

A NEW SPECIES OF *CYNODONTIUM* (RHABDOWEISIACEAE, BRYOPHYTA)
FROM RUSSIA WITH COMMENTS ON RELATED SPECIES
НОВЫЙ ВИД *CYNODONTIUM* (RHABDOWEISIACEAE, BRYOPHYTA) В РОССИИ
С КОММЕНТАРИЯМИ О БЛИЗКИХ ВИДАХ

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Abstract

Cynodontium caucasicum Ignatova & Fedosov is described as a species new for science from the Russian Caucasus based on morphological study and previously published plastid and mitochondrial molecular data. Its distinctions from closely related *C. gracilescens* and *C. asperifolium* are discussed. The Caucasian specimens were erroneously reported earlier under the name *C. fallax*. The latter species is identical to the Caucasian plants in plastid (*trnS-rps4* and *trnL-F*) and mitochondrial (*nad5*) DNA sequences, but morphological distinctions between them are bigger than between the Caucasian plants and *C. gracilescens* or *C. asperifolium*. *Cynodontium caucasicum* is confirmed for the Russian Caucasus and for Georgia, and it likely occurs also in Central Europe.

Резюме

Cynodontium caucasicum Ignatova & Fedosov описан как новый для науки вид по образцам с российского Кавказа на основании морфологического изучения и ранее опубликованных данных по пластидным и митохондриальным последовательностям ДНК. Обсуждаются его отличия от морфологически сходных и близкородственных *C. gracilescens* и *C. asperifolium*. Кавказские образцы ранее ошибочно приводились под названием *C. fallax*. Последний вид идентичен кавказским растениям по последовательностям пластидных (*trnS-rps4* и *trnL-F*) и митохондриального (*nad5*) маркеров, но по морфологическим признакам они отличаются друг от друга сильнее, чем кавказские растения отличаются от *C. gracilescens* или *C. asperifolium*. *Cynodontium caucasicum* в настоящее время достоверно известен на российском Кавказе и в Грузии, и его нахождение в Центральной Европе также весьма вероятно.

KEYWORDS: mosses, taxonomy, new species

INTRODUCTION

The genus *Cynodontium* Bruch, Schimp. & W. Gümbel, as it is currently understood (cf. Fedosov *et al.*, 2021; Brinda & Atwood, 2023), comprises ca. 30 species widely distributed in montane areas throughout the world. In Floras of Northern Hemisphere it is represented by 6–15 species, being variously treated by different authors, as some species are included in it or placed in a separate genera, *Cnestrum* I. Hag. and *Oreoweisia* (Bruch & Schimp.) De Not. (Mönkemeyer, 1927; Nyholm, 1986; Eckel, 2007; Heras & Infante, 2015; Hallingbäck *et al.*, 2006). The only treatment of *Cynodontium* for the moss flora of Russia was provided by Savicz-Lyubitskaya & Smirnova (1970). They listed 10 species for the U.S.S.R.

This treatment remains useful and is successfully applied in regional biodiversity studies for most species.

However, in the course of preparation of a review of the genus for the Moss Flora of Russia, we faced problems with two of its species, *Cynodontium fallax* Limpr. and *C. gracilescens* (F. Weber & D. Mohr) Schimp., which will be in the focus of this study.

Cynodontium fallax was considered by Savicz-Lyubitskaya & Smirnova (1970) as a rare montane species occurring in Russia in Urals, Siberia (Altai) and Far East, whereas *C. gracilescens*, also a rare alpine species, was recorded for the Caucasus and Far East (Amur River basin). Later Ignatov & Ignatova (2003) claimed that all Ural and probably all Siberian records of *C. fallax* actually belong to *C. asperifolium* (Lind. & H. Arnell) Par., and this point of view was reflected in Ignatov *et al.* (2006), who provided dubious records of *C. fallax* with question marks, except for the Russian Caucasus. How-

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ever, a preliminary revision of herbarium materials revealed that the occurrence of *C. fallax* in Russia is doubtful. We found that the Caucasian specimens identified earlier as *C. fallax* possess a combination of morphological characters which does not fit the description of this species in the protologue (Limpricht, 1890) and various Floras (Smith, 2004; Hallingbäck *et al.*, 2006; Cortini Pedrotti, 2001). *Cynodontium fallax* is characterized as having leaves with mammillae / papillae mainly on adaxial surface and few or none on abaxial one, and usually bistratose leaf margins. Instead, the Caucasian specimens have totally unistratose leaf laminae with mammillae / papillae in each cell on both surfaces. This combination of characters is also typical for *C. gracilescens* and *C. asperifolium*. However, the former species is described as having curved setae, which is not the case of the Caucasian plants in question. It also remained unclear how to separate the Caucasian plants from *C. asperifolium*. So, the aim of the present study is to reveal and describe morphological distinctions of the Caucasian specimens, to find out which species of this group occur in Russia and circumscribe their distribution within the country.

