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CEPHALOZIELLA ASPERICAULIS JØRG. WITH SPOROPHYTES IN CENTRAL EUROPE

CEPHALOZIELLA ASPERICAULIS JØRG. СО СПОРОФИТАМИ В ЦЕНТРАЛЬНОЙ ЕВРОПЕ

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Abstract

We present the first record of the rare liverwort species *Cephaloziella aspericaulis* in Central Europe. The population discovered in the Swiss Alps represents a disjunct location with respect to the nearest occurrences in Scandinavia and in the Caucasus and are the first record of sporophyte-bearing plants. The species differs from all other European taxa of the genus, except *C. varians* var. *scabra*, in the presence of cellular outgrowths on the stem that are also shared with the Asian/North American species *C. spinicaulis* and with *C. mammillifera* from Greenland. We provide information on how to distinguish *C. aspericaulis* from these and other similar taxa of the genus, especially *C. divaricata,* and illustrate the plants collected in the Alps. Since the genus *Cephaloziella* is notoriously undercollected and because similar habitats are widespread throughout the siliceous Central Alps it seems likely that further occurrences can be discovered in the region.

Резюме

Приводятся данные о первой находке в Центральной Европе редкого печеночника *Cephaloziella aspericaulis*. Популяция, в которой впервые для вида обнаружены спорофиты, выявлена в Швейцарских Альпах, ближайшие известные точки нахождения вида в Скандинавии и на Кавказе. Вид отличается от остальных известных в Европе таксонов рода, за исключением *C. varians* var. *scabra,* наличием клеточных выростов на стебле, что делает его похожим на Азиатско-Северо-Американский вид *C. spinicaulis* и на *C. mammillifera* из Южной Гренландии. Приводятся отличия *Cephaloziella aspericaulis* от похожих на нее видов рода, в особенности *C. divaricata*, и иллюстрации собранного в Альпах образца. Поскольку виды рода *Cephaloziella* явно пропускаются при сборах и, поскольку сходные местообитания широко представлены в Центральных Альпах, очень вероятны новые находки вида в этом регионе в дальнейшем.

KEYWORDS. Cephaloziellaceae, *Cephaloziella divaricata*, C*ephaloziella mammillifera*, *Cephaloziella spinicaulis*, liverworts, sexual conditions, Switzerland

INTRODUCTION

In Europe, *Cephaloziella aspericaulis* Jørg was so far only known from a few localities in Norway (Jørgensen, 1934; Damsholt, 2002), from one in Sweden (Hodgetts & Lockhart, 2020) and from the Caucasus (Konstantinova & Bakalin, 2009). Outside Europe, the species is reported from Siberia and the Russian Arctic (Konstantinova & Bakalin, 2009; Potemkin & Sofronova, 2009), Greenland (Schuster, 1988), and Alaska (Wagner: Cephaloziellaceae Douin. – Bryophyte Flora of North America, Provisional Publication. Buffalo, Buffalo Museum of Science, available at http://www.mobot.org/plantscience/bfna/V3/Cephaloziellaceae.htm [accessed 02 October 2021]). Because of the few occurrences, *C. aspericaulis* is treated as critically endangered in Europe (Hodgetts *et al.*, 2019).

Here, we present the first record of the taxon in Central Europe. We provide a detailed description and illustration of the plants discovered in the Swiss Alps and compare them to available data. Furthermore, we summarise the characters that differentiate the taxon from similar species and discuss the controversial taxonomic concepts that were applied to it.

MATERIALS AND METHODS

We examined two specimens of *C. aspericaulis* from the same locality in Switzerland using standard light-microscope techniques. The first specimen was collected during field work for the upcoming revision of the Swiss red list of bryophytes (Kiebacher *et al.*, 2017) in the Canton of Grisons: Bergün/Bravuogn, Crap Alv, N 46.573°, E 9.802°, 2207 m a.s.l., N-facing rock overhang, on granite, 29.VIII.2017, *leg.* T. Kiebacher *2831*, *det* E. Urmi (Z).

The second specimen was collected at the same site when Edwin Urmi revisited the locality in 2021 to esti-

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Fig. 1. The site in Switzerland where *Cephaloziella aspericaulis* has been found. Photo: © N. Schnyder.

mate the population size, to better describe the habitat and to collect additional material for a better estimation of the morphological variability (Urmi *11'105*, 21.IX.2021, priv. herb. E. Urmi; Fig. 1).

