

A STUDY OF THE DIDYMODON SPECIES (POTTIACEAE, MUSCI) IN RUSSIA. I. SPECIES WITH CADUCOUS LEAF APICES

ВИДЫ РОДА DIDYMODON (POTTIACEAE, MUSCI) В РОССИИ. I. ВИДЫ С ЛОМКИМИ ВЕРХУШКАМИ

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Abstract

Six species of the genus *Didymodon* with caducous leaf apices are reported from Russia (Siberia) based on collections from KRF, IRK, MHA, LE. The specimens previously identified as *D. rigidulus* s.lat. and *D. johansenii* (Williams) Crum are found to represent also *D. anserinocapitatus* (X.-j. Li) Zand., *D. hedysariformis* T. Otn., *D. gaochienii* B.C. Tan & Y. Jia, and a new species *Didymodon murrayae*, T. Otn. sp. nov. Diagnostic characters and illustrations are provided for the taxa. For *D. hedysariformis* and *D. johansenii* sporophytes are found, for *D. gaochienii* and *D. murrayae* perichaetia are also indicated.

Abstract

Рассматриваются 6 видов рода *Didymodon*, обладающих ломкими и опадающими верхушками, служащими органом вегетативного размножения. При изучении бриологических коллекций в гербариях KRF, IRK, MHA, LE обнаружено, что образцы, определявшиеся ранее как *Didymodon rigidulus* s. lat. и *D. johansenii* (Williams) Crum, включают также *D. anserinocapitatus* (X.-j. Li) Zand., *D. hedysariformis* T. Otn., *D. gaochienii* B.C. Tan et Y. Jia и новый для науки вид *Didymodon murrayae*. Для таксонов приводятся диагнозы и иллюстрации. У *D. hedysariformis* и *D. johansenii* обнаружены спорогонии, для *D. gaochienii* и *D. murrayae* известны только перихеции.

Present paper is a result of a study of the *Didymodon* species (Pottiaceae, Musci) firstly identified as *D. rigidulus* s.lat. and *D. johansenii* (Williams) Crum in herbaria IRK, LE, MHA. These species were found to be confused with *D. anserinocapitatus* (X.-j. Li) Zand. recently reported to Russia from South Siberia (Otnyukova & Zander, 1998), *D. hedysariformis* T. Otn. described from Tuva region of South Siberia (Otnyukova, 1998) and later found in Yakutia (Ignatov & al., 2001), *D. gaochienii* B.C. Tan & Y. Jia recently described from China (Tan & Jia Yu, 1997) and then reported to Tuva region (Otnyukova, 2000), and *D. murrayae*, described here as a new species.

KEY TO THE DIDYMODON SPECIES WITH CADUCOUS LEAF APICES AND LONG-EXCURRENT COSTA IN RUSSIA

1. Leaves appressed or spreading, gradually narrowing into a short or long apex, not

abruptly differentiated from the rest of leaf, sometimes partly fragile; costa excurrent, short and rigid or long and hairlike, straight or flexuose *D. rigidulus* s. l.
– Leaves appressed or coiled around the stem, gradually narrowing into the apex, abruptly differentiated from the rest of leaf (especially seen near an inflorescence), very fragile and caducous, often absent in collections; costa percurrent or excurrent 2
2. Leaf apices differentiated as swollen, thickened and fleshy propagulae, bearing only costa; leaf margins below the fracture entire 3
– Leaf apices differentiated as variably notched and partially fractured units, forming a series of caducous segments, including lamina as well as costa; leaf margins below the fracture notched or more rarely entire 4

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3. Costa excurrent as an even, spear-shaped or lanceolate propagulum without constrictions; costa in cross section with guide cells in two layers; upper laminal cells 6-8(10) μm wide *D. anserinocapitatus*
 – Costa excurrent as an irregular, lanceolate propagulum constricted medially once or twice; costa in cross section with guide cells in one layer; laminal cells below the fracture 11-13(15) μm wide *D. johansenii*
4. Leaf apex wide, with lamina in 2-6 rows (or more) of cells, fractured into wide, irregular units 5
 – Leaf apex narrow with lamina in 1(2) row of cells, fractured into narrow, square or rectangular segments 6
5. Leaf apex not winding, with a few and shallow notches, forming irregular-angular segments, marginally and apically dentate; cells of leaf apex conic-mamillose [*D. sinuosus* (Mitt.) Delogn.]*
 – Leaf apex unevenly windingly-broken into a series of angular-rounded segments, marginally and apically smooth; cells of leaf apex smooth *D. hedysarifformis*
6. Leaf apex cylindrical, regularly notched, forming square or rectangular segments, entire; costa ending in the apex or several cells below; upper laminal cells below the fracture 10-13 μm wide *D. gaochienii*
 – Leaf apex cylindrical to flexuose, irregularly notched, forming rectangular segments below, towards the tip indistinctly segmented, the distal segment toothed (mainly three-toothed) at tip; costa excurrent; upper laminal cells below the fracture 6-9 μm wide *D. murrayae*

Diagnostic characters of the *Didymodon* species are shown also in Tables 1 and 2.

Didymodon rigidulus Hedw., Sp. Musc. 104.1801. Fig. 1 (1-32).

This species is polymorphic, with several varieties (Zander, 1998) and it is included in the present investigation because of costa long-

excurrent (in some varieties) and sometimes fragile. Nevertheless this species differs from other species that included in the present study by characters given in the Table 1. When the upper margins are not bistratose or axillary gemmae are absent, *D. rigidulus* can be distinguished by the combination of the long-triangular or oblong-lanceolate leaves with the broadly ovate base, and the excurrent costa with cylindrical apex, that is never swollen or segmented, though sometimes flexuose or fragile. Two plants of *D. rigidulus* s. lat., with short- and long-excurrent costae are shown in Fig. 1. Excurrent portion of costa is flexuose in both of them. This group of taxa needs further study, which is outside of the scope of this paper.