MATERIAL AND METHODS

Herbarium collections from Russia identified as *Cynodontium fallax*, *C. asperifolium*, and *C. gracilescens* were revisited in LE, MW, and MHA. All available specimens of these species from Europe were also studied.

For morphological study, traditional methods were applied. For microscopic observations and measurements, a compound light microscope Olympus CX-43 with the Infinity 1-2 digital camera and a compound light microscope Zeiss Axiolab with ocular micrometer were used. To test a significance of differences in leaf length and width between species, Mann-Whitney U test for equal medians was computed in Past 4 (Hammer *et al.*, 2001).

RESULTS

Cynodontium fallax

All records of *C. fallax* from Urals, Altai and Russian Far East mentioned in Savicz-Lyubitskaya & Smirnova (1970) were based on misidentified specimens which we refer to *C. asperifolium* or *C. tenellum* (Schimp.) Limpr. We also failed to find any other specimens that can be referred to *C. fallax*. The combination of mammillae / papillae mainly on adaxial leaf surface and few or none papillae on abaxial one, usually bistratose leaf margins, and straight, cylindrical, furrowed in dry condition capsules makes this species very similar to *C. polycarpon* (Hedw.) Schimp. They are distinguished mainly by annulus structure: in *C. fallax*, the annulus is persistent, consisting of small cells, while in *C. polycarpon* it is revoluble, consisting of 2–3 rows of large, inflated cells. The latter species is rare in Russia, it is represented in herbaria by few collections, mainly with already deoperculate capsules, but we observed an annulus of large cells. Plants from Russian Caucasus, including those found identical to European specimen in sequences of plastid

and mitochondrial markers (Fedosov *et al.*, 2021) disagree with the latter species in morphology, therefore they are considered separately.

Cynodontium gracilescens

This species was erroneously reported by Savicz-Lyubitskaya & Smirnova (1970) from the Russian Far East: the only old specimen from Amur River basin in LE actually belongs to *C. tenellum*. All studied specimens from the Caucasus identified as *C. gracilescens* possessed straight setae, whereas in most Floras (e.g., Limpricht, 1890; Hallingbäck *et al.*, 2006) *C. gracilescens* is characterized as having setae cygneous in wet condition. No specimens from the territory of Russia fully fitting the concept of *C. gracilescens* were found.

Cynodontium asperifolium

This is another species with unistratose leaf laminae and mammillae / papillae in each cell on both surfaces. It was described from southern Siberia (Kuznetsky Alatau Mts.) and was hitherto known only in Russia (Asian part and Urals), Middle Asia (Kazakhstan and Kyrgyzstan) (Ignatov *et al.*, 2006), and Mongolia (Tsegmed, 2010). It differs from the Caucasian plants in having leaves with wider acute or occasionally sub-obtuse leaf apices, cells with lower mammillae, and perichaetial leaves abruptly narrowed into very short acumina. Savicz-Lyubitskaya & Smirnova (1970) describe its stem leaves as ca. 2 mm long, which is considerably shorter than it is observed in most Caucasian specimens. According to our observations, the leaf length of *C. asperifolium* is more variable and overlap with the Caucasian plants (Fig. 3). Our measurements of leaf length and width confirm that the Caucasian plants in most cases have longer and wider leaves than *C. asperifolium*, but in few cases specimens from the Caucasus with smaller leaves, as well as specimens of *C. asperifolium* with larger leaves were observed (Fig. 3). Nevertheless, Mann-Whitney U test indicates the significance of differences between them in both leaf length and width. In unclear cases, the most reliable distinguishing characters between the Caucasian taxon and *C. asperifolium* are the shape of perichaetial leaves (see Fig. 1 E, G vs. P) and height of mammillae / papillae (Fig. 1 J vs. Q). There is also a difference in shape of perigonal leaves: they are abruptly constricted into short acumina in the Caucasian plants and obtuse in *C. asperifolium* (Fig. 1 I vs. R).

In the molecular phylogenetic analysis in Fedosov *et al.* (2021), five specimens of *C. asperifolium* were resolved in a maximally supported clade sister to *C. bruntonii*, with their joint clade in a sister position to the clade composed of ‘*C. fallax*’ (as it was called there) & *C. gracilescens*. Thus, a separate status of *C. asperifolium* and the Caucasian plants in question was confirmed.

