are in various directions, not all longitudinal as in many *Brachythecium* species. When optimal-

ly developed the species have rather tumid foliage and lacks any complanate aspect, while in weakly developed plants (when growing on litter in shady forest, etc.) branches are complanate and plants look like *Gollania* species. Leaves are conspicuously narrowed to the base, cells across the base are even, only slightly smaller in poorly delimited alars. The species is dioicous, rarely producing sporophytes, but when present, calyptrae are sparsely hairy, which is a rare character, unique in Russian species of the genus.

Molecular data indicate the close relationship of *B. complanatum* to *B. campestre* that however differs in (1) autoicous sexual condition; (2) slightly rough to smooth seta vs. strongly rough; (3) clearly differentiated alar cells vs. undifferentiated.

Distribution. This species is known in mountain areas of South Siberia (Altai, Sayans, Kuznetsky Alatau), Transbaikalia, and the Amur River area, while it does not spread to the southern part of Primorsky Territory (southernmost locality in Terney Distr.), and also it is unknown in the Sakhalin and the Kuril Islands, although there is one collection of this species in Japan (Ignatov et al., 2006) and in NE China (see sequenced specimen). The species grows usually at lower elevation in valleys, on litter, rotten logs and on rocks.

Selected specimens: Primorsky Territory, Sikhote-Alin Reserve, 24.VI.1983 Cherdantseva (VLA, MHA).

Brachythecium coruscum I. Hagen, Kongel Norske Vidensk. Selsk. Skr. (Trondheim) 1908 (3): 3. 1908.

Discussion and illustrations: Kosovich-Anderson & Ignatov, 2010.

The species is characterized by: (1) rather extensive group of quadrate cells in leaf corners that expands up along leaf margin; (2) incrassate and porose basal juxtacostal cells; (3) strongly plicate leaves; (4) relatively short laminal cells in lower part of leaf. Plants usually form rather dense tufts where stems are rarely branched; however, in loose growth plants are fairly pinnate.

B. coruscum was never found with sporophytes, and even gametangia (female) were observed not in all collections. However the presumable dioicous sexual condition is still a useful character, because in *B. turgidum*, a species that can most likely be confused with *B. coruscum*, both perichaetia and perigonia can be found (although collections of plants without any gametangia were seen as well). *Brachythecium coruscum* is smaller than *B. turgidum*, and numerous alar cells are different from those of *B. turgidum*, where they are usually few. In few cases there is a problem of separation *B. coruscum* from *B. udum*, as both have rather short laminal cells and are dioicous. However, the larger alar cells and the weak to absent leaf plication differentiate the latter species. The comparison with *B. albicans* is given under that species. *Brachythecium jacuticum*, a common species in Chukotka, may have a certain superficial resemblance, but it is autoicous, has usually eplicate leaves with constantly few alar cells.

Distribution. The species is considered to be an Arctic element, but in addition, it seems to be confined in distribution to oceanic regions. It was described from Scandinavia, occurs in neighboring area of NW Russia (Khibiny Mountains in the Kola Peninsula), and in Chukotka. A number of records from other areas of Siberian Arctic need to be confirmed. In addition to the Arctic, *B. coruscum* was found recently in the Sakhalin, in a much more southern locality, in a "tundra-like" community at summit of the Vaida Mts.

Selected specimens: **Chukotka**: Pitlekai, Kjellman 15.VI.1879 (S, as *B.salebrosum*); Yanrakynnot, 15.VII.1986 Sekretareva (LE) [male plants]; Pekulney Range, 29.VII.1979 Afonina (MHA) [female plants]; Vrangel Island 21.VII. 1985 Afonina (MHA). **Sakhalin**, Ignatov & Teleganova 06-240 (MHA); Murmansk Prov., Khibiny, Schljakov 31.VIII.1949 (KPABG, LE, MHA).

Brachythecium dahuricum Ignatov sp. nova Fig. 3

Species nostra foliis serrulatis, cellulis quadratis et plantis monoicis Brachytheciis salebrosis similis sed apice valde longiore et ITS sequentia differt.

Type: "Transbaikalia, Alhanai National Park, protected zone, 50°55'N, 113°13'E, ca. 1100 m, upper forest belt, on boulder, 7.7.2006, O.M. Afonina #1006 (holotype in LE, isotype in MHA).

Plants medium-sized, in moderately loose to dense tufts, yellow-green to brownish or almost whitish. Stems to 5 cm, prostrate to upright in dense growth, terete foliate, irregularly to sparsely pinnate branching; branches to 5 mm, straight and usually erect, terete foliate. Stem leaves densely arranged, erect, 2.6-3.3×0.5-0.7 mm, lan-

ceolate (broadest at 1/7–1/10 of leaf length), gradually long acuminate, below the broadest point of leaf slightly narrowed, narrowly and shortly decurrent, decurrencies rarely come out with detached leaves, slightly concave, not to rather slightly plicate; margins plane to slightly recurved in places, serrulate to strongly so in acumen; costa slender, reaching 0.4-0.6 leaf length, ending in indistinct small tooth or smooth; laminal cells 60-100×6-8 μm, rather thick-walled, basal cells near costa slightly broader in 3-6 rows, to 15 μm wide, more or less thick-walled, alar cells forming a small well-delimited square group, short-rectangular, quadrate or occasionally transverse-rectangular, 12-30×12-15 μm. Branch leaves somewhat smaller, but otherwise similar. Sexual condition autoicous. Seta 15-20 mm, smooth. Capsule inclined to horizontal and curved, ca. 20 mm long, operculum conic.

Only young sporophytes were observed, not allowing spore size measurement.

Differentiation. The standard set of formal characters for this species indicates *B. salebrosum*, as the plants are autoicous, leaves have small quadrate alar group of square cells, and serrulate to serrate leaf margins. The appearance of plants, however, is quite different and more similar to small and very dense *B. glareosum* or narrow-leaved and relatively large *B. buchananii,* due to very long acuminate leaves. The distinction from *B. salebrosum* is confirmed also by molecular data: all three sequenced collections of *B. dahuricum* belong to '*turgidum*' haplotype, not '*salebrosum*' one. At the same time, all other plants of '*turgidum*' haplotype have entire leaves, the exception being only *salebrosum 'kamchaticum'* plants, but they differ from *B. dahuricum* in more robust plants, strongly plicate and falcate-secund leaves, usually short laminal cells, expanded alar group, etc. (cf. Figs. 3 & 11).

Distribution. *Brachythecium dahuricum* is locally common in xeric areas near and East of Baikal Lake, called in historical literature as Dahuria (Dauria). The Dahurian flora is abruptly delimited from the mesic Manchurian (Mandshurian) one, where East Asiatic temperate species prevail. The eastern limit of *B. dahuricum* remains unclear for us, but it seems the species is absent or rare in the Manchurian area. Collections were made between 648 to 1412 m alt.

Selected specimens: **Zabaikalsky Territory,** Taptanay, Afonina 4406 (LE, MHA); Onon River, Afonina 6405, (LE, MHA); **Buryatiya**, Dzerginsky Reserve, 8.VII.1999 Tubanova 26(III) (UUH, MHA); 5.VII.2000 Tubanova 73(III), 7(II) (UUH, MHA); East Sayan, Afonina 0108 (LE, MHA).

Brachythecium erythrorrhizon Bruch, Schimp. & Gümbel, Bryol. Eur. 6: 18. *547.* 1853.

Description and illustrations: Ignatov, 1998; Ignatov & Ignatova, 2004.

Molecular analysis revealed no difference between *B. salebrosum* and *B. erythrorrhizon*, and these species are similar in medium to robust plants, usually intense green, plicate and often more or less falcate leaves and square alar cells. However in *B. erythrorrhizon* (1) sexual condition is dioicous vs. autoicous; (2) leaves are conspicuously decurrent vs. only slightly so in *B. salebrosum)*; 3) alar group is large and poorly delimited vs. usually conspicuously well-delimited, small and square; 4) leaf margins are entire to slightly serrulate vs. serrate to serrulate; 5) leaves are usually curved from the base that is apparent in detached leaves vs. homomallous, usually appearing symmetric in microscope slides.

Siberian plants referred to this species are usually larger than European, so Ignatov (1998) described them as a separate subspecies, subsp. *asiaticum*. Subsequent observation revealed too broad variation in plant size in Eurasia and North America, making very difficult to segregate this subspecies.

Distribution. The species is rather common throughout the forest zone of Asiatic Russia and boreal zone of European Russia. In Siberia it is especially characteristic of herbaceous communities, both subalpine and in flood plains, where it was found growing in a very wide range of habitats, including rocks and tree trunks (especially those of *Populus*).

Brachythecium extremiorientale Ignatov, Arctoa 17: 123. 2008.

Description and illustrations: Ignatov et al., 2008.

This species has rather robust plants of rich brownish- to bronze-green color, autoicous sexual condition and common sporophyte occurrence. Microscopically, the species is peculiar in having sharp teeth along leaf margin, especially

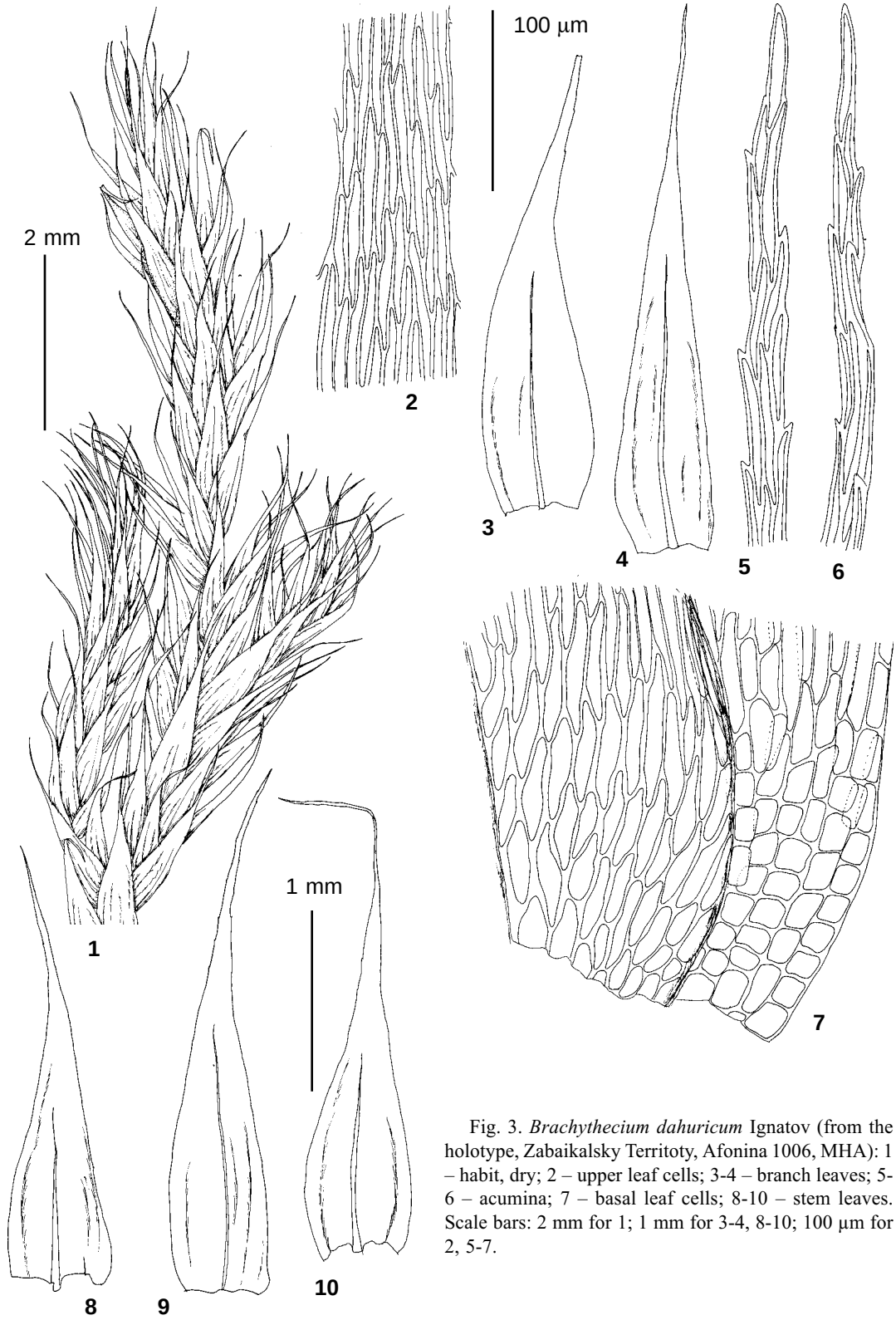


Fig. 3. *Brachythecium dahuricum* Ignatov (from the holotype, Zabaikalsky Territoty, Afonina 1006, MHA): 1 – habit, dry; 2 – upper leaf cells; 3-4 – branch leaves; 5-6 – acumina; 7 – basal leaf cells; 8-10 – stem leaves. Scale bars: 2 mm for 1; 1 mm for 3-4, 8-10; 100 µm for 2, 5-7.

in the apical part of leaf, and in rather large and broad basal cells that somewhat decrease in size towards leaf corners. These characters differentiate it from *B. buchananii* that is small to medium-sized, usually pale stramineous, dioicous, and its leaves are entire, or rarely in smaller plants serrulate. Differentiation from *B. kuroishicum* is given under that species.