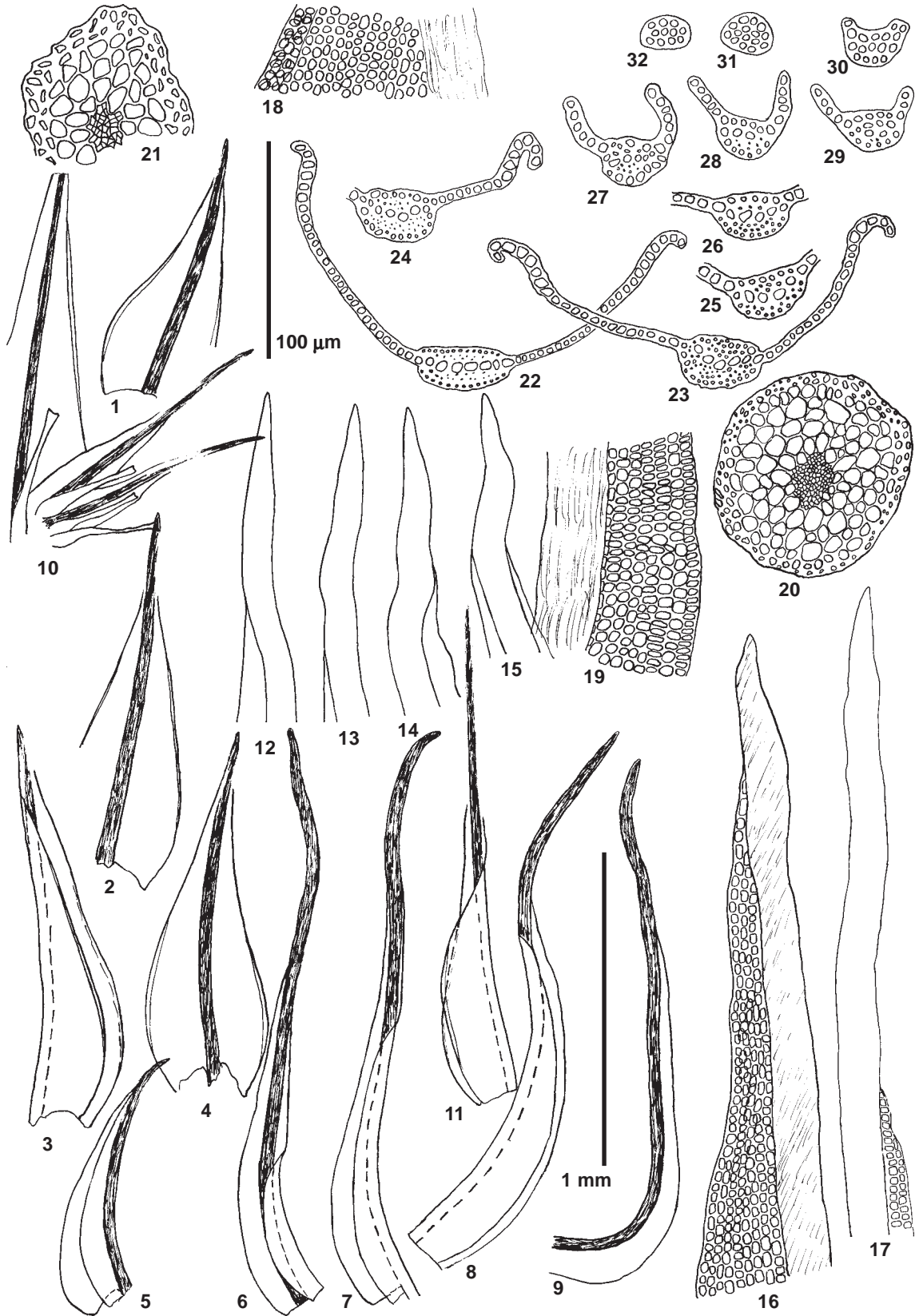
Specimens examined. **Tuva Republic:** Todginskaya Valley, Biy-Khem (Big Yenisey) River basin, its left bank, Arbyk Greek mouth, on weathered sandstone rocks, 26.VII.1996, T. Otnyukova (KRF). **Altai:** Tabozhok Creek, ca 2400m, 8 km upstream, xeric S-facing slope, among rocks, 29.VII.1992, M. Ignatov # 30/122 (MHA), rock outcrops on open slope, 29.VII.1992, M. Ignatov (MHA); Malyy Yaloman Creek, ca. 1000 m, 7 km upstream, rather wet cliff at valley bottom, with *D. anserinocapitatus*, 31.VII.1991, M. Ignatov 25/54 (MHA), ca 950 m, N-facing slope, cliff crevices, with *D. anserinocapitatus*, 30.VII.1991, M. Ignatov, 25/125 (MHA, as *D. johansenii*); Chemal, wet rock along Katun River bank, 5.VIII.1991, M. Ignatov, 29/62 (MHA); with *D. anserinocapitatus*, # 25/182 (MHA); with *D. anserinocapitatus* and *Bryum argenteum*, # 25/36 (MHA); with *D. anserinocapitatus*, # 17/42 (MHA).

Didymodon anserinocapitatus (X.-j. Li) Zand., Bul. Buffalo Soc. Nat. Sci. 32: 162. 1993.

Barbula anserino-capitata X.-j. Li. Acta Bot. Yunnan. 3: 103. 1981. Fig. 2 (1-11).

This propaguliferous species is easy to recognize as explained by Zander (1998, 1999), Zander & Weber (1997), and Otnyukova & Zander (1998). Before it was usually confused with *D. johansenii* and reported under this name (e.g., Otnyukova, 1995), and Tan & Jia Yu (1997) synonymized *D. anserinocapitatus* with *D. johansenii*. Both these species have swollen apices abruptly differentiated from the rest of the leaf and bearing only costa. Distinctive characters of *D. anserinocapitatus* include a regular, lanceolate or spear-shaped excurrent costa and the smaller size of the upper laminal cells. Nevertheless, some leaves can approach *D.*