Cynodontium species from the Caucasus

The Caucasian specimens erroneously called as *S. gracilescens* and *S. fallax* obviously represent the same

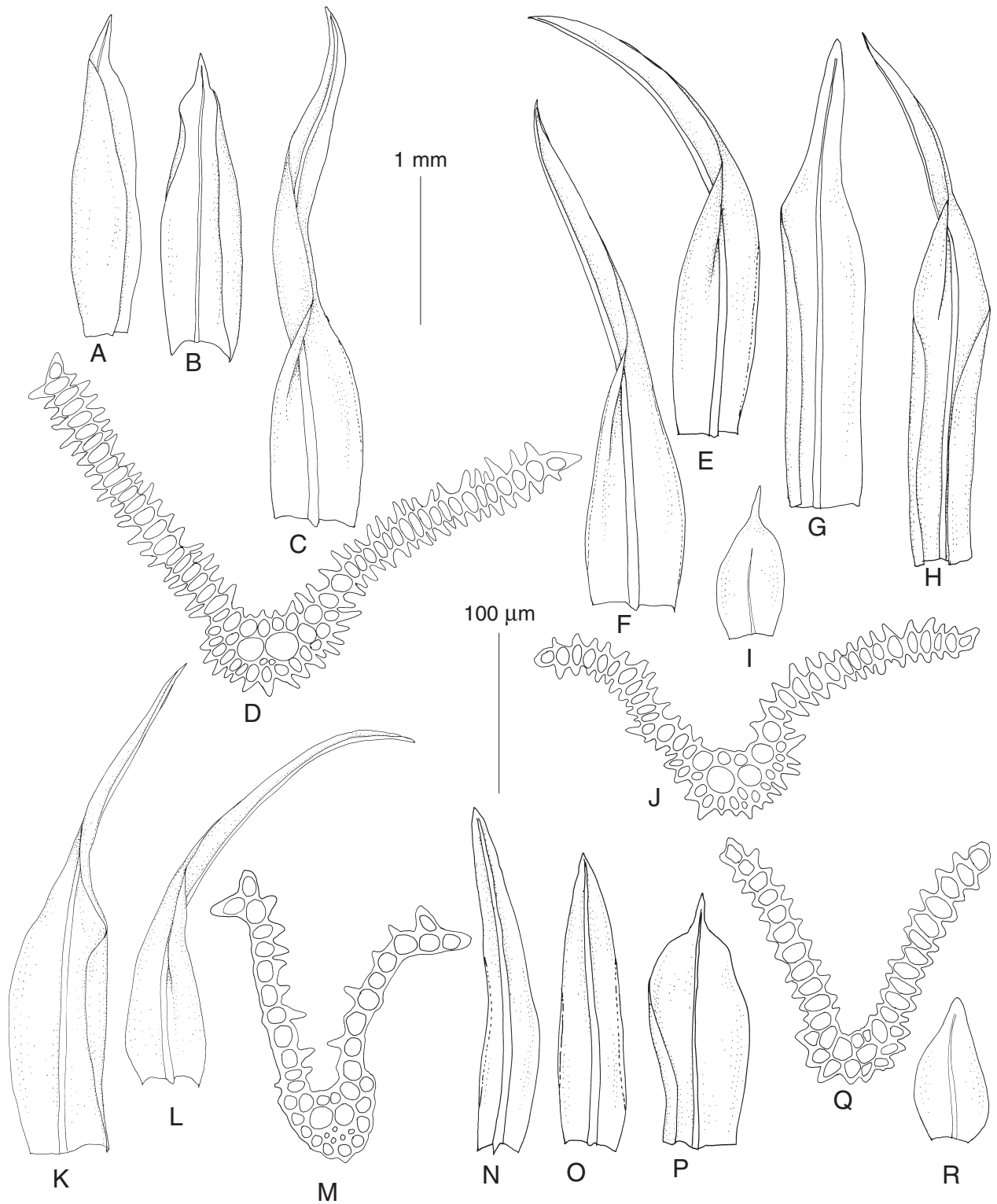


Fig. 1. A–D: *Cynodontium gracilescens* (from: [AUSTRIA] Tirolia (Vorarlberg), *C. Loitlesberger s.n.*, Kryptogamae exsiccatae №1071, LE); E–J: *C. caucasicum* (F–G: from Russia, Kabardino-Balkarian Republic, MW903217; E, H, I: from Russia, Dagestan, MW9111628); K–M: *C. fallax* (from: Adamstal in Mähren, *J. Podpera s.n.*: F. Petrak, Flora Bohemiae et Moraviae exsiccate, II Serie, №161, LE); N–R: *C. asperifolium* (from: Russia, Amurskaya Prov., N, P, Q, R – MW9079345, O – MW9118955). A–B, G–H, K, P: perichaetial leaves; C, F–E, L, N–O: stem leaves; D, J, M, Q: leaf transverse sections; I, R: perigonal leaves. Scale bars: 1 mm for A–C, F–I, K–L, N–P, R; 100 μ m for D, J, M, Q.