Distribution. Since a recent description (Ignatov et al., 2008), *B. extremiorientale* was found in other places in Primorsky Territory, and the range was found to include the Sakhalin and the Kuril Islands.

Selected specimens: Sakhalin, Pisarenko op03606 (MHA); Kuril Islands, Kunashir, Ignatov 06-3189 (MHA).

Brachythecium frigidum (Müll. Hal.) Besch., Mém. Soc. Sci. Nat. Cherbourg 16: 248. 1872. – *Hypnum frigidum* Müll. Hal., Bot. Zeitung. Berlin 14: 456. 1856.

Bakalin & Cherdantseva (2008) reported this species for Russia and their publication with its description and illustration is in progress.

Brachythecium frigidum has robust plants, rigid, triangular and plicate leaves, evenly serrulate to serrate leaf margins, somewhat auriculate base formed by the convex group of enlarged pellucid alar cells, dioicous sexual condition, and a rough seta.

Distribution. The species is widespread in western North America, while the only reliable record in Russia is the plant collected by Bakalin on the Commander Islands (Bakalin, K-50-1-04, VLA, MHA). Specimen reported by Bakalin et al. (2009) from the south Kuril Islands was subsequently studied for ITS, and found to be closer to *B. rivulare* (this case will be discussed elsewhere).

Brachythecium geheebii Milde, Hedwigia 8: 161. 1869, '*gehebii*'.

Description and illustrations: Ignatov & Ignatova, 2004.

The species has strongly appressed leaves in dry state similar to *Homalothecium* spp. The differences from other *Brachythecium* include costa often reaching 0.8-0.95 leaf length, strongly plicate leaves, short laminal cells and thick-walled basal cells. The three latter characters are shared with *B. laetum*, also a dioicous xerophytic species that has a similar distribution in Russia, the Caucasus and the South Urals (Bashkortostan), but differs in a shorter costa, to 0.5-0.75 leaf length. In addition, stems are usually rather regularly pinnate in *B. laetum*, while *B. geheebii* has irregular 'fasciculate' branching.

Distribution. The distribution of *B. geheebi* in Russia is confined to xeric regions and the Caucasus and the South Urals (Bashkortostan). It grows mostly on dry rocks.

Selected specimens: Bashkortostan, Kulgunino, 550 m, 53°35'N, 56°48'E, Ignatova 15/68 (MHA); Karachaevo-Cherkessia, Teberda Reserve, 2100 m, 43°22'N, 41°45'E, Ignatov & Ignatova 05-3953 (MHA).

Brachythecium glareosum (Bruch ex Spruce) Bruch, Schimp. & Gümbel, Bryol. Eur. 6: 23. 1853. — *Hypnum glareosum* Bruch ex Spruce, Musci Pyren. 29. 1847.

Description and illustrations: Ignatov & Ignatova, 2004.

The species is characterized by long piliferous leaves, and the identification keys put it often near *B. albicans*. However these species are not very similar habitually, because the foliage in the latter species is julaceous due to strongly concave leaf bases adjoining above leaves. Leaf base in *B. glareosum* is also concave, but in contrast to *B. albicans,* it is usually rigid, plicate and standing more or less separately from the neighboring leaves.

Although the characters differentiating *B. glareosum* from *B. salebrosum* and *B. campestre* are numerous, and include leaf margin serration (entire to subentire versus distinctly serrulate), alar group (large and indistinctly delimited versus small and rather well delimited), and sexual condition (dioicous versus autoicous), there are specimens which are difficult to interpret. An example could be one specimen from Belgorod, S7, that is autoicous, have entire leaf margins, alar cells of *glareosum*-type and a very long acumen. Such cases require additional studies.

According to ITS analysis, *B. glareosum* belong not to '*salebrosum*', but to '*buchananii*' clade.

Distribution. In Russia *Brachythecium glareosum* is confined to the European part, occurring mainly in areas with numerous limestone outcrops, in both rather dry areas in the Eastern Caucasus and in a quite humid areas, e.g., Pskov Prov-

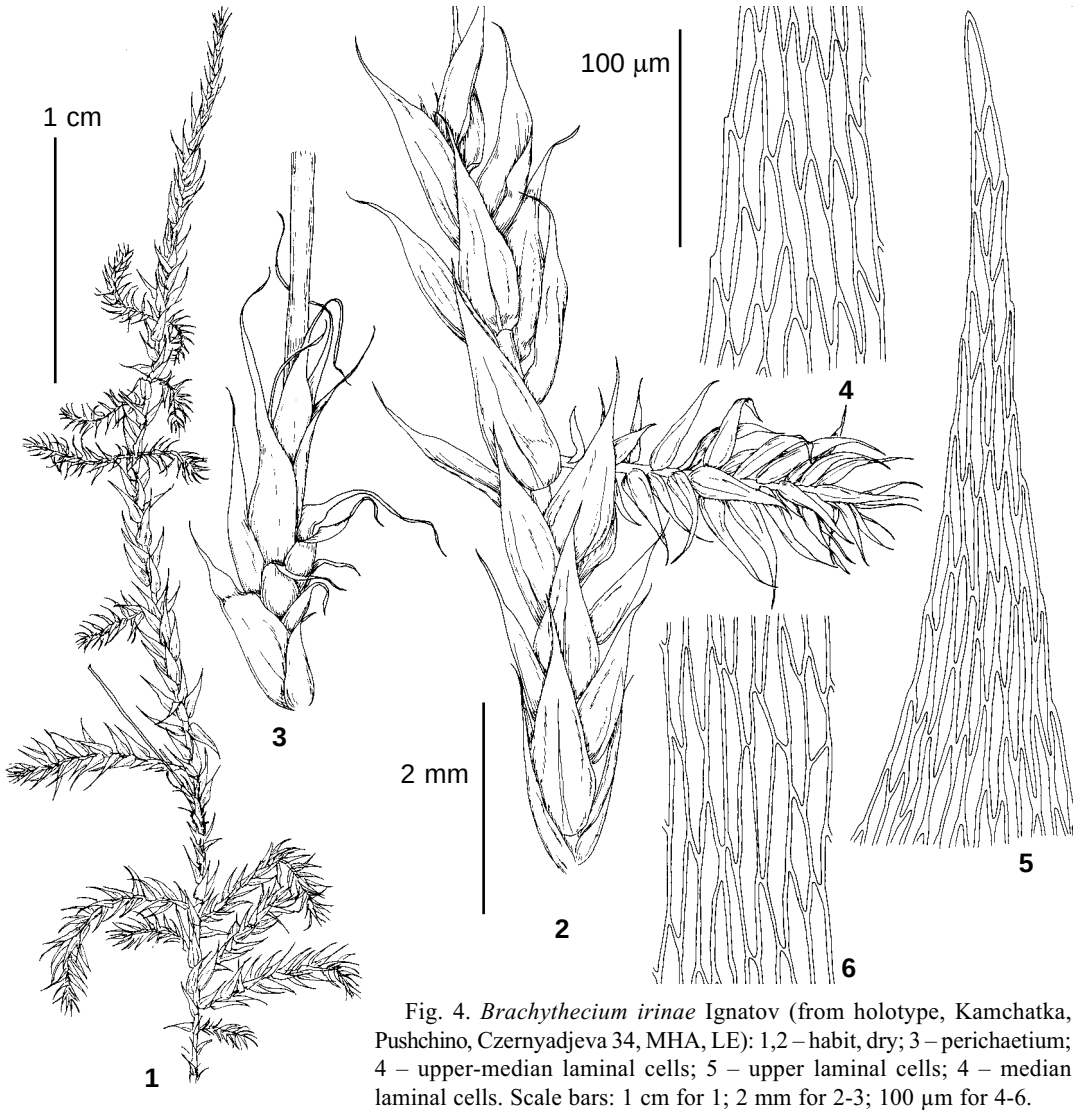


Fig. 4. *Brachythecium irinae* Ignatov (from holotype, Kamchatka, Pushchino, Czernyadjeva 34, MHA, LE): 1,2 – habit, dry; 3 – perichaetium; 4 – upper-median laminal cells; 5 – upper laminal cells; 4 – median laminal cells. Scale bars: 1 cm for 1; 2 mm for 2-3; 100 μm for 4-6.

ince. All the records from Asiatic Russia which we were able to check belong to other species.

Brachythecium helminthcladum Broth. & Paris, Rev. Bryol. 31: 63. 1904. — *B. kuroishicum* var. *helminthcladum* (Broth. & Paris) Card. in Dix., Rev. Bryol. Lichenol, 4: 156. 1932.

Fig. 8, also cf. http://www.tropicos.org/Image/100010358

Plants robust, in loose intricate mats, intense green with silvery shine. Stems to 8 cm, prostrate, terete foliate, irregularly and occasionally regularly pinnate branching; branches to 10 mm, straight to flexuose, terete foliate. Stem leaves imbricate, 2.6-3.2×1.1-1.7 mm, ovate, broadest at about 1/7 of leaf length, abruptly acuminate, below the broadest point of leaf rounded to leaf insertion, broadly and rather shortly decurrent, concave, not to slightly plicate; margins plane or recurved in some areas, not to slightly serrulate all around; costa slender, reaching 0.4-0.6 leaf length, ending in a small spine or smooth; laminal cells 50-80×8-12 μm; basal cells near costa broader and shorter, alar cells forming an indistinctly delimited expanded conspicuous group, quadrate to short rectangular, 15-25 μm, gradually transiting to laminal cells via numerous rhombic cells. Branch leaves somewhat