* – This species is known only from Europe



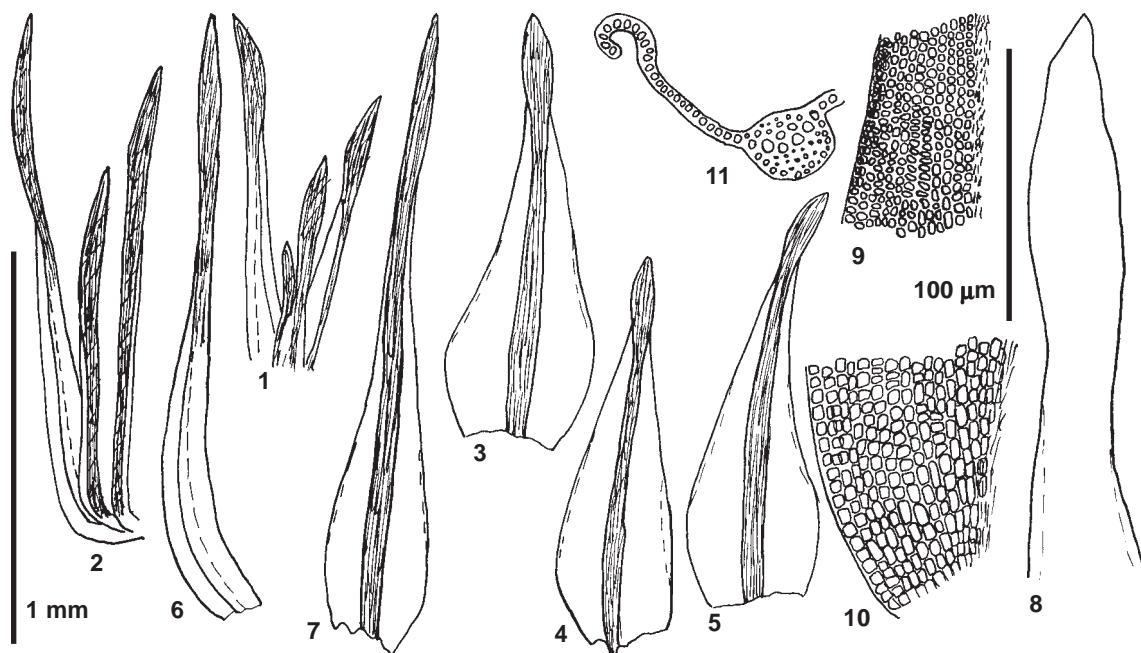


Fig. 2. *Didymodon anserinocapitatus* (X.-j. Li) Zand. (1, 3-5, 8-11 – from Yenisey River bank, 30.VI.1995, T. Otnyukova, KRF; 2, 6, 7 – from Altai, M. Ignatov # 25/155, MHA). 1, 2 – shoot tips with young leaves near inflorescence; 3-7 – leaves; 8 – leaf tip; 9 – median leaf cells; 10 – cells of leaf base; 11 – leaf cross section. Scale bars: 1 mm – for 1-7; 100 µm – for 8-11.

johanseni in having leaf apices not much widened or somewhat irregular in shape. In this case *D. anserinocapitatus* can be recognized by the double layer of guide cells in costa near leaf middle (single in *D. johanseni*).

Didymodon anserinocapitatus varies in size of plants and leaves, which are shorter in xeric habitats and longer in more mesic ones. This species is scarcely variable in shape of leaf base, which is broad- to long-ovate and sheathing at insertion.

Gametangia and sporophytes unknown.

Recently it was found also in Mongolia (Tsegmed, 2001).

Specimens examined. **Krasnoyarsk Territory:** Krasnoyarsk City vicinity, Yenisey River left bank, ca. 250 m., on rocks, 30.VI.1995, 6.VII.1996, T. Otnyukova (KRF). **Khakasia:** Shirinskii District, Efremkino Village vicinity, Bolshoi (Big) Iyus River valley, ca. 410 m, on rocks, 16.VI.1970, A.N. Vasiljev (IRK, as *D. johanseni*). **Altai:** Malyi Yaloman Creek, ca. 1000 m, 7 km upstream, rather wet cliff at valley bottom, with *D. rigidulus* s.l., 31.VII.1991, M. Ignatov # 25/54 (MHA); ca. 950 m, N-facing xeric slope, cliff crevices, with *D. rigidulus* s.l., 30.VII.1991, M. Ignatov # 25/155

(MHA, as *D. johanseni*); with *D. rigidulus* s.l., # 25/182 (MHA); with *D. rigidulus* s.l. and *Bryum argenteum*, # 25/36 (MHA); with *D. rigidulus* s.l., # 17/42 (MHA).

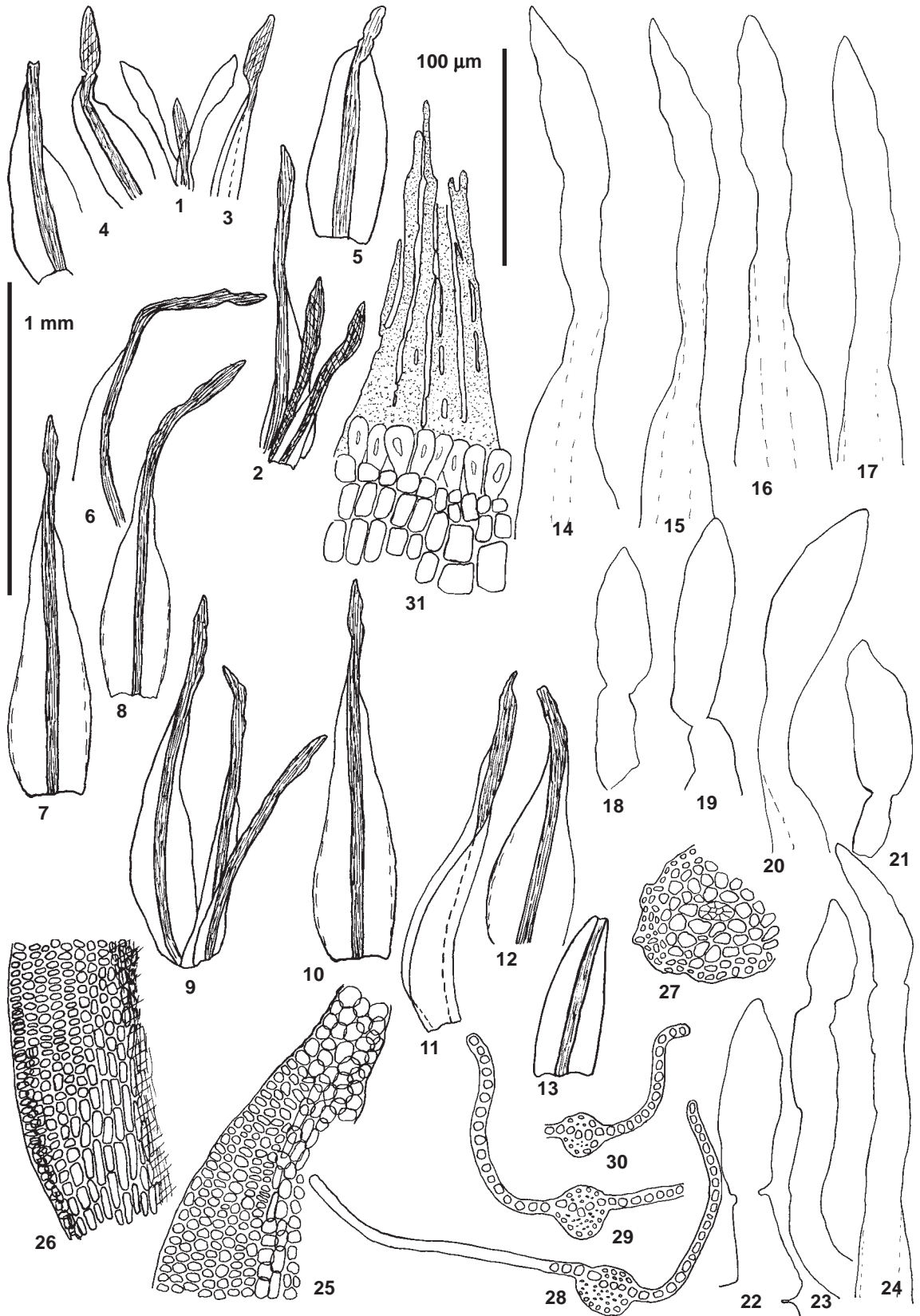
Didymodon johanseni (R.S. Williams) H.A. Crum, *Canad. Field-Nat.* 83:157. 1969.

Barbula johanseni R.S. Williams, *Rep. Canad. Arctic Exped.* 1913-18, Bot. 4E: 4. 1921.