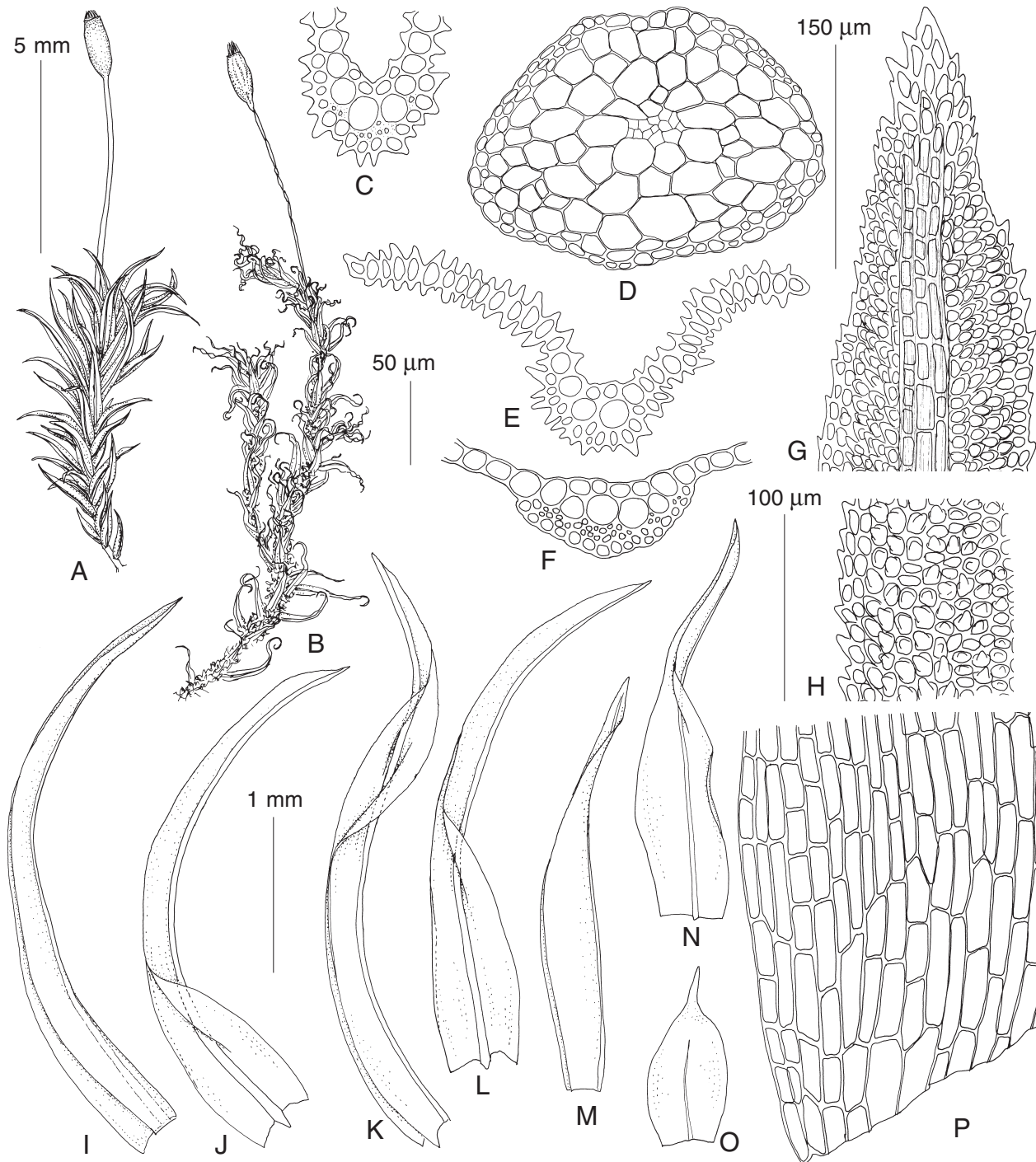


Fig. 2. *Cynodontium caucasicum* (from holotype). A: habit, wet; B: habit, dry. C, E, F: leaf transverse sections; D: stem transverse section; G: upper leaf cells; H: mid-leaf cells; I–L: stem leaves; M, N: perichaetial leaves; O: perigonal leaf; P: basal leaf cells. Scale bars: 5 mm for A–B; 1 mm for I–O; 50 μm for C, E, F; 100 μm for G, H, P; 150 μm for D.