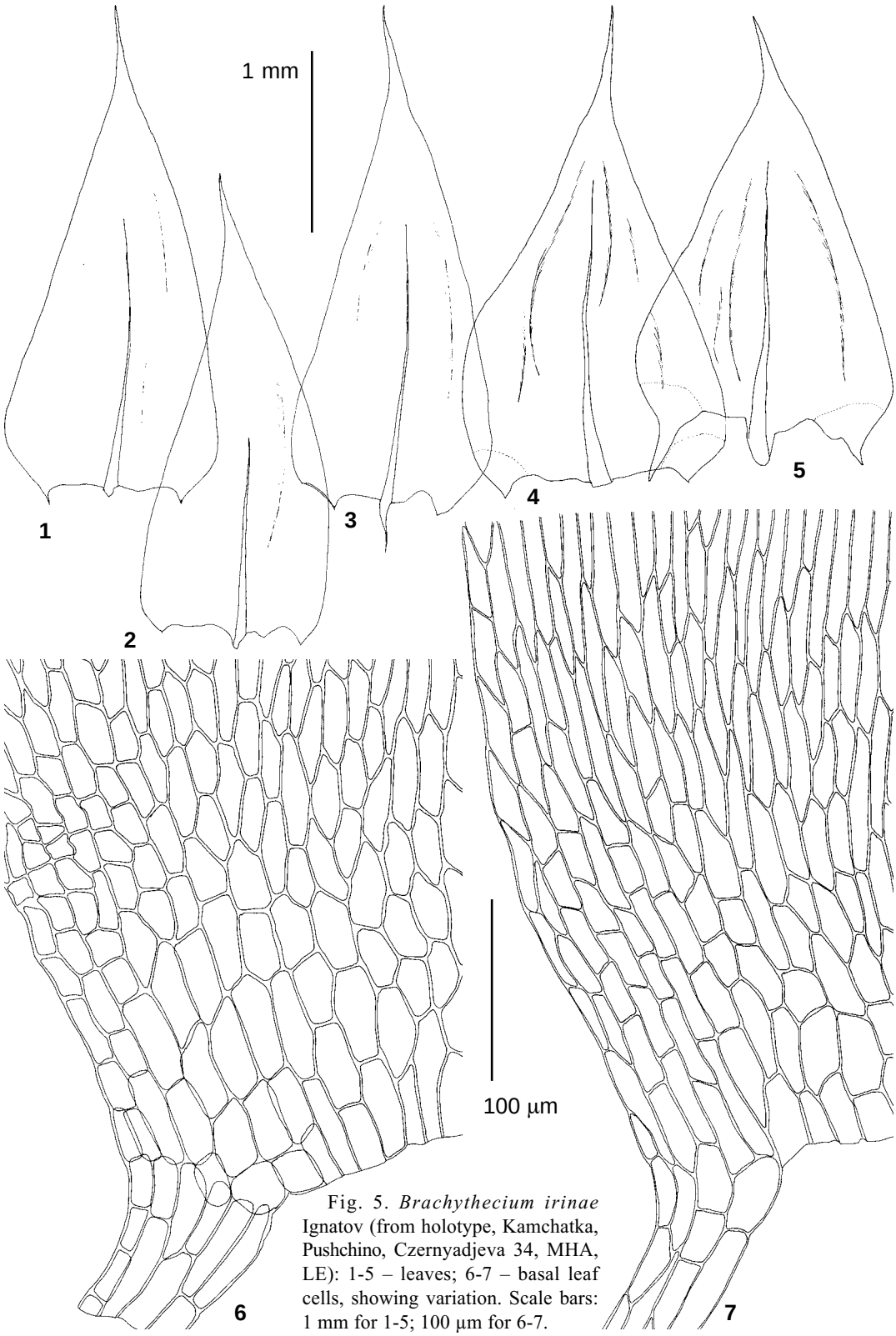


Fig. 5. *Brachythecium irinae* Ignatov (from holotype, Kamchatka, Pushchino, Czernyadjeva 34, MHA, LE): 1-5 – leaves; 6-7 – basal leaf cells, showing variation. Scale bars: 1 mm for 1-5; 100 μm for 6-7.

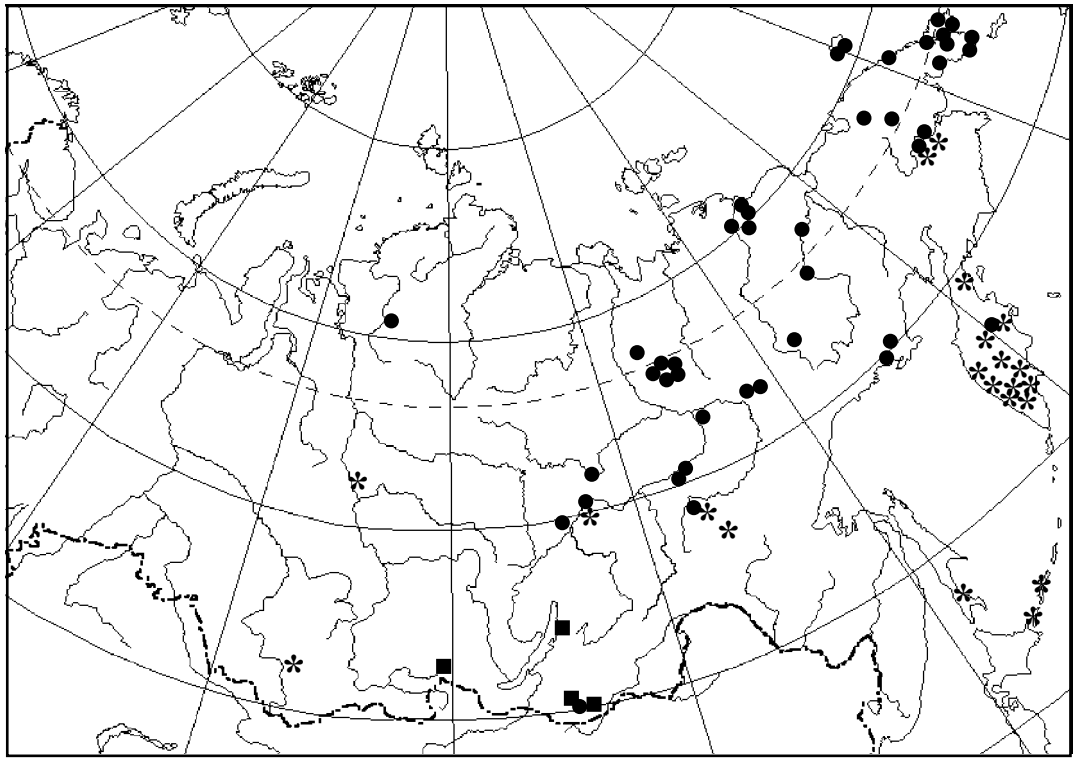


Fig. 6. Distribution of *Brachythecium jacuticum* (circles), *B. dahuricum* (squares) and *B. irinae (asterisks)* in Russia.

smaller, but otherwise similar. Gametangia and sporophytes not found in Russia.

The species belongs to the '*buchananii'* clade (Fig. 1), and usually considered to be closely related to *B. kuroishicum*, sometimes included in the latter as a variety. However, despite some habitual similarity, *B. helminthocladum* is distinct in leaf areolation: the 'alar area' in lower part of leaf is fairly extensive and is composed of relatively small cells; being rather thin-walled, these cells are forming conspicuous 'not especially opaque, not especially pellucide' area, very different from pellucide alars in *B. kuroishicum* (cf. Figs. 8-9). Also, plants of *B. helminthocladum* are usually larger than those of *B. kuroishicum*.

Distribution. Previously *B. helminthocladum* was known in Japan and China. In Russia it was collected in a valley pine-hardwood forest in the Sikhote-Alin Mountains, rich in rare East Asiatic bryophyte species.

***Selected specimens*:** Primorsky Territory, Artemovka Creek, Ignatov 08-233 (MHA); Elomovsky Creek, 4.IX.2010 Orgaz Alvarez (MHA).

Brachythecium irinae Ignatov sp. nova Fig. 4-5

Species haec foliis subintegris et cellulis basalibus dilatatis Brachythecio mildeano et B. udo propinqua sed prior species a nostrum cellulis alaribus distictis et ITS sequentia, altera inflorescentiis monoicis et ambo species caulibus prostratis, laxifoliis regulariter pinnatisque differt.

Type: Kamchatka, near Pushchino, Kamchatka River Valley, flood valley forest, on rotten log, 54°11' N, 158°00'E 300 m alt., 1.VIII.2004 coll. I.V. Czernyadjeva #34 (Holotype in LE, isotype in MHA).

Ethymology: The species epithet is in honour of Irina V. Czernyadjeva, who made a great contribution to the knowledge of mosses of Kamchatka.

Plants medium-sized to robust, in loose soft mats, usually green or occasionally yellowish green. Stems to 6 cm, prostrate, rarely ascending, terete foliate, rather regularly although sparsely pinnate branching; branches to 5 mm, straight to slightly curved or flexuose, terete foliate. Stem leaves moderately loosely arranged, erect, (2.0-) 2.3-2.7×(0.8-)1.1-1.5 mm, ovate-lanceolate to ovate (broadest at 1/7-1/10 of leaf length), gradually acute or short acuminate, weakly narrowed to

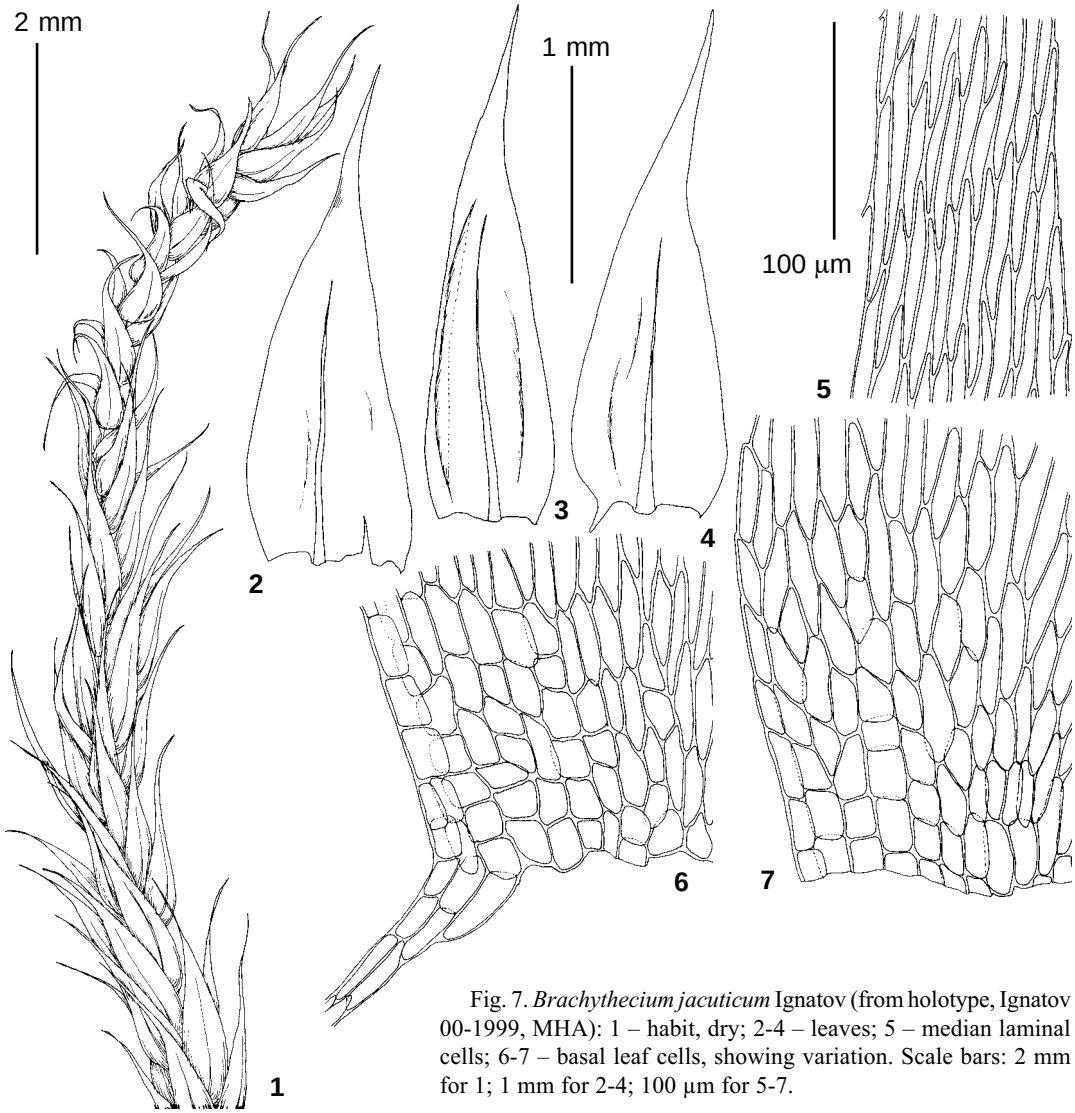


Fig. 7. *Brachythecium jacuticum* Ignatov (from holotype, Ignatov 00-1999, MHA): 1 – habit, dry; 2-4 – leaves; 5 – median laminal cells; 6-7 – basal leaf cells, showing variation. Scale bars: 2 mm for 1; 1 mm for 2-4; 100 μm for 5-7.

leaf insertion, narrowly and shortly decurrent, decurrencies occasionally coming out with detached leaves, slightly concave, not or weakly plicate; margins plane, recurved only near leaf base, entire or indistinctly serrulate in places; costa slender, reaching ca. 0.6 leaf length, ending in indistinct small tooth or smooth; laminal cells 70-140×7-11 μm, thin-walled, basal cells near costa broader, to 20(-25) μm, very gradually transiting to median laminal cells, which often makes the lower leaf areolation looking lax; alar cells occasionally abruptly enlarged, but more commonly indistinctly grading to other basal cells. Branch leaves smaller, but otherwise similar. Sexual condition autoicous. Seta 15-20 mm, smooth. Capsule inclined to horizontal and curved, ca. 20 mm long, operculum conic, annulus separated at places. Spores ca. 15 μm (from somewhat premature capsule).