(1-36). Fig. 3

Until recently all the specimens of *Dydimodon* with swollen and fragile leaf apices were referred to *D. johanseni*. The present understanding of this species is narrower. It is characterized by the clavate or the constricted medially once or twice leaf apices, and the mainly oblate and the relatively large cells below the caducous apices (11-13(-15) µm wide). This species is very variable in shape of leaves. The upper mature leaves have distinctly clavate, swollen and fragile apices. However the lower leaves are rather gradually tapering and have no deciduous apices. Arctic and some high-

Fig. 3. *Didymodon johanseni* (R.S. Williams) H.A. Crum (1, 3-5, 13, 18-22, 25 – from Chukotka, 9.VIII.1991, O.M. Afonina, LE); 2, 6-12, 14-17, 23, 24, 26-31 – from Altai, 16.VII.1966, L.V. Bardunov, IRK). 1, 2 – shoot tips with young leaves near an inflorescence; 3-13 – upper stem leaves; 14-24 – tips of leaves; 25 – cells of leaf upper part; 26 – cells of leaf base; 27 – stem cross section; 28-30 – cross section of leaves; 31 – peristome teeth. Scale bar: 1 mm – for 1-13; 100 µm – for 14-31.



mountain populations have relatively short and wide leaf apex, approaching that of *D. anserinocapitatus*. At the same time, plants from the more southern mountain populations have longer apices, which are not much widened or clavate and are somewhat flexuose, thus approaching to those of *D. gaochienii* and *D. murrayae*.

Didymodon anserinocapitatus and *D. johansenii* can be recognized by of the double layer of guide cells and the smaller upper laminal cells in the former, vs. one layer of guide cells and the bigger upper laminal cells in the latter.

Didymodon johansenii and *D. gaochienii* have similar lower leaves, gradually narrowed to the apex, which is neither segmented, nor widened; also both species have large laminal cells. However the leaves near inflorescence are different: the leaf apices are regularly segmented and not swollen in *D. gaochienii* and irregularly constricted or clavate and swollen in *D. johansenii*.

Sporophytes are very rare:

Perichaetial leaves similar to stem leaves. Seta 4-5 mm long, red-brown. Capsule almost erect, ovate, symmetric; urn about 1.5-1.7 mm long and up to 0.6 mm wide; operculum rostrate, rostrum slightly curved, 0.8-1.0 mm long. Peristome teeth very pale, almost white, erect and long, 170-200 μm , papillose throughout. Spores 6-8 μm , papillose.

Specimens examined: **Chukotka**: Chegitun River upper course, on rocks, 9.VIII.1991, O.M. Afonina (LE). **West Sayan Mts.**: Karasy River upstream, goltsy, ca. 2200 m, on rock, 6.VII.1968, L.V. Bardunov (IRK). **Altai**: Belii (White) Bom, ca. 900 m, *Betula* forest, on rotten wood, with sporophytes, 16.VII.1966, L.V. Bardunov (IRK); Tokpak Creek, ca. 2400 m, upper course, rather dry S-facing rocks, 24.VII.1993, M. Ignatov # 36/274 (MHA).

Didymodon hedysarifformis T. Otn., Arctoa. 7: 207-210. 1998. Fig. 4 (1-18).

This species was recently described from Tuva Republic, South Siberia (Otnyukova, 1998) and was subsequently found in Yakutia (Ignatov & al., 2001) and in several localities in Mongolia (Tsegmed, 2001). Among the species with caducous leaf apices *D. hedysarifformis* is easily recognized by the broadly oblong and deeply notched and windingly-fractured leaf apex, fragmenting into irregular, angular-rounded units. However some mature leaves if they are not so windingly-broken approach *D. gaochienii* in the leaf-apex appearance. In this case specimens can be checked for the presence

of the strongly windingly-broken apices in leaves near an inflorescence, which always have lamina of 2-6 rows of cells in *D. hedysarifformis*.

Perichaetia are very common in of *D. hedysarifformis*, while perigonia are very rare. Sporophytes if present are usually numerous.

Outer perichaetial leaves similar to vegetative leaves and different from inner ones. Inner perichaetial leaves oblong-lanceolate, sheathing below, abruptly constricted above into a cylindrical, weakly notched and blunt apex. Perigonial leaves broadly ovate, sheathing below, abruptly constricted above into a short, weakly notched and blunt apex. Seta 6-7 mm long, red-brown. Capsule erect, ovate, symmetric. Urn about 1.5-1.7 mm long and 0.6-0.7 mm wide; the peristome teeth yellow-orange above and red-orange below, short and eroded, 50-70(100) μm , papillose throughout. Operculum slightly curved, 0.9-1.1 mm long. Spores 6-8 μm , papillose.

Didymodon hedysarifformis is variable mainly in leaf characters: leaves are short or long, abruptly or gradually narrowed upward. Plants form small and dense tufts in xerix and open habitats or tall and loose ones in mesic and shady places.

Specimens examined. **Tuva Republic**: Todginskaya Valley, Biy-Khem (Big Yenisey) River basin, its right bank, Toora-Khem River, on eroded basalt sones, with sporophytes, 24.VII.1999, T. Otnyukova (KRF); at base of trunk of *Betula*, with sporophytes, 24.VII.1999, T. Otnyukova (KRF); Azas (Todga) Lake basin, Azas River, its lower part, on eroded sandstone rocks, with sporophytes and perigonia, 27.VIII.1997, T. Otnyukova (KRF). **Altai**: Chulcha River, ca. 1100 m, in middle course, on dry rock in shade of aspen, 10.VII.1991, M. Ignatov # 9/168 (MHA, as *D. johansenii*); Ust-Sema, ca. 340 m, on exposed boulder of Katun River bar, 27.VII.1991, M. Ignatov # 24/53 (MHA, as *D. johansenii*).

Didymodon gaochienii B.C. Tan et Y. Jia, J. Hattori Bot. Lab. 82: 309. 1997. Fig. 5 (1-31).