species. It is very similar to *C. gracilescens* in having high mammillae / papillae in each cell on both surfaces (Fig. 1 D & J); however, its leaves have sharply acute apices, whereas they are described and illustrated as usually subobtuse in *C. gracilescens* (e.g., Lüth. 2019). The Caucasian plants never have setae cygneous when wet or geniculate when dry. Limpricht (1890) also provided an illustration of perichaetium of *C. gracilescens* (Figure on page 285) showing inner perichaetial leaves abruptly

narrowed into very short acumina. Instead, the Caucasian plants always possess more gradually tapered perichaetial leaves with longer acumina (Fig. 1 G–H). There is also an evidence from molecular data for separating the Caucasian specimens from *C. gracilescens*. Previously published molecular phylogenetic analysis based on plastid (*trnS-rps4* and *trnL-F*) and mitochondrial (*nad5*) DNA sequences (Fedosov *et al.*, 2021) resolved the Caucasian specimens (called *C. fallax*) and Central

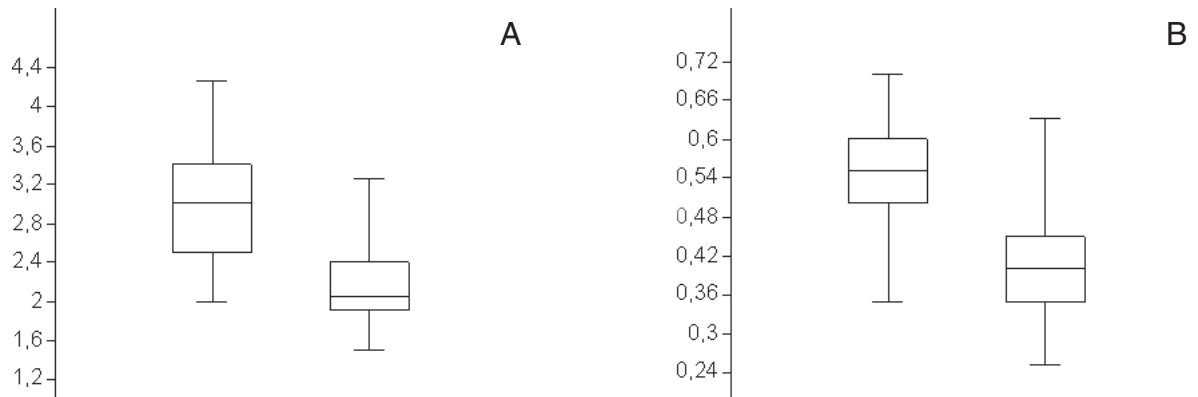


Fig. 3. Stem leaf length, mm (A) and width, mm (B) of *Cynodontium caucasicum* (left) and *C. asperifolium* (right). In total, 13 specimens of *C. caucasicum* and 22 of *C. asperifolium* were taken, from each specimen five stem leaves were measured.

European specimens of *C. gracilescens* in separate, well supported clades sister to each other.

All other species of *Cynodontium* and *Cnestrum* with similar mammillae / papillae on both leaf surfaces possess other morphological traits not allowing referring the Caucasian specimens into any of them. Therefore here we describe these plants as a new species.

TAXONOMY

Cynodontium caucasicum Ignatova & Fedosov, species nova. Fig. 2

Type: Russia, Caucasus, Dagestan Republic, Charodinsky District, near Zajach'i Gates. 42°18'N, 46°48'E. In pine forest, on rotten log. 11 May 2013. Coll. V. E. Fedosov #13-1-193 (Holotype: MW9111628!, isotype: MHA9131857!).

Etymology: The name refers to the region where the most specimens of the species originate from.

Diagnosis. Similar to *Cynodontium gracilescens* (F. Weber & D. Mohr) Schimp. in having high, spinulose mammillae/papillae in each cell on both adaxial and abaxial leaf surface, and unistratose leaf laminae including leaf margins, but differs from it in having straight versus arcuate setae when wet, and narrowly acute versus often subobtuse leaf apices.