Differentiation. The entire leaf margin and conspicuously even areolation across leaf base in this species immediately implied *B. mildeanum*, as specimens of *B. irinae* were mostly identified earlier. There morpholoical differences between these species exist, but not always apparent. The well-developed plants of *B. mildeanum* have yellow-green to yellow color and usually ascending growth, terete foliage and irregular branching, whereas *B. irinae* has usually purely green color,

prostrate growth, more or less complanate foliage, and rather regular pinnate branching. Areolation also looks slightly different: it is 'too homogeneous' in *B. irinae*, as it is lax throughout leaf base and extending upward, gradually changing or almost not changing to mid leaf; contrary to that, the lax areolation at base in *B. mildeanum* transits rather rapidly to more or less dense areolation of the most part of leaf.

There is a somewhat different variation pattern of alar cells between these species: in *B. mildeanum* they are variable, ranging from somewhat larger to somewhat smaller than neighboring ones; while in *B. irinae* the alar cells are almost undifferentiated, but within triangular decurrencies cells are sometimes enlarged. Underdeveloped plants of *B. mildeanum* would be very difficult (if possible) to separate from *B. irinae*, at least at the moment we cannot suggest reliable characters. However, *B. irinae* deserves separation as an independent species, because molecular data indicate its affinity to '*turgidum*' haplotype within '*salebrosum*' clade that is rather strongly differentiated from *B. mildeanum* (Fig. 1).

Haplotype network (Fig. 2) indicates that most specimens of *B. irinae* have ITS identical with *B. dahuricum, B. salebrosum 'kamchaticum', B. jacuticum, B. turgidum,* and *B. udum*. Two former species differ from *B. irinae* in serrulate leaf margin, *B. jacuticum* has narrow leaves, small quadrate alar cells and thick-walled laminal cells; *B. turgidum* is a robust plant with strongly plicate leaves and strongly incrassate basal cell walls, and *B. udum* is different in dioicous sexual condition, ascending growth, irregular branching, and more concave leaves.

Distribution. *B. irinae* is widespread in Kamchatka, and there is a number of specimens from other regions of Siberia, Yakutia and the Altai, similar to it by morphology and ITS; similar old herbarium specimens from the valley of the Yenisey River were also seen (cf. Fig. 6).

***Selected specimens*:** Kamchatka, meddan Petropavlovsk och Avatcha volkanum 250 m 21.VIII.1920 [*Hulten*] (S, as *B. salebrosum*); Chukotka, Anadyr River, 7.VIII. 1978 Afonina (MHA); SW Yakutia, Olekma Distr., 31.VII.1910 Sukachev & Poplavskaya (LE); Krasnoyarsk Territory, Mirnoe, Rodenkov & Telesnina 2543-3 (MHA); Altai, Kayra River, Ignatov *15/112* (MHA).

Brachythecium jacuticum Ignatov, sp. nova
Fig. 7

A B. salebrosi foliis eplicatis, margine integris, planta albicantis differt.

Type: Republic Saha/Yakutia, Ust-Maya District, Yugorenok Creek, 59°45' N – 137°37' E, ca. 300 m alt., bank on Yudoma River, 6.IX.2000 M. Ignatov 00-1999 (holotype in MHA, isotypes in MW, LE, H, S, SASY).

Plants slender to medium-sized, in loose to moderately dense mats, light, yellowish or whitish green. Stems to 5 cm, prostrate, terete foliate, irregularly or, often, sparsely pinnately branched; branches to 5 mm, straight to slightly curved, terete foliate. Stem leaves moderately loosely arranged, erect, 2.0-2.4×0.6-0.9 mm, ovate-lanceolate or lanceolate, broadest at ca. 1/7 leaf length, gradually acuminate, indistinctly (in narrow leaves) to distinctly (in broader leaves) rounded to leaf insertion, narrowly short-decurrent, slightly concave, not or weakly plicate; margins plane or recurved near leaf base, entire; costa slender, reaching ca. 0.6 the leaf length, terminal tooth indistinct or absent; laminal cells linear, 70-125×5-9 μm, rather thick-walled; basal cells ovate-rectangular, in 1-3 rows, thick-walled and somewhat porose, forming distinctly or indistinctly delimited belt across leaf base; alar cells forming more or less distinctly delimited group of 4-5×3-5 cells, subquadrate to short rectangular, 13-30×12-16 μm, thick-walled. Branch leaves somewhat smaller, otherwise similar. Sexual condition autoicous. Seta red-brown, 15-20 mm, smooth. Capsule red-brown, inclined to horizontal and curved, ca. 2 mm long, operculum conic, annulus separating by fragments. Spores 12-16 μm.

Differentiation. *Brachythecium jacuticum* is described here to accommodate numerous collections of an "entire-leaved *B. salebrosum*" from the coldest regions of continental northern Asia. The species is characterized by rather slender plants, usually with a pale whitish, '*B. albicans*' color, in the Arctic sometimes bright yellow or in shady places light green, but never intense green; lanceolate leaves with entire margins; narrow laminal cells, reaching almost to the leaf base; thick-walled and porose basal cells, and a small group of quadrate alar cells. Perigonia and perichaetia are usually expressed in the severe condi-

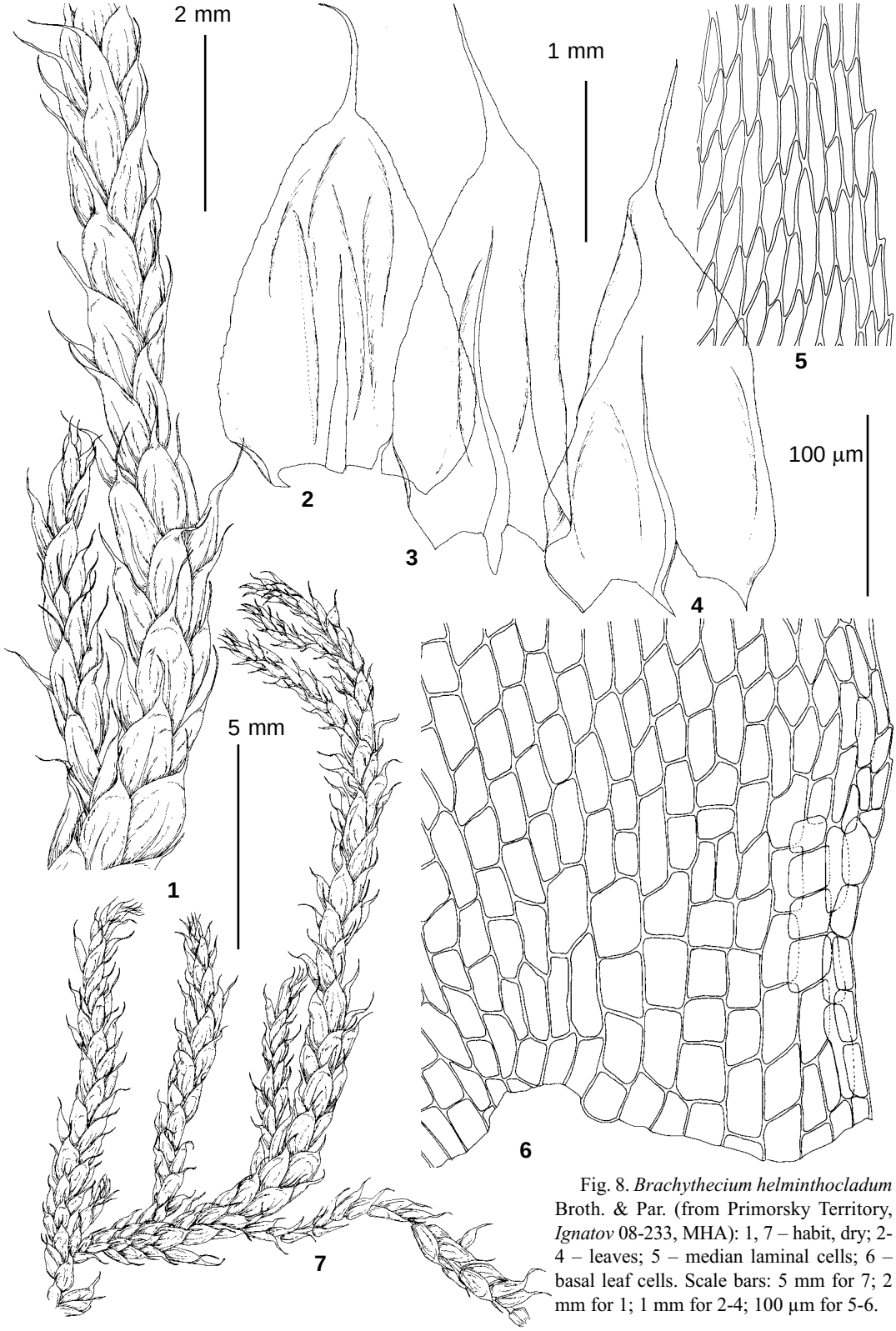


Fig. 8. *Brachythecium helminthocladum* Broth. & Par. (from Primorsky Territory, *Ignatov* 08-233, MHA): 1, 7 – habit, dry; 2-4 – leaves; 5 – median laminal cells; 6 – basal leaf cells. Scale bars: 5 mm for 7; 2 mm for 1; 1 mm for 2-4; 100 μm for 5-6.

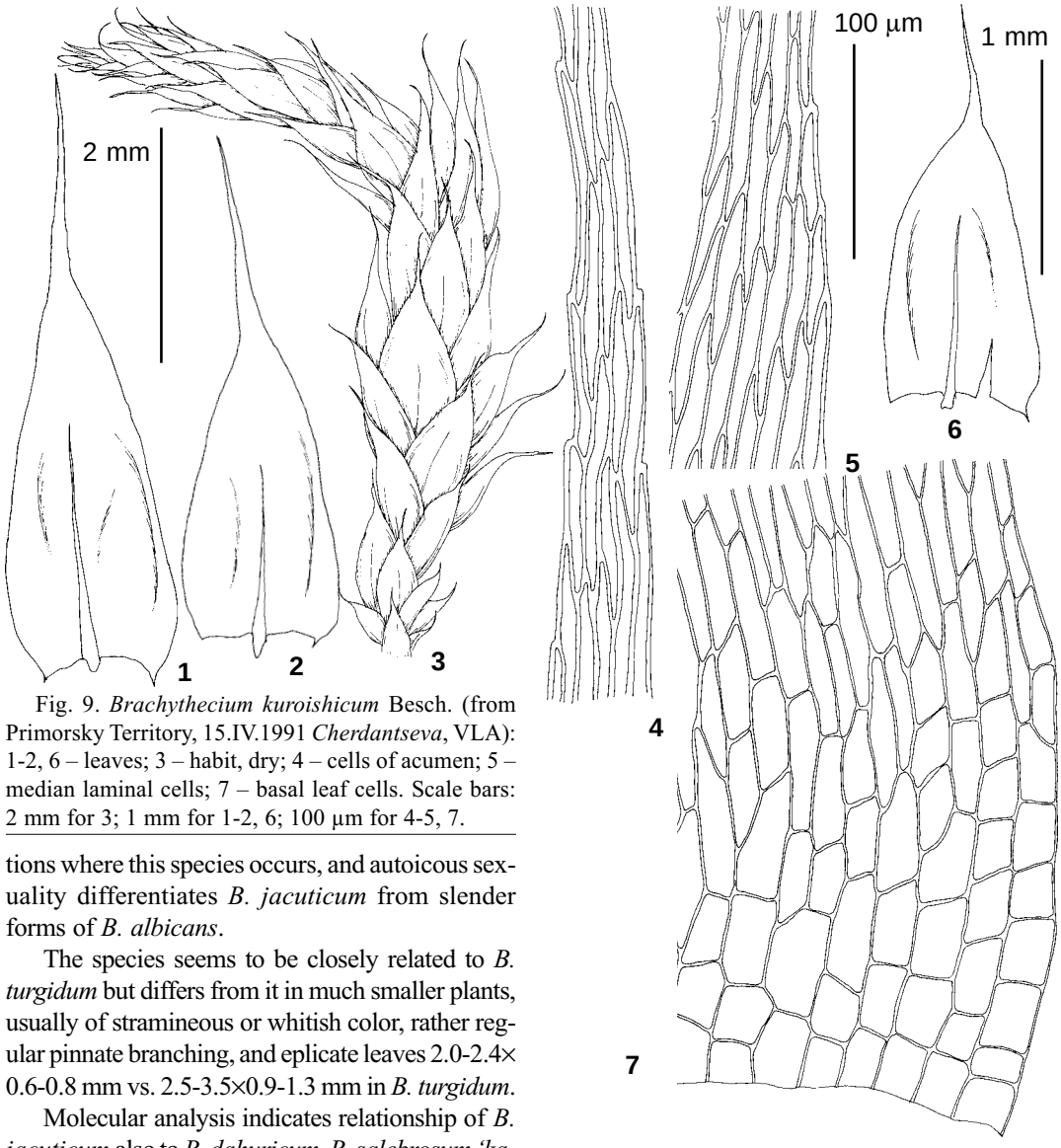


Fig. 9. *Brachythecium kuroishicum* Besch. (from Primorsky Territory, 15.IV.1991 *Cherdantseva*, VLA): 1-2, 6 – leaves; 3 – habit, dry; 4 – cells of acumen; 5 – median laminal cells; 7 – basal leaf cells. Scale bars: 2 mm for 3; 1 mm for 1-2, 6; 100 μm for 4-5, 7.

tions where this species occurs, and autoicous sexuality differentiates *B. jacuticum* from slender forms of *B. albicans*.