RESULTS

Description of the plants collected in Switzerland (Figs. 2–3). Plants small and rigid, as rarely branched, ±scattered shoots of less than 5 mm length and 0.15–0.25 µm width, green. Stem 50–80 µm wide, rough from 1- to 3-celled cellular outgrowths, which are often densely arranged in longitudinal rows forming ridges. Underleaves usually large on sterile shoots, sometimes nearly as long as lateral leaves and ±bifid. Lateral leaves ±contiguous, bilobed for more than half the length, lobes mostly 7–8 cells wide at base, margins with or without 1-celled teeth, towards base with conical projections on the abaxial surface, lobe apices early hyaline; leaf cells thick-walled, coarsely papillose; many papillae hemispherical, the largest ones about half as wide as the cells; apical cell of the lobes spiniform, usually ca 1.5 × as long as wide and with remarkably incrassate apical wall. Leaf cells 9–12 µm wide, at margins 10–11(–12) µm long. Gemmae few, ±fusiform, 2-celled, pale purplish, 14–21 × 8–11 µm. Sexual condition possibly variable: We observed paroicy (but with poorly developed antheridia) on two shoots and also shoots without any trace of antheridia in leaf axils below perianths; we have not observed purely male shoots. Bracts larger than the leaves and more spinosely dentate. Perianth mouth crenulate with narrow and very thick-walled cells.

Sporophytes ripe, but setae not yet elongated. Capsules ca 0.3 × 0.2 mm, with 2-stratose wall, both cell layers with only radial cell wall thickenings (nodular in surface view). Elaters 5–8 µm wide, bispiral with 1–2 µm wide bands. Spores 7–10 µm in diameter, surface verruculose.

Due to the large papillae that cover the whole surface, the aspect of the plants is rather fuzzy. The shape and size of the oil bodies and their number per cell is therefore difficult to ascertain. They seem homogeneous and spherical or ellipsoidal.

Population size. The plants grew on a small spot of much less than one square meter. No additional occurrences could be found in the surrounding area, but many potential sites are inaccessible.

Habitat. In the crevices under the overhang where *C. aspericaulis* was collected the species grows intermixed with *Amphidium mougeotii* (Schimp.) Schimp., *Eremonotus myriocarpus* (Carrington) Pearson, *Diplophyllum taxifolium* (Wahlenb.) Dumort. and, among other algae, *Trentepohlia* cf. *aurea* (L.) Mart. Furthermore, close to it we found *Tetrodontium repandum* (Funck) Schwägr., *Blindia acuta* (Hedw.) Bruch & Schimp., and *Tritomaria quinquedentata* (Huds.) H. Buch.

DISCUSSION

Cephaloziella aspericaulis was described from Norway (Jørgensen, 1934) at species rank. Later on, it was treated as a synonym of *Cephaloziella starkei* var. *scabra* (M. Howe) L. Clark & Frye by Müller (1957, p. 1050), and as var. *aspericaulis* (Jørg.) R.M. Schust. of *C. byssacea* (Roth) Warnst. by Schuster (1980). At present, *Cephaloziella aspericaulis* is mostly accepted at species rank (e.g., Damsholt, 2002, 2013; Schumacker & Váňa, 2005; Söderström & al., 2016). However, to date no molecular data are available and consequently the phylogenetic position as well as the appropriate rank of the taxon are uncertain. The morphological similarities indicate a close relation to the highly variable *C. divaricata*. The different expressions of this species, especially *C. divaricata* var. *scabra* (M. Howe) Haynes (=*Cephaloziella divaricata* var. *asperifolia* (Taylor) Damsh. according to Söderström *et al.*, 2002) should be considered in a taxonomic revision of the taxon. *Cephaloziella divaricata* var. *scabra* like *C. aspericaulis* has cell-projections on the abaxial leaf surface. *Cephaloziella aspericaulis* may furthermore be related to some south-hemispherical taxa, e.g., *C. pulcherrima* R.M. Schust subsp. *sphagnicola* R.M. Schust. (Schuster, 1971).

The species epithet of *C. aspericaulis* refers to the rough stem surface that is due to teethlike outgrwths and, occasionally, paraphyllia. This morphological peculiarity is rare in the genus and else in Europe only known from *C. varians* var. *scabra* (S.W. Arnell) Damsh. Furthermore, it is shared with *C. spinicaulis* Douin, known from Asia and North America (e.g., Schuster, 1980) and with *C. mammillifera* R.M. Schust. & Damsh. from Greenland (Schuster, 1988). *Cephaloziella varians* var. *scabra* was formally treated as synonym of *C. mammillifera* by Damsholt (2013) but the taxonomic relations of these two taxa are not conclusively clarified (Damsholt, 2002, 2013). In *C. varians* var. *scabra* and *C. mammillifera* the roughness of the stems is much less developed (usually only towards shoot apices) than in *C. aspericaulis* and not due to cellular outgrowths but due to pro-