Description. Plants in loose tufts, yellowish-green or light green, dull. Stems 2–5(–8) cm. Leaves crisped when dry, widely spreading to arcuate-recurved when wet, (1.9–)2.5–3.4(–4.3) × (0.35–)0.5–0.6(–0.7) mm, narrow lanceolate, narrowly acute or acuminate at apex; margins recurved in lower 1/2 on one or both sides, plane distally, crenulate due to high mammillae; costa percurrent or ending few cells below leaf apex, strongly mammillose on dorsal surface in the upper 1/3; leaf lamina unistratose; cells in upper and median leaf portion transverse-rectangular, quadrate and short rectangular, 7–10(–12) μm wide, on both surfaces sharply mammillose-papillose, opaque; in lower part of leaf elongate rectangular, (35–)50–85(–120) μm long, smooth, becoming shorter towards leaf margins. Autoicous. Sporophytes frequent. Pericha-

etial leaves from semi-sheathing bases gradually narrowed into long acumina, mammillose-papillose in distal portion; perigonal leaves acuminate. Setae 0.5–0.9(–1.2) cm, straight when dry and wet, yellow or brownish. Capsules erect or slightly inclined, straight, 0.9–1.8 mm long, ovate, symmetrical, not strumose, furrowed when mature, constricted below mouth after spore release, yellowish to brownish. Peristome well-developed, teeth split to 1/2 of their length or lower into 2(3) unequal prongs, reddish, often lighter at tips, papillose and vertically striolate. Opercula with long oblique beaks. Annuli persistent, formed of one row of small cells. Spores 17–25 μm, brownish, finely papillose.

Differentiation. Separating *Cynodontium caucasicum* from *C. gracilescens* is not easy. Their distinctions include straight vs. arcuate setae and usually acute vs. subobtuse leaf apices. We managed to study only few old specimens of *C. gracilescens*, and in all of them capsules were elevated high above the tuft on thin, yellow setae 10–14 mm long, geniculate when dry and cygneous when moist. Plants of *C. caucasicum* in most specimens had slightly shorter (usually 6–8 mm long) and stouter setae, usually straight but occasionally curved when moist but never geniculate when dry. However, according to the descriptions of *C. gracilescens* in European floras, it has setae of the same length as in *C. caucasicum* (Limpricht, 1890), or even shorter, 5.5–8.5 mm, apparently based on specimens from the Iberian Peninsula (Heras & Infante, 2015). It can be, however, caused by presence of *C. caucasicum* in Europe, which has not been distinguished from *C. gracilescens* before the molecular evidence appeared. Note that Heras & Infante (2015) describe the seta of *C. gracilescens* as 'recta a ligeramente flexuosa' (straight to slightly flexuose) but not cygneous. We also tentatively refer to *C. caucasicum* one specimen from LE without exact data on locality, collected by D.H. Hoppe and C.F. Hornschuch 'in albus' (apparently in Europe). It has setae 5 mm long, totally straight.