The species seems to be closely related to *B. turgidum* but differs from it in much smaller plants, usually of stramineous or whitish color, rather regular pinnate branching, and eplicate leaves 2.0-2.4× 0.6-0.8 mm vs. 2.5-3.5×0.9-1.3 mm in *B. turgidum*.

Molecular analysis indicates relationship of *B. jacuticum* also to *B. dahuricum, B. salebrosum 'kamchaticum'* and *B. udum*. However two former species differ in serrulate leaf margins, while the latter one has broader laminal cells and dioicous sexual condition.

Distribution. *Brachythecium jacuticum* occurs in coldest areas of Yakutia and Chukotka. Solitary collections are known from Transbaikal region, the southern Taimyr and Alaska (Fig. 6).

Selected specimens: **Kamchatka,** Bilchenok Glacier, 1000 m, 56°11'N, 160°21' 24.VII.2003, I.V. Czernyadjeva (LE); **Taimyr,** Pyasina River, Kresty, 1.VII.1976 Matveeva (LE); **Zabaikalsky** Territory**,** Sokhondo Reserve, 26.VII.2008 Afonina (LE); **Magadan** Prov., Nagaeva Bay, 10.IX.1972 Blagodatskikh (MHA); **Chukotka,** Palyavaam River, 16.VII.1989 Afonina (LE); Vrangel Island, Krasnyj Flag River, 19.VIII.1938 Gorodkov (LE); **Yakutia**: Yana Distr., Bytantai, 7.IX.1965 Perfilieva (SASY); Yakutia, Aldan Distr. 22.VII.1995 Ivanova (SASY); Kobyaisk Distr., 8.VII.1990 Nikolin (SASY); Lower Indigirka, Kondakovo Upland, 8.VIII. 1978 Perfilieva (SASY); Lenskie Stolby 6.VII.1999 Ivanova (SASY); Suntar Distr., 6.VIII.1956 Dobretsova (SASY); Lesnk Distr., 6.VII.1989 Timofeev (SASY); Srednekolymsk, 1.IX.1991 Ivanova (SASY); Verkhnekolymsk Distr., Zyryanka, 30.VII.1992 Ivanova (SASY); **Alaska:** Seword Peninsula, Nom, 1.IX.2001 Afonina #N-7 (LE).

Brachythecium kuroishicum Besch., Ann. Sci. Nat. Bot., sér. 7, 17: 373. 1893. Fig. 9

Description: Bardunov & Cherdantseva, 1982.

The species is related to *B. buchananii*, but differs in larger plants, usually irregular 'fasciculate' branching, larger leaves with more abruptly differentiated acumen, enlarged alar cells and autoicous sexuality. When optimally developed, plants have conspicuous "*Cirriphyllum*-like" foliage, although leaves are contracted not as sharp as in *B. cirrosum,* and the less developed plants have less apparent ciriphylloid habit, being more similar to large plants of *B. buchananii*.

Plants are often rich in color and glossy, being similar in this aspect to *B. extremiorientale* that is also autoicous and relatively large plant. However *B. extremiorientale* differs from *B. kuroishicum* in (1) the basal cells large across leaf base vs. enlarged towards leaf corners, (2) sharply serrate leaf margins vs. subentire to weakly serrulate, and (3) the leaves erect and rigid, never imbricate to julaceous. Difference from *B. helminthocladum* is discussed under that species (also cf. Figs. 8-9).

Distribution. In Russia, *B. kuroishicum* occurs in the southern Kuril Islands, the Sakhalin and the southern part of Primorsky Territory, usually on trunk and shrub bases in moderately open places.

Selected specimens: Kuril Islands, Kunashir, 40 m alt., Ignatov 06-1851 (MHA); Primorsky Territory, Cherdantseva 15.IV.1991(MHA ex VLA).

Brachythecium laetum (Brid.) Bruch, Schimp. & Gümbel, Bryologia Europaea 6: 24. Fig. 554. 1853. – *Hypnum laetum* Brid., Bryologia Universa 2: 479. 1827.

Fig. 10. Illustrations of North American plants see in e.g. Ignatov et al. (2008).

Brachythecium laetum is characterized by numerous short cells across leaf base, deeply plicate leaves and dioicous sexual condition. The plicae look like two convex foldings on each side of costa and in most cases are conspicuous enough to separate the species from *B. salebrosum*. Plants are variable in degree of margin serration, from entire to regularly serrulate by even, moderately small and rather blunt teeth (Fig. 10: *4-5*).

Distribution. *Brachythecium laetum* has been reported by Podpera (1921) from the South Urals, but his specimens were not located, and Ignatov & Ignatova (2004) excluded it from the flora of the Middle European Russia. However, the recent collections from the xeric areas of the Central Caucasus and the South Urals confirmed its presence in Russia.

***Selected specimens*:** Ingush Republic, Leimi, 15.VII. 2004, Bersanova (MHA); Kabardino-Balkaria, 29.VII.2004, Ignatov et al. (MHA); Bashkortostan, Sterlitamak Distr., L.M. Abramova #10-1 (UFA, MHA).

Brachythecium mildeanum (Schimp.) Schimp. in Milde, Bot. Zeitung (Berlin) 20: 452. 1862. — *Hypnum mildeanum* Schimp., Syn. Musc. Eur. 694. 1860.

Description and illustrations: Ignatov, 1998; Ignatov & Ignatova, 2004.

In European Russia south from the Arctic this species is usually easy to identify, as other *Brachythecium* species with entire leaves are very distinct: *B. albicans* and *B. glareosum* have long narrow acumina, while *B. erythrorrhizon* has falcate leaves. In contrast to them, *B. mildeanum* has straight narrowly triangular leaves gradually tapered to apex.

There are problems in separation *B. mildeanum* from *B.udum* in the Arctic and Siberia, and in the latter region also from *B. irinae*; their distictions are discussed under these species correspondingly.

Variation of *B. mildeanum* in Asiatic Russia is somewhat different from that in Europe. Plants from the Yenisey River valley have broadly triangular leaves, and also numerous very short leaves in proximal part of shoots, while in Yakutia plants are relatively narrow-leaved and have distinctly enlarged alar cells. Study a variation along the stem allows to find at least some 'typical *mildeanum* leaves', so these plants are attributed to this species.

Distribution. *Brachythecium mildeanum* is not a very abundant moss in most areas, but its distribution in Russia is broader than that of any other species: it grows in tundra in the Arctic, in wet places throughout the forest zone, including permafrost areas, and is known from xeric regions of southern Russia as well.

Brachythecium rivulare Bruch, Schimp. & Gümbel, Bryol. Eur. 6: 17. *546.* 1853.

Description and illustrations: Ignatov, 1998; Ignatov & Ignatova, 2004.

Brachythecium rivulare is usually distinguished by the alar group of strongly inflated

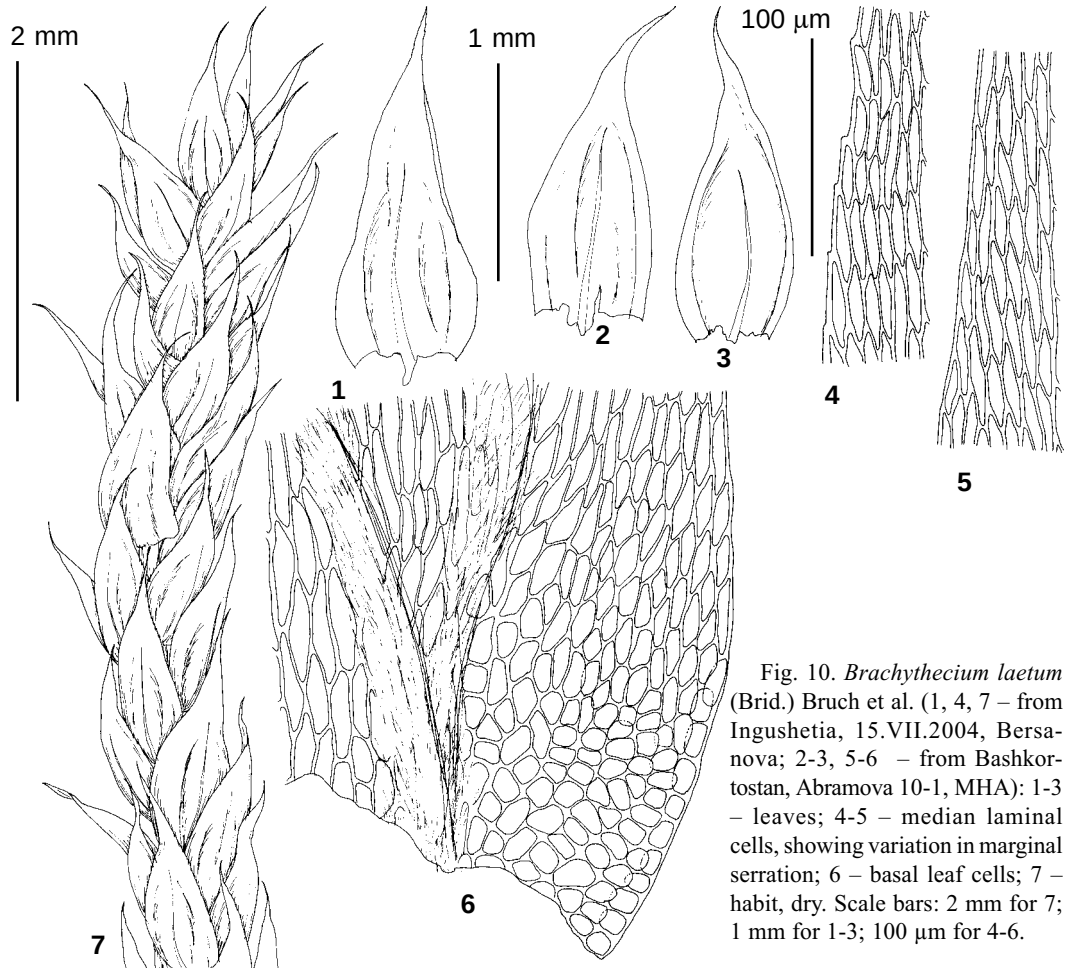


Fig. 10. *Brachythecium laetum* (Brid.) Bruch et al. (1, 4, 7 – from Ingushetia, 15.VII.2004, Bersanova; 2-3, 5-6 – from Bashkortostan, Abramova 10-1, MHA): 1-3 – leaves; 4-5 – median laminal cells, showing variation in marginal serration; 6 – basal leaf cells; 7 – habit, dry. Scale bars: 2 mm for 7; 1 mm for 1-3; 100 µm for 4-6.

cells. In the NW Russia, however, there are phenotypes of *B. rutabulum* with strongly inflated cells, so in these cases the autoicous versus dioicous sexual condition would be the most reliable character (cf. Wigh, 1975). In xeric regions, *B, rivulare* sometimes develops forms with repeatedly branched stems, and secondary and tertiary 'stems' are much thinner, with thinner leaves, having characters of branch leaves that lack a clearly differentiated alar group. Having such plants, it is essential to find stem leaves from the best developed plant.

Distribution. The species is very common in Europe, West Siberia, and the Russian Far East. In these areas, it reaches the Arctic, but surprisingly is absent in East Siberia in the permafrost zone. All confirmed Yakutian specimens are from southern and southwestern regions.