This species was just recently described from China. Later it was reported from Tuva Republic in Siberia (Otnyukova, 2000) and also from several localities in Mongolia (Tsegmed, 2001). This species is characterized by the shape of leaf apex: narrowly oblong and repeatedly segmented into regular, square and rectangular units. It is easily recognized in the field by the numerous leaves without apices closely coiled around the stem when dry, as well as the young leaves coiled but bearing straight, long-cylindrical and segmented apices. The latter

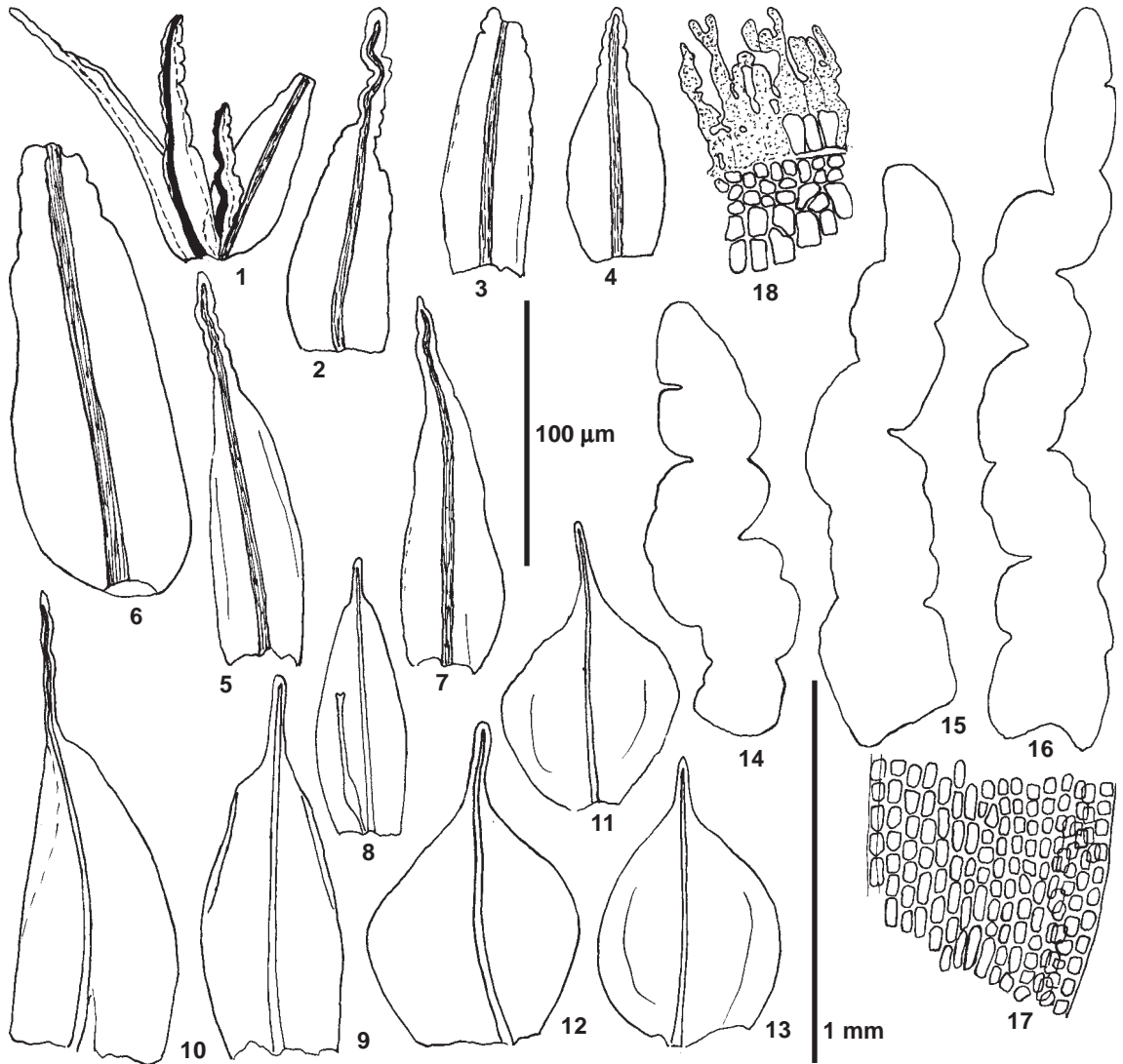


Fig. 4. *Didymodon hedysarifformis* T. Otn. (1, 3-5, 7 – from Altai, M. Ignatov # 9/168, MHA; 2, 6, 8-13-18 – from Tuva, 27.VIII.1997, T. Otnyukova, KRF). 1 – tip of shoot with young leaves near an inflorescence; 2-7 – leaves; 8-10 – perichaetial leaves; 11-13 – perigonal leaves; 14-16 – fragile upper part of leaves; 17 – cells of leaf base; 18 – peristome teeth. Scale bars: 1 mm – for 1-13; 100 μm – for 14-18.

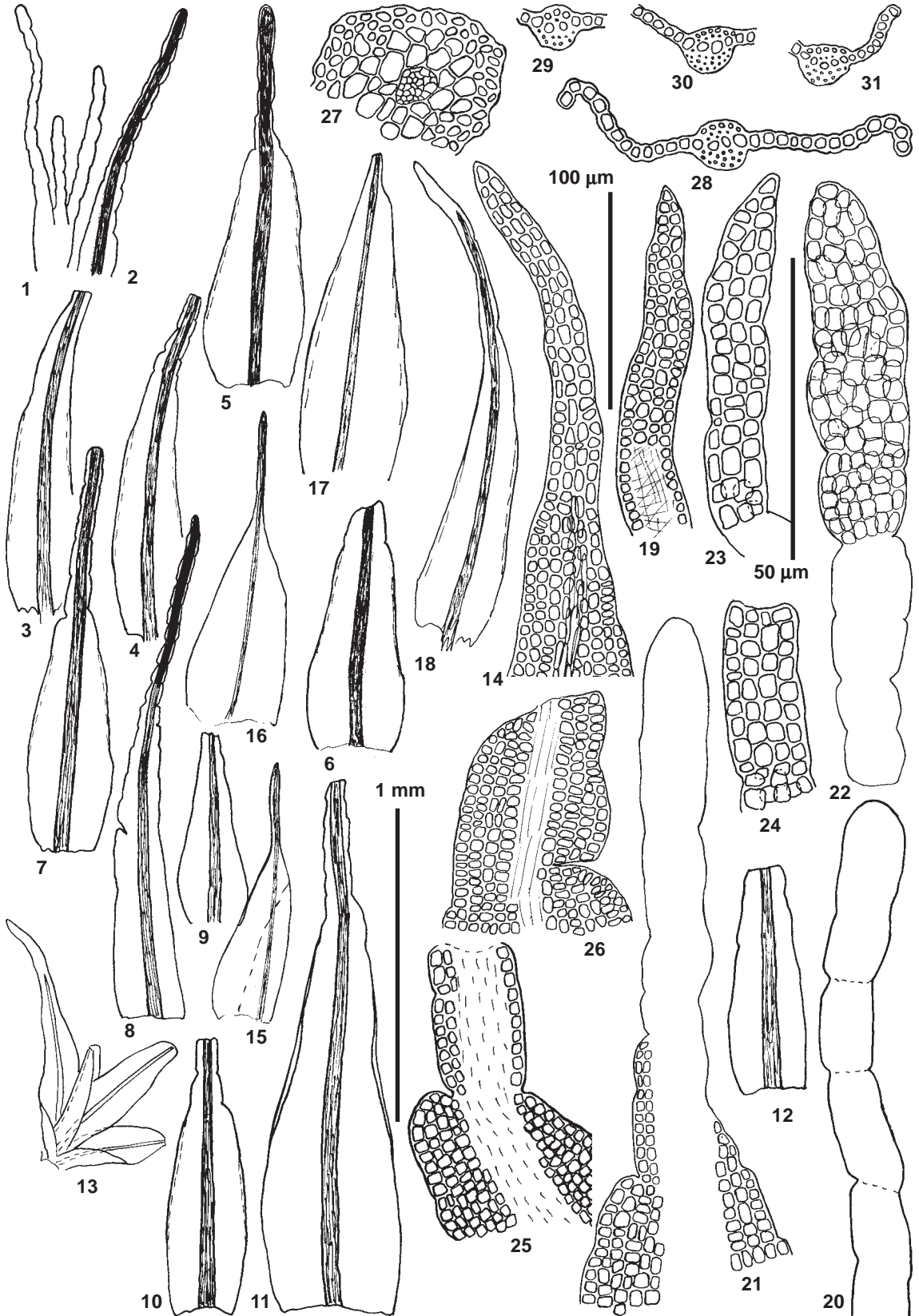
are very fragile and usually are absent in herbarium specimens.