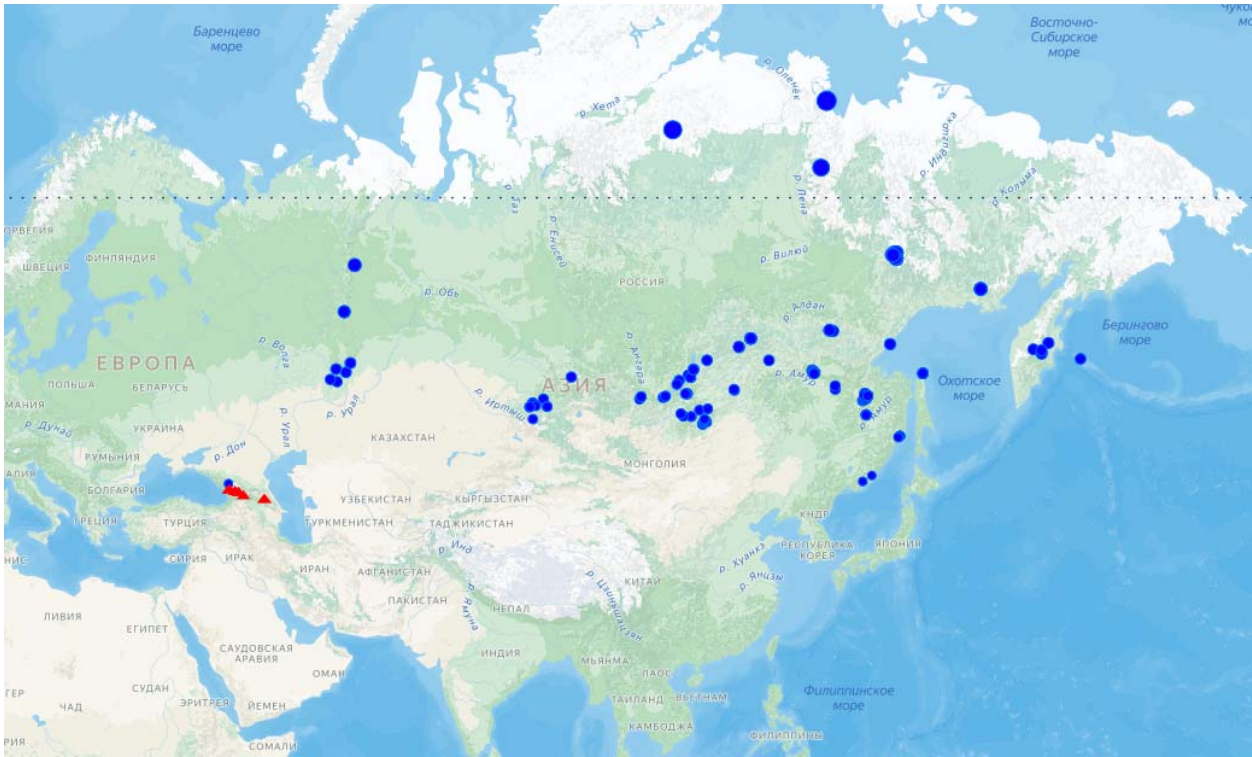


Fig. 4. Distribution of *Cynodontium caucasicum* (red triangles) and *C. asperifolium* (blue circles) in Russia.

An additional character which can be helpful for separating *C. caucasicum* and *C. gracilescens* is the shape of perichaetial leaves: they are gradually tapered into long acumina in the former species and abruptly constricted into short apiculi in the latter one (see Fig. 1 G & H vs. A & B). However, only a restricted number of *C. gracilescens* specimens were available for our study, so we suggest the use of this character with caution.

There is also a great resemblance between *C. caucasicum* and *C. serrulatum* (Funck ex Brid.) Lindb. (= *Oreoweisia torquesens*) in having unistratose leaf laminae, densely mammilose-papillose on both surfaces, but leaves of *O. torquesens* are more widely acute, and its capsules are smooth, with shorter, more slender and not divided peristome teeth; this species is also unknown in Russia.

Distribution and ecology: *Cynodontium caucasicum* is currently known in Russia only from the Caucasus (Republics Karachayevo-Circassian, Kabardino-Balkarian, North Ossetia–Alania, and Dagestan), it was also collected in Georgia (South Ossetia). Few old herbarium specimens from Central Europe were also observed; however, distribution of this species in Europe outside Russia and neighboring countries of the Caucasus needs to be clarified. In the Caucasus, it grows in altitudinal range ca. 1850–2400 m, in pine and birch forests in niches under and between rocks, on vertical and overhanging rock surfaces, on rotten logs, tree bases and exposed roots.

Cynodontium asperifolium occurs in Russia mainly in its Asian part and Urals, but it was also found in one locality in Karachaevo-Circassian Republic, Teberda Nature Park. The identity of the Caucasian specimen was

confirmed by molecular data (specimen RF77 in Fedosov *et al.*, 2021).

Distribution of *C. caucasicum* and *C. asperifolium* in Russia is mapped in Fig. 4.

Other studied specimens: ***Cynodontium caucasicum***. CAUCASUS. RUSSIA: **Karachayevo-Circassian Republic:** Teberda Nature Reserve: Oriuchat Creek valley (Nazlykol River tributary), *Ignatova 07-73* (MW9030220); Oriuchat Creek valley (Nazlykol River tributary), *Ignatova 07-73* (MW9030220); right slope of Ullu-Murudzhu River valley, *Ignatov & Ignatova 05-3935* (MW9030227); same place, *Ignatov & Ignatova 05-3809* (MW9030228); same place, 9.VIII.1986, *Ignatova s.n.* (MHA9013705); Goralyskol River valley, *Ignatova 07-126* (MW9030219); Kyschkadzher River valley, 14.VIII.1986, *Ignatova s.n.* (MHA9013706); Azgek River valley, left bank at confluence with Mukhu River, 17.VIII.1955, *A.L. Abramova & I.I. Abramov s.n.* (LE B 0000903). Gudgora, 14.VII.2010, *Ukrainskaya & Shilnikov s.n.* (LE B 0014637); Daut River valley, 5.VII.1993, *Ukrainskaya s.n.* (LE B 0025512). **Kabardino-Balkarian Republic:** Bezengi River gorge 1 km downstream Mizhirgi River mouth, 27.IX.1986, *Portenier s.n.* (MHA9013704); Shkhelda Creek, a tributary of Adyl-Su River, 29.VII.2004, *Ignatov, Ignatova & Kharzinov s.n.* (MHA9013709 & MHA9013711); Cherek-Bezengiyskiy Gorge, 20.VII.2000, *Tuziev s.n.* (MW9030217); Adyr-Su River valley, 23.VII.1991, *Ukrainskaya s.n.* (LE B 0025782). **Republic of North Ossetia–Alania:** North Ossetian State Reserve, Tsei River gorge 21.VII.1976, *L.I. Abramova s.n.* (MW9030221 & MW9030225); same place, 10.VII.2013, *Ukrainskaya s.n.* (LE B 0015883). GEORGIA: Dzhava Distr., upper course of Bolshaya Liakhva River, 17.IX.1947, *I. Abramov s.n.* (LE B0000899); **Republic of Dagestan:** Gunib District, near station of Gorny Botanical Garden, *Ignatov & Ignatova 09-360* (MHA9013703); Charodinsky District: near Zayach'i gates,