Brachythecium rotaeanum De Not., Cron. Briol. Ital. 2: 19. 1867. — ?*Hypnum salebrosum* var. *capillaceum* F. Weber & D. Mohr, Bot. Taschenbuch 313. 1807. — *Brachythecium capillaceum* (F. Weber & D. Mohr) Giac., Atti Ist. Bot. "Giovanni Briosi" ser. 5, 4: 268. 1947.

Description and illustrations: Ignatov, 1998; Ignatov & Ignatova, 2004; Ignatov et al., 2008.

This species was often treated as a variety of *B. salebrosum*: both have similar leaf serration, and variation in many characters is overlapping. However, alar cells in *B. rotaeanum* do not form a well-delimited square group, and juxtacostal cells are rather lax, gradually transiting to smaller cells in alar region. A conspicuous character of *B. rotaeanum* is a development of shorter leaves in dry conditions, approaching in habit to *B. laetum* or sometimes even to *B. buchananii*.

Plants from Kamchatka and Kuril Islands with narrow and somewhat falcate leaves were referred to *B. rotaeanum* with a question mark (R6 in Fig. 2). They look unusual for the species, occurring in the area where the common phenotype of species occurs as well. In other areas, *B. rotaeanum* always has straight leaves, which is often helpful for its differentiation from *B. salebrosum* that has straight leaves in dry conditions, but in mesic habitats has a tendency to falcate leaves. The plant color is also suggestive: *B. rotaeanum* are usually pure green to somewhat glaucous, while the color of *B. salebrosum* is green to yellowish or bronwish green. Capsules in *B. rotaeanum* are often only slightly curved and suberect, although some populations have them curved and inclined to horizontal.

Distribution. From the Altai and eastward, *B. rotaeanum* is the most common species in many, especially southern areas. It is equally common in the southern Russian Far East, while more rare in the Kuril Islands. The species is common on tree trunks, rotten logs, in mountain areas also on rocks. In Europe it occurs mostly on trunks, usually of aspen in southern boreal forests, although occasional collections are from other places, including oak forests in the steppe zone.

Brachythecium rutabulum (Hedw.) B. S. G., Bryol. Eur. 6: 15. 1853. — *Hypnum rutabulum* Hedw., Sp. Musc. Frond. 276. 1801.

Description and illustrations: Ignatov, 1998; Ignatov & Ignatova, 2004.

Brachythecium rutabulum is a little variable species in most parts of the European Russia, where the main problem is the separation of its slender plants from *Sciuro-hypnum curtum*. This is unlikely with optimally developed plants, because they have rather dense terete foliage, leaves are more gradually tapered to apex and somewhat plicate, and alar cells are in a quite delimited group, while in *Sciuro-hypnum curtum* the branch foliage is often subcomplanate, leaves are less concave, eplicate, and the alar cells are not in so well delimited group. However, in poor collections these distinctions are sometimes difficult to apply, and the leaf shape variation remains the most reliable character.

In the NW European Russia, *B. rutabulum* provides difficulties with the separation from *B. rivulare*, which almost never happens in other parts of Russia, where *B. rutabulum* grows in mesic, not wet habitats. However in NW European Russia, where it commonly grows on soil in *Alnus* and mixed forests with spruce, plants often have sparsely arranged leaves and quite inflated alar cells. Essential in these case is the autoicous sexual condition that differentiates itfrom dioicous *B. rivulare* (cf. Wigh, 1975).

In the Caucasus, the foliage of *B. rutabulum* is densely imbricate to tumid, so plants have an appearance approaching to *Cirriphyllum crassinervium*. However pellucide vs. moderately opaque alar group, linear vs. elongate laminal cells, and autoicous vs. dioicous sexual condition allow their differentiation.

Distribution. The species is common in the the south and western parts of European Russia, in broad-leaved and hemiboreal forests, but almost absent in the boreal zone, having the northern limits more or less the same as *Tilia*. In Siberia it reaches the Altai and the Kuznetsky Alatau Mountains (only places in Siberia where *Tilia* occur) then is absent further to the East, appearing in southern Far East, mostly in nemoral forest.

Brachythecium salebrosum (F. Weber & D. Mohr) Bruch, Schimp. & Gümbel, Bryol. Eur. 6: 20. 1853. — *Hypnum salebrosum* F. Weber & D. Mohr, Bot. Taschenbuch 312. 1807.

Description and illustrations: Ignatov, 1998; Ignatov & Ignatova, 2004.

This species is very common in European Russia, developing a great diversity of forms, which sometimes are not easy to separate from *B. rotaeanum*, *B. campestre, B. glareosum* and *B erythrorrhizon*. The species is usually recognized by serrulate to serrate leaf margin, rather well delimited square group of small quadrate alar cells, autoicous sexual condition and smooth seta. Morphotypes with subentire leaves were seen in European Russia and Caucasus, so *B. salebrosum* is included in the key twice, including its branch with entire-leaved species, although the vast majority of specimens from Russia have leaves disticntly serrualte to serrate.

Distribution. The species is common almost throughout European Russia and West Siberia (although rare to absent in the Arctic) and occur

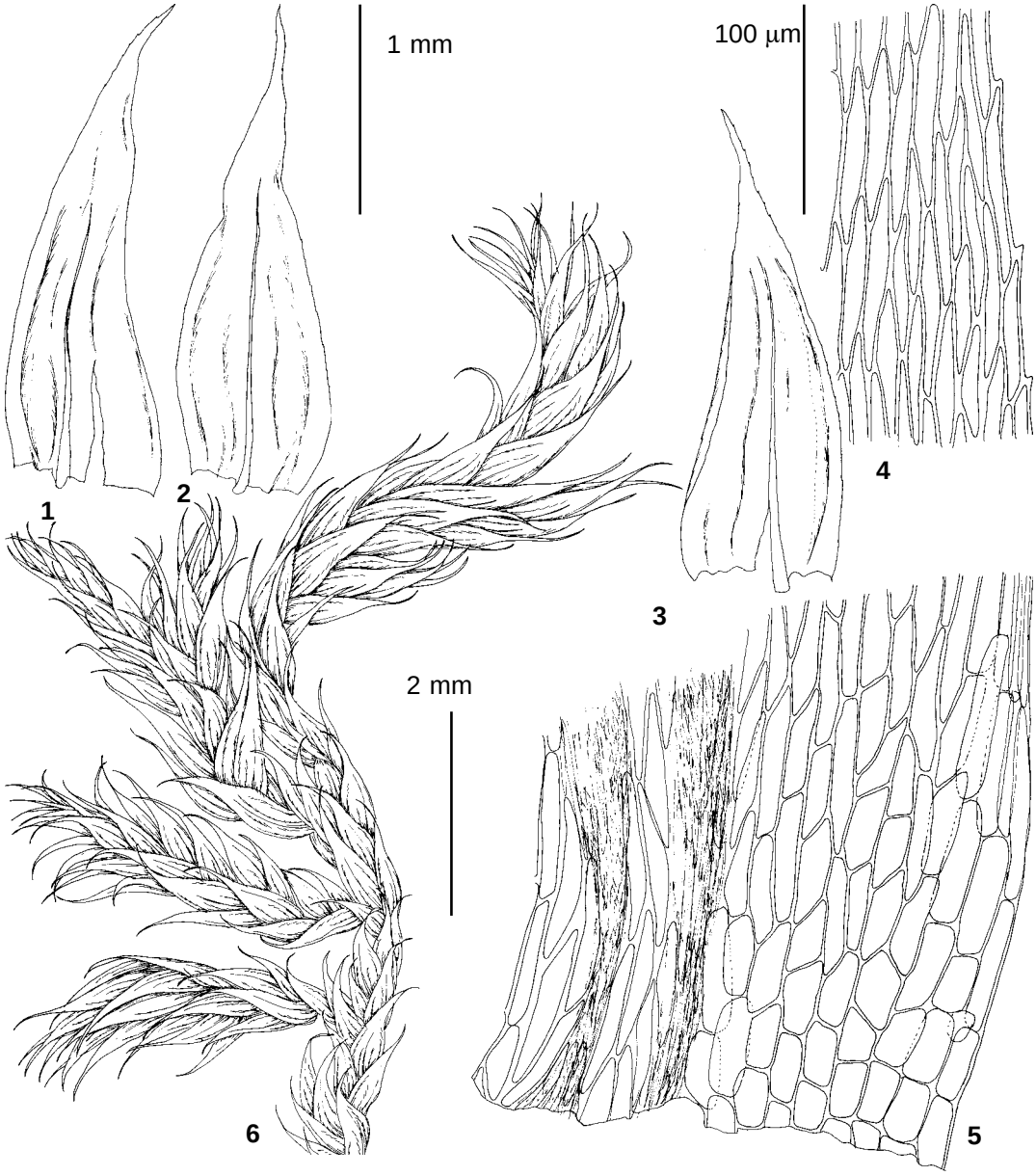


Fig. 11. *Brachythecium salebrosum 'kamchaticum'* (from 6.VIII.2005 Czernyadjeva #17, LE): 1-3 – leaves; 4 – median laminal cells; 5 – basal leaf cells; 6 – habit, dry. Scale bars: 2 mm for 6; 1 mm for 1-3; 100 μm for 4-5.

also in Kamchatka in the Russian Far East. In permafrost areas of the East Siberia *B. salebrosum* is rare and occurs only in the western and southern regions. In South Siberia, *B. salebrosum* is a much more rare plant than *B. rotaeanum*, although its scattered collections are known from the Altai and the Baikal regions, including the upper Lena River Basin (to the confluence with the Olekma River).

No collections East from the Baikal were confirmed as *B. salebrosum* in South Siberia. So-named specimens from the area were reidentified as *B. dahuricum, B. rotaeanum*, and *B. jacuticum.*

The complicated situation is in Kamchatka and the Sakhalin. Many collections are distinct from the 'typical' *B. salebrosum* in very strong plication, often strongly falcate leaves, rather short laminal cells, 45-80× 6-8 μm, and expand-

ed alar group (Fig. 11). Many characters are shared with *B. erythrorrhizon*, but plants are autoicous. In addition, these plants were found to belong to '*turgidum*' rather than to '*salebrosum*' haplotype. The attempts to segregate this morphotype, however, was not successful: many plants intermediate between *'kamchaticum'* and 'typical' *B. salebrosum* exist and some of them were found to belong to '*salebrosum*' haplotype. So even a status of variety would be difficult to apply in practice. Note, however, that this is the only case in our study where plants with *B. salebrosum* morphology belong to '*turgidum*' haplotype.

Brachythecium tommasinii (Sendtn. ex Boulay) Ignatov et Huttunen, Arctoa 11: 268. 2002. — *Hypnum tommasinii* Sendtn. ex Boulay, Fl. Crypt. Est, Muscin. 225. 1872. — *Cirriphyllum tenuinerve* (Lindb.) Wijk et Marg., Taxon 8: 73. 1959. — *Hypnum tenuinerve* Lindb., Oefvers. Foerh. Kongl. Svenska Vetensk.-Akad. 20: 397. 1863. — *Cirriphyllum vaucheri* Loeske et Fleisch., Allg. Bot. Z. Syst. 13: 22. 1907.

Description and illustrations: Ignatov & Ignatova, 2004.

For a long time this species was classified within *Cirriphyllum* and keys concentrated on its separation from *Cirriphyllum piliferum*, a most simialr species in Europe. *Brachythecium tommasinii* differs from *C. piliferum* in the lack of regular pinnate branching and usually grows in compact tufts of intense green color, which is never observed in both light-green *C. piliferum* and usually stramineous *Brachythecium cirrosum*. The latter species differs in soft, rarely branching plants, and leaves much more distinctly constricted to filiform acumen.

Distribution: We saw specimens only from Karelia and SE Komi Republic. Records from Georgia and Azerbaijan indicate its possible occurrence in the Russain part of Caucasus as well.

Selected specimens: Komi, Pechero-Ilych Reserve, 200 m, 62°06'N, 58°25'E, 24.VI.2000 Bezgodov & Kucherov #100 (PPU, MHA); Karelia, Kondopoga Distr., 18.VI.2000 Maksimov & Maksimova (MHA, PTZ).

Brachythecium turgidum (Hartm.) Kindb., Vidensk. Meddel. Dansk Naturhist. Foren. Kjobenhavn 9: 294. 1888. — *Hypnum salebrosum* var. *turgidum* C. Hartm., Handb. Skand. Fl. (ed. 3) 3: 309. 1838.