Inner and outer perichaetial leaves are different: outer perichaetial leaves oblong-lanceolate, not sheathing, gradually narrowing into a long-cylindrical, slightly winding, not segmented, acute apex, costa strong, ending near middle part apex. Inner perichaetial leaves ovate-lanceolate, sheathing, abruptly narrowing into a cylindrical and blunt apex, costa weak and narrow, ending in apex. Sporophytes unknown.

Didymodon gaochienii is variable in height of cushions from very short, 3-5 mm (in xerix

and open places) to more tall, 1.8-2.5 cm (in more mesic and shady habitats). Leaves are different along the stem in their width of the leaf base. The upper stem leaves are also variable in shape of their apices, from widely rounded to bluntly acuminate. The lower stem leaves and the outer perichaetial leaves of *D. gaochienii* are somewhat similar to the lower stem leaves of *D. murrayae*, but they differ in size of the laminal cells and some other characters summarized in Tabl. 2.

Specimens examined. Tuva Republic: Todginskaya Valley, the west extremity of the Kadysh Lake, its north bank, ca.



1100 m., on stone, 30.VII.1999, T. Otnyukova (KRF). **Altai:** Seminskiy Pass, ca. 1600 m., in fissures of rock, with perichaetia, 14.VI.1966, L.V. Bardunov (IRK, as *D. johansenii*); Kayakkatuyarykskij Creek, ca. 1900 m, S-facing slope, in shade of *Rhododendron*, with perichaetia, 6.VII.1991, M. Ignatov # 8/329 (MHA); ca. 2150 m, S-facing slope, dry rock outcrops, I.VII.1991, M. Ignatov # 7/114 (MHA, as *D. johansenii*); Chulcha River, ca. 1100 m, in middle course rock outcrops on S-facing slope, on dry rocks, 11.VII.1991, M. Ignatov # 9/42 (MHA, as *D. johansenii*); Karakhem Valley, Kukhol Cliff, dry rocks, 22.VI.1989, M. Ignatov (MHA, as *D. johansenii*). **China:** Qinghai province, Nangqen Co., Bagu Valley, Upper Laxiu, river bank, on trunk of willow, 23.VI.1995, B.C. Tan 95-250. **Mongolia:** SE Khentei, on rocks, 23.VIII.1986, Ts. Tsegmed 9544.

Didymodon murrayae T. Otn., sp. nov.

Fig. 6

(1-42).

Plantae caespitosae. Folia juvenila ovato-lanceolata, margine inferne planata, superne sinuata; apex inferne sinuatus segmentatus, superne flexuosus; nervus excurrens et dentatus apiculatus in cuspidem. Folia matura infracta.

Species affinis *Didymodon gaochienii* B.C. Tan et Y. Jia cui est apex longus angustatus, nervus percurrens, cellulae majores.

HOLOTYPUS: Russia, Altai, Katanda, 1190 m s.m., in ripa, supra lapides, 21.VI.1966, L.V. Bardunov (IRK, isotypi – KRF, MHA).

Plants forming lax or dense tufts, yellow-green to yellow-brown. Stem up to 1.5(-2.0) cm long or smaller, branched in upper part; sclerodermis present, thick, central strand present, distinct; rhizoids few below, scarcely scattered above. Leaves appressed when dry, spreading when moist, lanceolate, 1.5 mm long, without apices 0.6-0.9 mm long, 0.2-0.4 mm wide, margins recurved at mid-leaf, near the fracture entire or notched. Apices 0.3-0.7 mm long, very fragile and caducous, acute, scarcely angular-winding, repeatedly segmented into a series of rectangular units, bearing lamina as well as costa, basal segments with 2-4 rows of laminal cells, upper segments with 1(2) rows of distinct or indistinct cells, apical segment three-toothed. Costa excurrent, red-brown, gradually narrowing towards apex, not widened in excurrency, excurrent portion 0.1-0.3 mm long; dorsal stereid

band strong, ventral stereid band weak or absent, guide cells in one layer. Upper laminal cells irregularly polygonal, rectangular or quadrate, (4)6-9(12) μm long, 5-7(9) μm wide, more or less thick-walled, papillae essentially absent; basal laminal cells 15-20(30) μm long, 6-9 μm wide.

Inner perichaetial leaves ovate, strongly sheathing, abruptly constricted into a narrow, cylindrical and weakly notched subula with costa ending in apex, very fragile and caducous; outer leaves long, oblong-lanceolate, caducous (apex not seen). Sporophyte unknown.

HOLOTYPUS: Russia. Altai Mts, Katanda, ca 1190 m, river bank, on stone, 21.VI.1966, L.V. Bardunov (IRK; isotyps – KRF, MHA).

This new species is very similar to *D. gaochienii* and can be easily confused with it. For their differentiation it is very important to study fallen apices of leaves (they can be found among plants and soil in envelope with samples). The leaf apices in *D. murrayae* are usually almost black-brown, scarcely angular-winding, unclearly segmented or not segmented and bluntly acute or acute at the tip, whereas in *D. gaochienii* leaf apices are usually green or green-brown, not winding, but clearly regularly segmented and rounded or rounded-acute at the tip. Besides this, in *D. murrayae* all juvenile leaves bear three-toothed apical segment (especially seen in an inflorescence) whereas in *D. gaochienii* juvenile leaf apices are rounded, sometimes they may be bluntly-acute at the tip but never three-toothed. These two species are also distinguished in size of cells.

Didymodon murrayae differs from *D. rigidulus* s. lat. in narrower and lanceolate leaves vs. long-triangular in the latter. Other species with caducous leaf apices differ from *D. murrayae* by the entire juvenile leaf apices as seen in an inflorescence.

This species is named in honor of American bryologist, Barbara Murray.

Specimens examined: **Altai:** Mts, Katanda, ca. 1190 m, river bank, on stone, with perichaetia, L.V. Bardunov, 21.VII.1966 (IRK); # 13/34 (MHA), # 0/166, on rotten wood, with perichaetia (MHA).