Fedosov 13-1-188 (MW9132026); Karackskaja lesnaja dacha, *Fedosov 13-1-137* (MW9131992).

Cynodontium gracilescens NORWAY: ST: Oppdal, Kongsvoll, 18.VII.1970, A.A. Frisvoll s.n. (LE). [AUSTRIA] Tirolia (Vorarlberg), ad “Vermalen-Joch” prope Danöfen, C. Loitlesberger s.n., Kryptogamae exsiccatae №1071 (LE). [SWITZERLAND] Wengrn Alp, *Breutel 157* (LE).

Cynodontium fallax [GERMANY] Adamstal in Mähren: Josefske udoli, March 1913, J. Podpera s.n.: F. Petrak, Flora Bohemiae et Moraviae exsiccatae, II Serie, №161 (LE).

Cynodontium asperifolium (selected specimens used for measurements of leaf length and width): EUROPEAN RUSSIA: **Perm Territory**: Basegi Reserve (MHA9013670). **Bashkortostan Republic**: Burzyanky District, Bainazarovo Settl. (MW9030190). **Karachayevo-Circassian Republic**: Malaya Khatipara Creek (MHA9013707). **ASIAN RUSSIA: Altai Republic**: Shebalino Distr., Elekmonar Creek (MW9030191). **Krasnoyarsk Territory**: Taimyr, Kotuikan River (MW9007428 & MW9030192). **Republic of Sakha/Yakutia**: Suntar-Khayata Mt. Range (MHA9013657 & MHA9013661); Sette Daban Mt. Range (MW9090003 & MW9090027). **Irkutsk Province**: Slyudyanka River valley (MW9111751). **Zabaikalsky Territory**: Barguzinsky Reserve (MW9118413); Kodar Range (MW9079093). **Amurskaya Province**: Zeya Reserve (MW9079686). **Khabarovsk Territory**: Botchi Reserve (MHA9013647 & MHA 9013650). **Sakhalinskaya Province**: Sakhalin Island (MHA9013667).

Specimens from Asian Russia misidentified as *Cynodontium fallax* (all in LE)

[**Republic of Bashkortostan**] South Urals: Bashkirsky State Reserve, Ural-Tau Mt., upper course of Belaya River, 26.VII.1946, *Selivanova-Gorodkova s.n.* – re-identified as ***Cynodontium asperifolium***; east slope of Ural-Tau Mt., upper course of Ural River, Kazmash-tash Mt., 29.VII.1946, *Selivanova-Gorodkova s.n.* – re-identified as ***Cynodontium asperifolium***. **Tyumen Province**, Berezovo District: Lyapin River basin, Saryakpner Mt., 13.IX.1950, *Kil'dyushevsky s.n.* – re-identified as ***Cynodontium strumiferum***; Nyurtso-yu Creek (tributary of Maniya River), 2.IX.1950, *Kil'dyushevsky s.n.* – re-identified as ***Cynodontium asperifolium***. **Republic of Sakha/Yakutia**: lower course of Lena River, Tiksi Bay, 1.VIII.1955, *Kil'dyushevsky 32/1* – re-identified as ***Cnestrum alpestre***.

Specimens from Asian Russia misidentified as *Cynodontium gracilescens* (all in LE)

Amur [region], 14.VII.[18]54, ?illegible – re-identified as ***Cynodontium tenellum***. **Magadan Province**, Ol'sky District, middle course of Chyolomdzhii River, 18.VII.1983, *Blagodatskikh s.n.* – re-identified as ***Cynodontium asperifolium***.

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