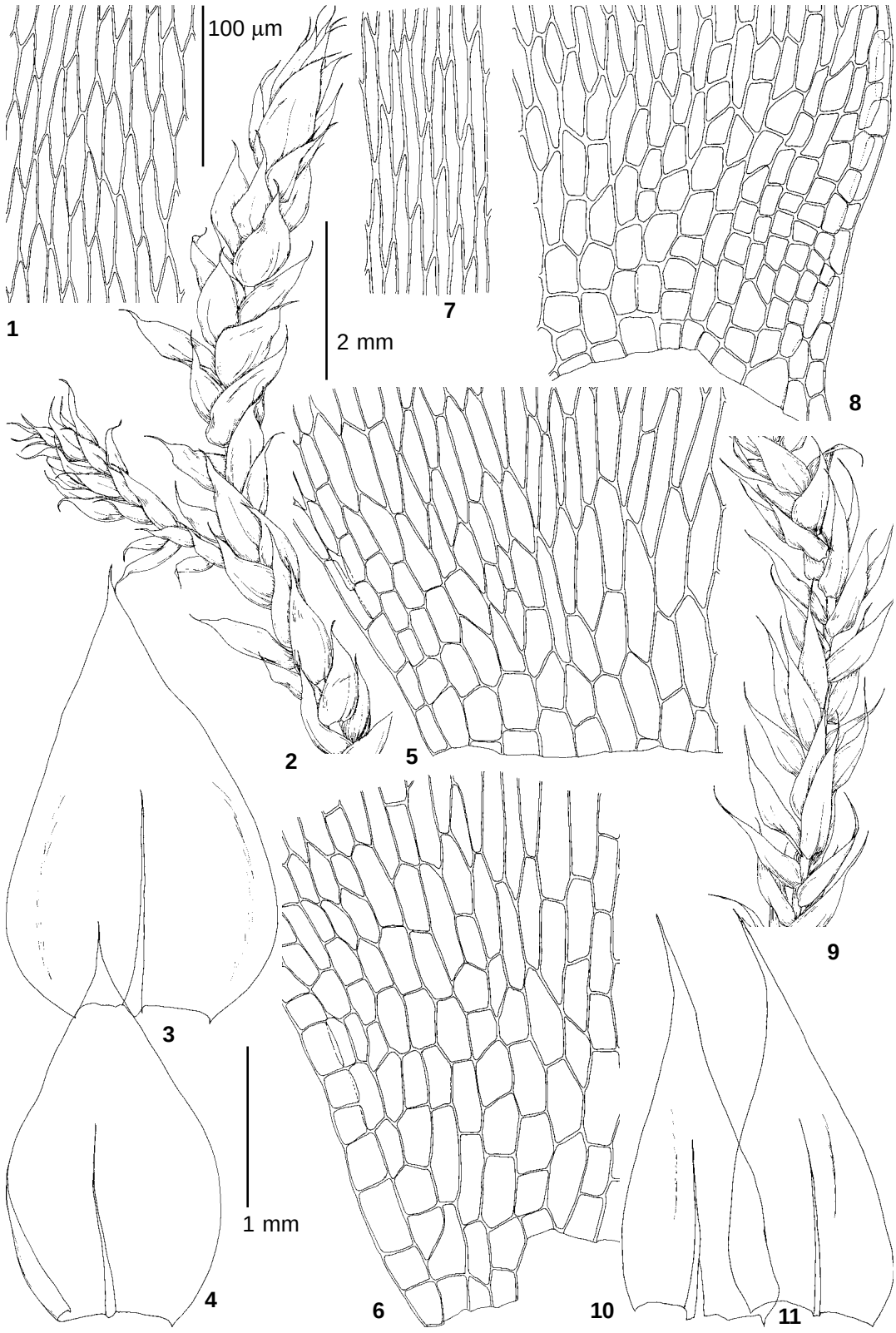
Description and illustrations: Ignatov, 1998; Ignatov & Ignatova, 2004.

Most collections of *Brachythecium turgidum* can be recognized usually by its appearance alone due to robust brown-green plants, erect growth, poor branching, dense foliage and erect-appressed leaves. Also characteristic for the species is the combination of autoicous sexual condition, incrassate basal cells and relatively thick-walled laminal cells.

However, marginal phenotypes are contrastingly different, and it would be interesting to note that Carl Hartman, the author of the species, in the 6th edition of *Flora Suecica* mentioned that this species was considered by Schimper to be *B. glareosum*, while Hampe thought that this is *B. cirrosum*. The *cirrosum*-like phenotype occurs in the Arctic and northern mountains, growing in flooded places near late snow beds. Plants in this type of habitat usually have rather short leaves, abruptly contracted into acumen and less plicate to perfectly smooth. Also in such places the plant color is often quite pale. We saw a number of confusions of such phenotypes of *Brachythecium cirrosum* in herbaria. Usually *cirrosum*-like plants are not difficult to identify: in most cases one can find inside the tuft better developed shoots representing transition to the most common phenotype of *B. turgidum.* In critical cases, the entire leaf margin and autoicous sexuality would be the most reliable characters. Difference from *B. jacuticum* and *B. udum* is discussed under those species.

Distribution. *Brachythecium turgidum* is a widespread species in the Arctic and high mountains in South Siberia (Altai, etc.), and in the the Caucasus, but absent in the Urals, except for the most northern areas. Outside the Arctic and the permafrost area it is usually confined to higher elevations (e.g. in the Altai at 2300-2800 m). However, in the oceanic climate in Europe it occurs in moderately northern areas with numer-

Fig. 12 (page 27). *Brachythecium udum* I. Hagen (1-6 – from Altai, Ignatov 0/444, MHA; 7-11 – from Karachaevo-Cherkesia, Ignatova 07-156, MW): 1, 7 – median laminal cells; 2, 9 – habit, dry; 3-4, 10-11 – leaves; 5-6, 8 – basal leaf cells, showing variation. Scale bars: 2 mm for 2, 9; 1 mm for 5-6, 8; 100 μm for 1, 5-8.


100 µm
1
7
8
2 mm
2
5
9
3
1 mm
4
6
10
11

ous rocks, as e.g. in Estonia, but in Russia, its southern border in lowland is more northern (in Karelia and Arkhangelsk Province).

Brachythecium udum I. Hagen, Kongel Norske Vidensk. Selsk. Skr. (Trondheim) 1908 (3): 4. *1. f. 1.* 1908. Figs. 12-13

The understanding of this species is quite poor. We left under this name superficially quite different plants from wet habitats in cold regions that are rather robust, usually with ascending to erect growth, irregular branching, ovate to ovate-lanceolate leaves, rather abruptly acuminate, subentire leaf margins, moderately thin-walled laminal cells, rather lax areolation in lower leaf and variable alar cells from somewhat larger to somewhat smaller that other basal cells, in both cases in an indistinct group. According to the original description, the sexual condition is probably dioicous, as only female plants have been found, and we also never saw male plants and sporophytes as well.

Most commonly this species is considered as a variety of *B. mildeanum*, but the latter has autoicous to synoicous sexual condition, more gradually tapered leaves and ITS markers indicate their different affinity, close to: *B. dahuricum*, *B. salebrosum 'kamchaticum', B. turgidum, B. irinae, and B. jacuticum.* The two former taxa have serrulate leaves and can be separated by this character. The three latter ones are autoicous, and the following additional differences can be mentioned.

'Cirriphylloid' phenotypes of *B. turgidum* are quite habitually similar to *B. udum*, but their laminal cells are thick-walled, especially at leaf base.

Brachythecium jacuticum has narrow cells reaching almost the leaf base, and plants are quite slender.

Brachythecium irinae is similar to *B. udum* in lax basal areolation, but plants are green, rather regularly branched, usually prostrate and leavae are rather triangular, more similar to that of *B. mildeanum*, whereas in *B. udum* leaves are acuminate to abruptly acuminate.

Distribution. We refer to *B. udum* plants from Arctoa, high mountains and scattered localitis of boreal zone of Siberia, where it grows mostly on wet soil.

Specimen examined: [Irkutsk Province], Lena River,, Ust-Kut, 4.VI.1898 Nilsson-Ehle (S, as *salebrosum*); Krasnoyarsk Territory, Putorana Plateau, 900 m alt., Bardunov 4.VIII.1971 (IRK, MHA); Jenisej, Ust-Kureika 19.VII.1976 Arnell (S, as *salebrosum*); Murmansk Province, Khibiny 3.VII.1966 Schljakov (KPABG: Bryophyta Murmanica Exs. #63).

ACKNOWLEDGEMENTS

We are grateful to curators of S, H, LE, UUH, SASY, MW, PPU for loan of material, and all collegues who supplied us with their recent collections, V. Prokhorov and R. Ochyra for translation to Latin, and A. Ivanova and E. Kosovich-Anderson for correcting English, E. Ignatova for preparing illustrations. The work was partly supported by RFBR 09-04-01234 and 10-04-00678 and Biodiversity Program of RAS.

LITERATURE CITED

[BAKALIN, V.A. & V.Ya. CHERDANTSEVA] БАКАЛИН В.А., В.Я. ЧЕРДАНЦЕВА 2008. Бриофлора острова Медный и бриогеография Алеут (Северная Пацифика). – [Bryophyte flora of Mednyj Island and bryogeography of Aleutians (North Pacifica)] *Сохранение биоразнообразия Камчатки и прилегающих морей* [*Sokhranenie bioraznoobraziya Kamchatki i prilegayushchikh morej*]: *36-56*.

CLEMENT M., D. POSADA & K. A. CRANDALL 2000. TCS: a computer program to estimate gene genealogies. – Molec. Ecol. **9**: *1657-1659.*

FLOWERS, S. 1973. Mosses of Utah new to science. – *Bryologist* **76**: *286-292.*

GARDINER, A., M. IGNATOV, S. HUTTUNEN & A. TROITSKY 2005. On resurrection of the families Pseudoleskeaceae Schimp. and Pylaisiaceae Schimp. (Musci, Hypnales). – *Taxon* **54:** *651-663.*

GOLOBOFF, P. A. 1994. NONA: A Tree Searching Program. – *Program and documentation. Argentina, Tucumбn, published by the author.*

HALL, T.A. 1999. BioEdit: a user-friendly biological sequence alignment editor and analysis program for Windows 95/98/NT. *Nucl. Acids. Symp. Ser*. **41**: *95-98.*

HEDENДS, L. 1995. On the identity of Brachythecium campestre (C. Müll.) B., S. & G., in Sweden, Norway and Finland. – *Lindbergia* **20**: *94-101*.

HUTTUNEN, S., A. GARDINER & M. S. IGNATOV 2007. Additional comments on the phylogeny of the Brachytheciaceae (Bryophyta). – *In: Newton, A.E. & R. Tangney (eds.) Pleurocarpous mosses: systematics and evolution. CRC Press, Boca Raton-London-New York (Systematic Association Special Volume 71): 117-143.*

HUTTUNEN, S. & M. S. IGNATOV 2004. Phylogenetic analysis of Brachytheciaceae (Bryophyta) based on morphology, and sequence level data. – *Cladistics* **20**: *151-183*.

IGNATOV, M. S. 1998. Bryophyte flora of Altai Mountains. VIII. Brachytheciaceae. — *Arctoa* **7**: *85-152.*

IGNATOV, M.S. 2011. Brachythecium. – *In: Flora of North America. Vol. **28**. Mosses, part. 2.* (in press).

IGNATOV, M.S. & E.A. IGNATOVA] ИГНАТОВ М.С., Е.А.

ИГНАТОВА 2004. Флора мхов средней части Европейской России. Т. 2. – [Bryophyte flora of Middle Part of European Russia. Vol. 2] *KMK, M.* [*KMK, Moscow*], *609-960.*

IGNATOV, M. S. & T. KOPONEN 1996. On the taxonomy of some East Asian Brachythecium (Brachytheciaceae, Musci). – *Ann. Bot. Fennici* **33**: *285-301.*

IGNATOV, M.S., I.A. MILYUTINA & V.K. BOBROVA 2008. Problematic groups of Brachythecium and Eurhynchiastrum (Brachytheciaceae, Bryophyta) and taxonomic solutions suggested by nrITS sequences. – *Arctoa* **17**: *113-138.*

IGNATOV, M. S., I. A. MILYUTINA & S. HUTTUNEN 2006. On two East Asian species of Brachythecium (Brachytheciaceae, Musci). – *J. Hattori Bot. Lab.* **100**: *191-199.*

McFARLAND, K. D. 1988. Revision of Brachythecium (Musci) for Mexico, Central America, South America, Antarctica and circum-Subantarctic islands. – *Ph. D. dissertation, Univ. Tennessee. xii + 537 pp.*

NIXON, K.C. 1999. *Winclada (BETA) ver. 0.9.9*. available at http://www.cladistics.com/about_winc.html.