Fig. 5. *Didymodon gaochienii* B.C. Tan et Y. Jia (1-4, 10-12, 13, 21, 22 – from Tuva, 30.VII.1999, T. Otnyukova, KRF; 5, 6, 7-9, 18-20, 25 – from Altai, 14.VI.1966, L.V. Bardunov, IRK; 14-17, 23, 24, 26-31 – from Altai, 6.VII.1991, M. Ignatov # 8/329, MHA): 1 – tip of shoot with young leaves near inflorescence; 2-13 – upper stem leaves; 14 – leaf cells of lower stem leaf; 15-17 – inner perichaetial leaves; 18 – outer perichaetial leaf; 19 – leaf cells of outer perichaetial leaf; 20, 21 – upper part of leaves; 22, 23 – cells of juvenile leaves; 24 – cells of lower part of fragile leaf tip; 25, 26 – upper leaf cells near truncation; 27 – stem cross section; 28-31 – cross section of stem leaves. Scale bar: 1 mm – for 1-13, 15-18; 100 μm – for 14, 19-21, 25-31; 50 μm – for 22-24.

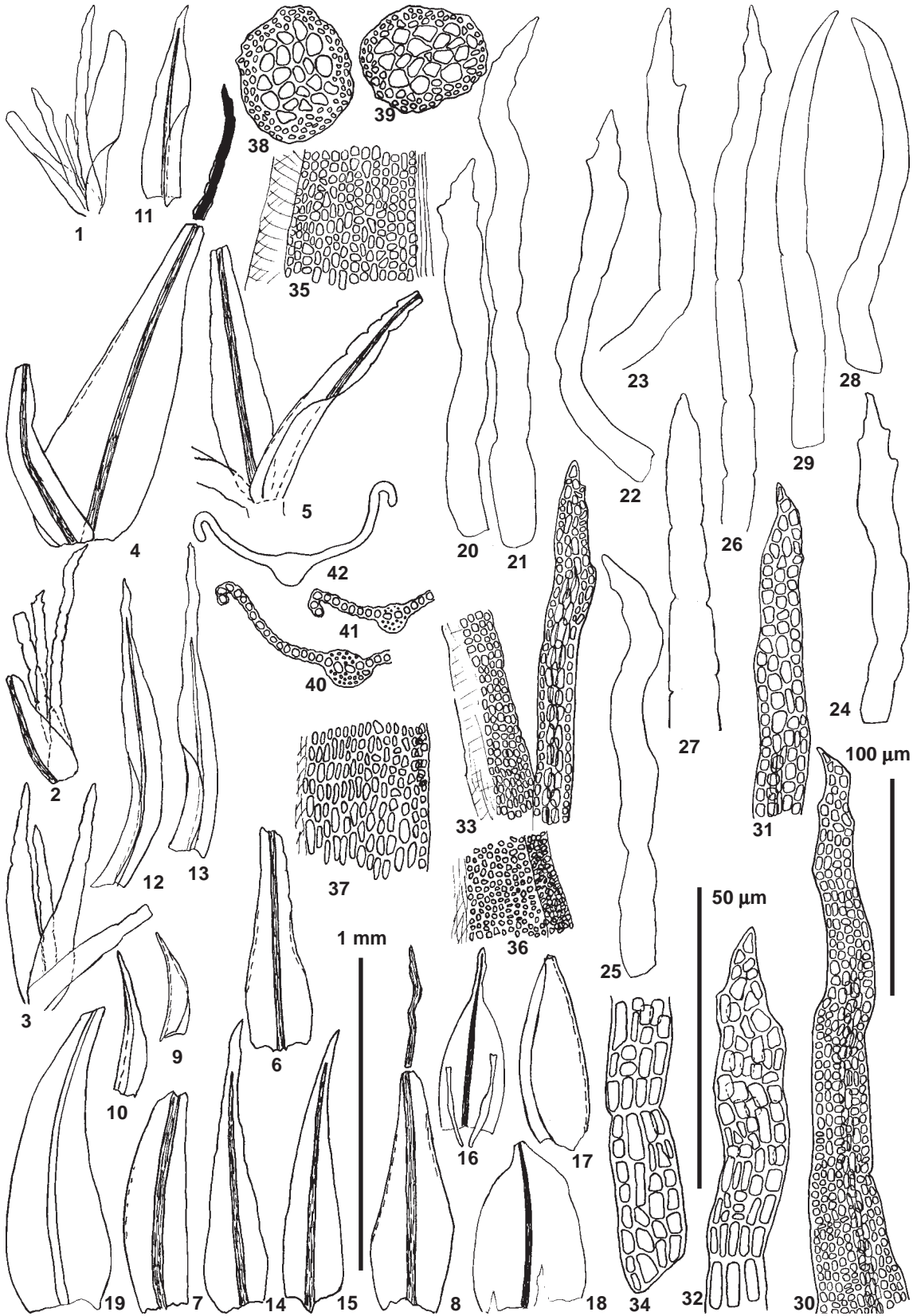


Table 1. Comparison of *Didymodon* species with the long-excurrent costa, swollen and caducous or fragile leaf apices.

Character	<i>D. rigidulus</i>	<i>D. anserinocapitatus</i>	<i>D. johansenii</i>
Plants	yellowish to brownish or dark green	reddish green	brownish green
Leaves	appressed to slightly curved or spreading when dry, erect-spreading when moist, long-triangular to long-ovate; base evenly or abruptly broadened, sheathing in insertion; margins bistratose or unistratose in the upper part, strongly or slightly recurved at midleaf, entire	erect-appressed when dry, spreading when moist, lanceolate; base short-sheathing to long-ovate; margins strongly recurved at midleaf, entire	erect-appressed when dry, spreading when moist, lanceolate; base oblong-lanceolate; margins slightly recurved at midleaf, entire
Costa	strong, short to long-excurrent, excurrency 1/12-1/2 of the leaf length, straight or flexuose, gradually narrowing towards apex or almost cylindrical, shape in excurrency, excurrency, not deciduous as propagulum, sometimes occasionally fragile (usually in herbarium)	very strong, excurrent, little widened at midleaf, gradually narrowing towards apex but swollen in excurrency, scarcely differentiated in excurrency, strongly deciduous as a propagulum	more or less strong, excurrent, little widened at midleaf, gradually tapering towards apex but swollen in acute in apex, not swollen in differentiated in shape in excurrency, in upper leaves swollen and deciduous as a propagulum, in lower leaves slightly swollen and usually not deciduous
Upper leaf cells	rounded-quadrate to short-rectangular or transverse-rectangular, (5)7-9(12) μm long and (6)8-11(13) μm wide, papillose or smooth	rounded-quadrate, (4)7-10 μm long and (5)6-8(10) μm wide, mainly thin-walled, smooth	transverse-elliptic to rounded-quadrate, (6)10-13 μm long and (8)11-13(15) μm wide, mainly thick-walled, smooth
Lower leaf cells	16-23x7-9 μm	14-23x6-8 μm	20-33x7-10 μm
Costa in cross section at midleaf	guide cells in one layer, dorsal stereid band strong, ventral stereid band weak, dorsal and ventral epidermis differentiated	guide cells in two layers, dorsal stereid band strong, ventral stereid band very weak or absent, dorsal and ventral epidermis differentiated	guide cells in one layer, dorsal stereid band strong, ventral stereid band weak, dorsal and ventral epidermis differentiated
Stem in cross section	with small or large sclerodermis cells, and strong central strand	with small sclerodermis cells, and weak central strand	with large sclerodermis cells, and relatively strong central strand
Propagula	gemmae composed of 1 or several cells or absent	consist of mainly fallen costa, swollen, regular in shape, spear-like or lanceolate, mainly rounded in cross section	consist of mainly fallen costa, swollen, generally irregular in shape, constricted medially once or twice, sometimes clavate, mainly elliptic in cross section
Perichaetial leaves	like vegetative leaves, but larger, long-triangular; costa long-excurrent, excurrency 1/8-1/3 of leaf length, erect-appressed or curved	unknown	inner leaves large, convolute-sheathing, abruptly narrowing into a cylindrical subula, deciduous very soon; outer leaves like stem leaves