PODPERA, J. 1921. Ad bryophytorum cisuralensium cognitionem additamentum. — *Publ. Fac. Sci. Univ. Masaryk. Brno* **5**: *1-42.*

TAKAKI, N. 1955. Researches on the Brachytheciaceae of Japan and its adjacent areas. 2. — *J. Hattori Bot. Lab*. **15**: *1-69.*

WIGH, K. 1975. Scandinavian species of the genus Brachythecium (Bryophyta). I. Modification and biometric study in the B. rutabulum–B. rivulare complex. – *Bot. Notiser* **128**(4): *463-475.*

Appendix 1. Species/region as they are appeared in Figs. 1-2, herbarium voucher and GenBank accession numbers for ITS1-2 (two numbers in some species refer to ITS1 and ITS2 correspondingly)

Brachythecium acutum Missouri	U.S.A., Missouri, Allen 26741 (MO)	Q246822
B. acutum Newfoundland	Canada, Newfoundland, Buck 52529 (NY)	GQ246823
B. albicans California A2	U.S.A., California, 12.VIII.1989 Ignatov (MHA)	JF280920
B. albicans Kamchatka A1	Russia, Kamchatka, 20.VII.2002 Czernyadjeva 5 (MHA)	JF280919
B. albicans Sweden A3	Sweden, 29.VIII.1992 Hedenäs (S-B87486)	EU567472
B. asperrimum Alaska	U.S.A., Alaska, Schofield 108002 (MHA)	JF280921
B. asperrimum Oregon	U.S.A., Oregon, Darigo 3977 (MO)	GQ246824
B. auriculatum Kuril Is	Russia, Kuril Is., 10.IX.1980 Bardunov (MHA ex IRK)	DQ497446
B. baicalense Irkutsk 1	Russia, Irkutsk, Ignatov & Kazanovsky 05-6010 (MHA)	GQ246826
B. baicalense Irkutsk 2	Russia, Irkutsk, Ignatov & Kazanovsky 05-6099 (MHA)	JF280922
B. boreale Kamchatka	Russia, Kamchatka 12.VIII.2004 Czernyadjeva 63 (LE,MHA)	JF280923
B. boreale Taimyr 1	Russia, Taimyr, Fedosov, 05-31 (MW)	GQ246829
B. boreale Taimyr 2	Russia, Taimyr, Fedosov 05-650 (MW)	GQ246830
B. brandegei U.S.A., Colorado B1	U.S.A., Colorado, Weber B-114286 (MHA ex COLO)	GQ246831
B. buchananii Altai	Russia, Altai, Ignatov 29/29 (MHA)	GQ246833
B. buchananii Sakhalin	Russia, Sakhalin, Ignatov 06-196 (MHA)	GQ246834
B. buchananii Kuril Islands	Russia, Kuril Is., Bakalin K-50-23-07 (MHA ex VLA)	JF280925
B. buchananii China Shaanxi	China, Shaanxi, Wang 4765 30-5-2005 (MHA)	JF280924
B. buchananii China Hunan	China, Hunan, Koponen et al. 53972 (H)	DQ200075/AF403595
B. buchananii Perm	Russia, Perm, 11.VIII.2005 Bezgodov 176 (MHA)	GQ246832
B. campestre Kuril Islands	Russia, Kuril Is., Ignatov 06-1560 (MHA)	GQ246835
B. campestre Kaluga	Russia, Kaluga, Teleganova 07-427 (MHA)	JF280926
B. campestre U.S.A., Wisconsin	U.S.A., Wisconsin, Bowers 11-10-1990 (MO)	GQ246837
B. complanatum China	China, Heilongjiang, Cao Tong 040063 (MHA)	GQ246838
B. conostomum Mexico	Mexico, 9.VIII.1995 Hedenäs (S)	JF280928
B. coruscum Sweden C1	Sweden, 31.VII.2009 Hedenäs (S)	JF280930
B. coruscum Sakhalin C2	Russia, Sakhalin, Ignatov 06-240 (MHA)	JF280929
B. dahuricum Zabaikalsky D1	Russia, Chita, Afonina 1006 (MHA ex LE)	JF280933
B. dahuricum Buryatia D2	Russia, Buryatia, 5.VII.2000 Tubanova #73(III) (MHA)	JF280932
B. dahuricum Zabaikalsky D3	Russia, Zabaikalsky, 14.VII.2006 Afonina (MHA ex LE)	JF280931
B. erythrorhizon U.S.A., Maine E1	U.S.A., Maine, Allen 28225 (MO)	GQ246839
B. erythrorhizon Primorsky E2	Russia, Primorsky, Ignatov et al. 06-2122 (MHA)	GQ246840
B. erythrorhizon U.S.A., California E5	U.S.A., California, 27.VIII.1989 Ignatov (MHA)	GQ246841
B. erythrorhizon Sweden E3	Sweden 24.VI.2008 Hedenäs (S)	JF280935
B. erythrorhizon Kamchatka E7	Russia, Kamchatka 7.VIII.2007 Czernyadjeva 11-07 (LE, MHA)	JF280934
B. erythrorhizon Yakutia E4	Russia, Yakutia 22.VI.2004 Ivanova (MHA ex SASY)	JF280936
B. erythrorrhizon Altai E6	Russia, Altai, Ignatov 14/61 (MHA)	GQ246853
B. extremiorientale Primorsky	Russia, Primorsky, Ignatov & Ignatova 06-2935 (MHA)	GQ246842
B. frigidum (Müll. Hal.) Besch.	USA, California, 23.IV.1981 Düll (H)	DQ336898/AF403638

B. garovaglioides China	China, Fuan 960785 (MHA ex PE)	DQ497445
B. glareosum Dagestan	Russia, Dagestan, Ignatov & Ignatova 09-612 (MHA)	JF280937
B. glareosum Perm	Russia, Perm, Bezgodov 11-8-2005 #152 (MHA)	JF280938
B. helminthocladum Primorsky	Russia, Prmorsky, Ignatov 08-233 (MHA)	JF280939
B. irinae Yakutia I6	Russia, Yakutia, Ivanova 13.VIII.2002 (MHA ex SASY)	F280945
B. irinae Kamchatka I2	Russia, Kamchatka 27.VIII.2007 Czernyadjeva 54-07 (LE, MHA)	JF280941
B. irinae Kamchatka I1	Russia, Kamchatka 10.VIII.2005 Chernyad'eva 29 (LE, MHA)	JF280940
B. irinae Kamchatka I3	Russia, Kamchatka 30.VII.2003 Chernyad'eva 71 (LE, MHA)	JF280942
B. irinae Kamchatka I5	Russia, Kamchatka 5.VIII.2001 Chernyad'eva 59 (LE, MHA)	JF280944
B. irinae Kamchatka I4	Russia, Kamchatka 1.VIII.2004 Chernyad'eva 34 (LE, MHA)	JF280943
B. irinae Altai I7	Russia, Altai, Ignatov 15/112 (MHA)	GQ246858
B. jacuticum Chukotka J4	Russia, Chukotka, 21.VII.1985 Afonina (MHA)	JF280947
B. jacuticum SE Yakutia J1	Russia, Yakutia, Ignatov 00-1999 (MHA)	JF280948
B. jacuticum Central Yakutia, J2	Russia, Yakutia, 22.VII.1999 Ivanova (MHA, SASY)	JF280949
B. jacuticum Chukotka J3	Russia, Chukotka 7.VIII.1991 (MHA)	JF280946
B. jacuticum Yakutia, Kolyma J5	Russia, Yakutia, Kolyma, 30.VII.1992 Ivanova (MHA, SASY)	JF280950
B. kuroishicum Primorsky	Russia, Primorsky, 15.IV.1991 Cherdantseva (MHA ex VLA)	DQ497444
B. laetum Ingushetia	Russia, Ingushetia, 15.VII.2004 Bersanova (MHA)	JF28095
B. laetum U.S.A., Maine	U.S.A., Maine, Allen 28393 (MO)	GQ246845
B. mildeanum Buryatia	Russia, Buryatia, Tubanova EpT-16-08 (MHA ex UUH)	JF280952
B. rivulare Finland	Finland, 19.V.1996 Parnela (H)	DQ200076/AF403651
B. rotaeanum Astrakhan R4	Russia, Astrakhan, 5.V.2002 Suragina (MHA)	GQ246848
B. rotaeanum Altai R3	Russia, Altai, Ignatov 0/3004 (MHA)	GQ246849
B. rotaeanum Perm R2	Russia, Perm, 20.IX.2003 Bezgodov 65 (MHA)	GQ246850
B. rotaeanum U.S.A., Maine R5	U.S.A., Maine, Allen 28536 (MO)	GQ246851
B. cf. rotaeanum Kuril Islands R6	Russia, Kunashir, Ignatov 06-1793 (MHA)	JF280927
B. rotaeanum Chukotka R1	Russia, Chukotka, 24.VIII.2001 Afonina (MHA ex LE)	GQ246847
B. rutabulum Canada	U.S.A., Belland 11900 (MHA)	JF280953
B. salebrosum Belgorod S7	Russia, Belgorod, 14.V.1999 Ignatov (MHA)	GQ246843
B. salebrosum Ryazan S6	Russia, Ryazan, 4.IX.2009 Donskov (MHA)	JF280957
B. salebrosum Kamchatka S5	Russia, Kamchatka, 8.VIII.2002 Czernyadjeva (MHA)	JF280956
B. salebrosum Vologda S4	Russia, Vologda, 12.VIII.2001 Ignatov & Ignatova (MHA)	GQ246854
B. salebrosum Yakutia S1	Russia, Yakutia, Ignatov 00-866 (MHA)	GQ246855
B. salebrosum Irkutsk S3	Russia, Irkutsk, 8.VI.2005 Ignatov (MHA)	GQ246852
B. salebrosum 'kamchaticum' Kamchatka SK1	Russia, Kamchatka, 6.VIII.2005 Czernyadjeva #17 (LE,MHA)	JF280954
B. salebrosum 'kamchaticum' Sakhalin SK2	Russia, Sakhalin, Ignatov 06-521 (MHA)	JF280955
B. turgidum Altai T1	Russia, Altai, Ignatov 31/290 (MHA)	GQ246856
B. turgidum Chukotka T2	Russia, Chukotka, 9.VIII.1984 Sekretareva (MHA ex LE)	JF280958
B. turgidum Sweden T3	Sweden, 10.VII.2007 Hedenäs (S)	JF280959
B. udum Sakhalin U2	Russia, Sakhalin, 21.VIII.2006 Ignatov & Teleganova (MHA)	GQ246861
B. udum Teberda U3	Russia, Karachaevo-Cherkesia, Teberda, Ignatova 07-156 (MW)	GQ246860
B. udum Karelia U5	Russia, Karelia, Maksimov 2005 (MHA ex PTZ)	JF280960
B. udum Altai U3	Russia, Altai, Ignatov 31/297 (MHA)	GQ246859
B. udum I. Hag. Altai U1	Russia, Altai, Ignatov 0/444 (MHA)	GQ246857
Sciuro-hypnum brotheri Sakhalin	Russia, Sakhalin, Pisarenko 3574 (MHA ex NVS)	JF280961
S. reflexum Bashkortostan	Russia, Bashkortostan, 11.VII.2004 Martynenko (MHA)	JF280963
S. reflexum Arkhangelsk	Russia, Arkhangelsk 12.VI.2001 Churakova (MHA)	JF280962

ADDENDA

During study of *Brachecium salebrosum* and *B. suberuthrorrhizon* in North America, the conclusion was made on *Brachythecium delicatulum* Flowers, which should be placed in the *Brachytheciastrum*. Thus this transfer is made here: *Brachytheciastrum delicatulum* (Flowers) Ignatov, comb. nov. – *Brachythecium delicatulum* Flowers, Bryologist 76: 287. 1973.