Fig. 6. *Didymodon murrayae* T. Otn., sp. nov. (1, 5, 16-19, 26, 31, 33, 35, 40-42 – from Altai, Ignatov, # 0/166, MHA; 2, 4, 6-11, 14, 15, 20-24, 32, 34, 36, 37, 39 – from Altai, 21.VI.1966, L.V. Bardunov, IRK; 3, 12, 13, 25, 27-31, 38 – from Altai, Ignatov, # 13/34, MHA). 1-3 – shoot tips with young leaves near inflorescence; 4, 5 – mature truncate leaves in the middle part of stems; 6-8 – median stem leaves; 9-15 – lower stem leaves; 16-18 – inner perichaetial leaves; 19 – outer perichaetial leaf; 20-29 – fragile upper part of leaves (front view, 20-27, and side view, 28-29); 30 – leaf cells of lower stem leaf; 31, 32 – cells of juvenile leaves; 33 – upper and median cells of juvenile leaves; 34 – cells of lower part of fragile leaf tip; 35, 36 – median leaf cells; 37 – cells of leaf base; 38, 39 – stem cross sections; 40-41 – cross sections of stem leaves. Scale bars: 1 mm – for 1-19; 100 μm – for 20-30, 33, 35-42; 50 μm – for 31, 32, 34

Table 2. Comparison characters of *Didymodon* species with leaf apices deciduous as propagula

Character	<i>D. hedysarififormis</i>	<i>D. gaochienii</i>	<i>D. murrayae</i>
Plants	green above, brown below	green above, brown below	yellowish green
Leaves	curved to appressed, oblong-lanceolate, gradually narrowing into oblong-lanceolate, rounded or blunt apex, caducous when mature, margin recurved at midleaf, near fracture notched or entire; lower leaves small, entire, not fragile	coiled to curved, oblong-lanceolate, gradually narrowing into cylindrical and somewhat flexuose, broadly- or acute-rounded apex, caducous when mature, margin recurved at midleaf, near fracture notched or entire; lower leaves shorter, lanceolate, gradually narrowing into long, cylindrical subula, entire, not fragile	coiled to curved, oblong-lanceolate, gradually or \pm abruptly narrowing into cylindrical, flexuose and acute apex (especially well seen near inflorescence), very fragile, margins recurved at midleaf, near fracture entire or notched; lower leaves shorter, lanceolate, entire below and more or less clearly toothed (three-toothed) at tip, not fragile
Costa	more or less strong, red, percurrent, gradually narrowing, ending in the apex or few cells below, in lower leaves percurrent or ending several cells below	more or less strong, red, percurrent, gradually narrowing, ending in the apex or few cells below, in lower leaves ending many cells below	more or less strong, red, excurrent, gradually narrowing, not widened in excurrency, in lower leaves ending many cells below
Leaf apices	1/5-1/3 of leaf length, bearing lamina as well as costa, lamina of (2)4-6(8) rows of cells throughout, irregularly deeply notched, windingly-fractured, forming angular-rounded segments, smooth, serving as propagula	1/3-1/5 of leaf length, bearing lamina as well as costa, lamina in upper part of only 1 row of cells, below of 2-4 rows of cells, regularly notched, forming a series of square or rectangular segments, smooth, serving as propagula	1/3-1/5 of leaf length, bearing lamina as well as costa, lamina in upper part of only 1 row of cells, below of 2-4 rows of cells, regularly notched, forming a series of rectangular segments, smooth, but the distal one dentate (mainly three-toothed), serving as propagula
Upper leaf cells	quadrate to short-rectangular, rectangular, (4)8-10(13) μm long and (5)6-8(13) μm wide, mainly thin-walled, smooth	transverse-ovate to rounded-quadrate, (6)9-12(15) μm long and (8)10-13(15) μm wide, mainly thick-walled, smooth	angular to quadrate or short-rectangular, (4)6-9(12) μm long and (5)6-9 μm wide, mainly thick-walled, smooth
Lower leaf cells	22-28x8-11 μm	22-29x7-10 μm	16-25x6-8 μm
Costa in cross section	dorsal and ventral epidermis somewhat differentiated	only ventral epidermis differentiated	dorsal and ventral epidermis weak or not differentiated
Stem in cross section	sclerodermis cells small, central strand strong	sclerodermis cells large, central strand strong	sclerodermis cells small central strand weak or absent
Propagula	flattened, bearing lamina as well as costa, windingly-fractured into irregular, rounded-angular units	flattened, bearing lamina as well as costa, segmented and fractured into regular, quadrate and rectangular units	flattened, bearing lamina as well as costa, flexuose, segmented into regular, rectangular units
Cells of propagula	mainly quadrate to short-rectangular, a little larger than adjoining lamina cells	mainly quadrate to short-rectangular, a little larger than adjoining lamina cells	mainly rectangular, irregular, a little larger than adjoining lamina cells

Table 2. Comparison characters of *Didymodon* species with leaf apices deciduous as propagula (end)

Perichaetial leaves	inner leaves ovate-lanceolate, sheathing, abruptly constricted into narrow, cylindrical and weakly notched subula with costa weak, ending in apex, and apex not fragile; outer leaves like stem leaves	inner leaves ovate-lanceolate, slightly sheathing, more or less abruptly constricted into narrow, cylindrical and entire or weakly notched subula with costa weak, ending in apex, weakly fragile; outer leaves long, oblong-lanceolate, gradually narrowing into acute subula with costa ending many cells below and apex not fragile	inner leaves ovate, strongly sheathing, abruptly constricted into narrow, cylindrical and unclear notched subula with costa weak, ending in apex, often caducous; outer leaves like stem leaves, strongly fragile (apex not seen)
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