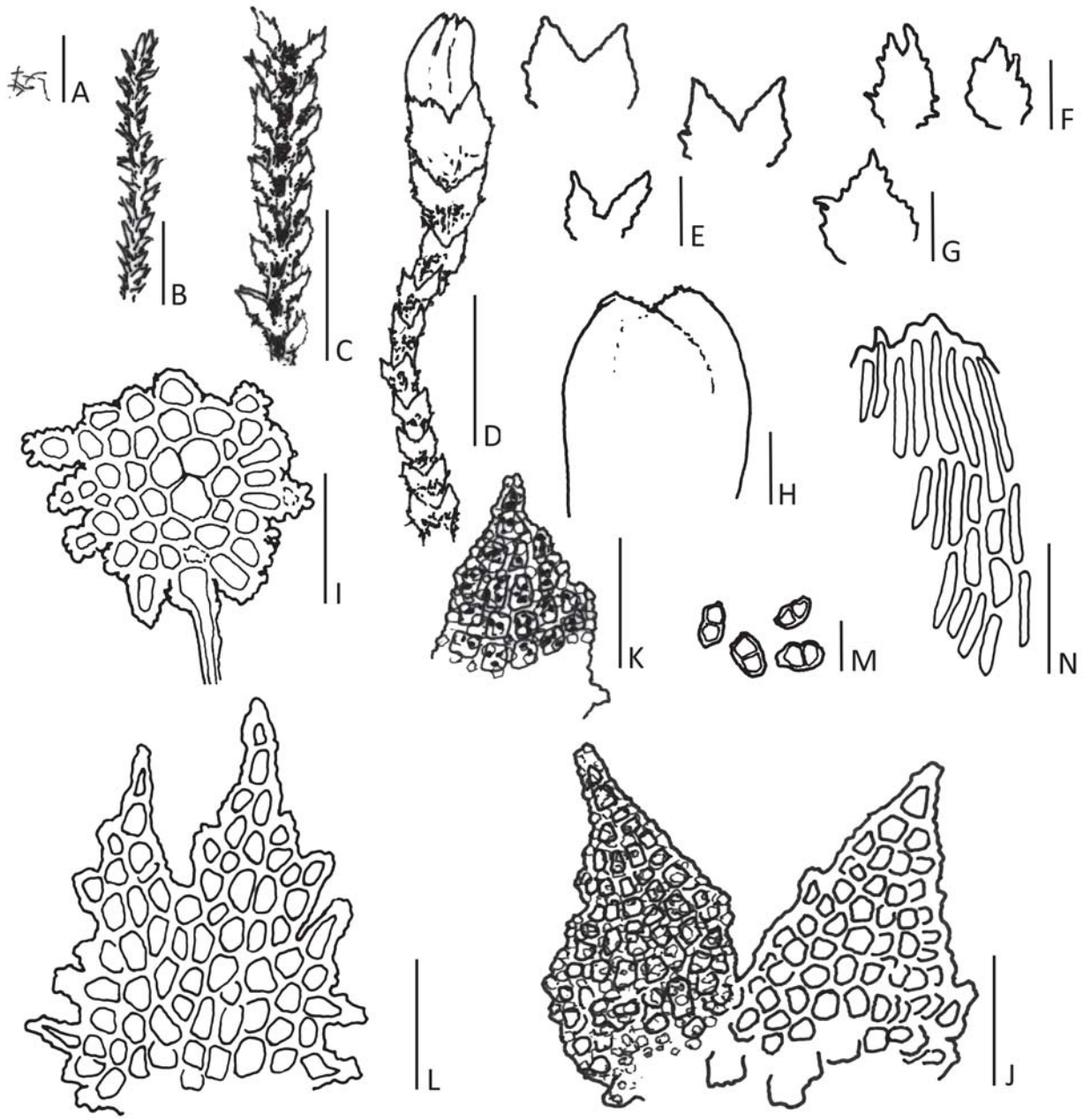

Fig. 2. *Cephaloziella aspericaulis* (from Kiebacher *2831* and Urmi *11'105*). A: Habitus; B: Shoot, antical view; C: Part of a shoot, postical view with underleaves (in black); D: Female plant with perianth, lateral view; E: Lateral leaves; F: Underleaves; G: Female bract; H: Apical part of a perianth; I: Cross section of a stem with a rhizoid; J: Leaf with cell structure, left half with papillae indicated; K: Leaf lobe with papillae and oil bodies (black dots) indicated; L: Underleaf; M: Gemmae; N: Part of perianth mouth with elongated cells. Scales: A 1 cm; B, C, D 500 µm; E, F, G, H 100 µm; I, J, K, L, M, N 50 µm; M 20 µm. Drawings: E. Urmi, CC BY-NC-SA 4.0.

tuberant cells of the cortex (Tab. 1). They are furthermore easily distinguished by the indistinct underleaves from *C. aspericaulis.* In *C. spinicaulis* the whole plant, including abaxial leaf surfaces are covered with spines formed by cellular outgrowths, whereas in *C. aspericaulis* cellular outgrowths are confined to the stems, and cell-projections from the abaxial leaf base. Furthermore, in *C. spinicaulis* the cuticula is smooth whereas in *C. aspericaulis* it is distinctly papillose (Tab. 1, Figs. 2–3). In *C. divaricata* the cuticle is at most verruculose with few papillae. Apart from the roughness of the stem the elongated apical cell of the leaf lobes clearly differentiates *C. aspericaulis* from *C. divaricata* var *scabra.*

The description of a variety in *C. varians* that is characterised by rough stems could indicate that this characteristic may facultatively be expressed also in other species, possibly in response to certain ecological conditions. Interestingly, but without giving details, Köckinger (2017) reports the occurrence of morphs of *C. divaricata* in Austria that approach *C. aspericaulis*.

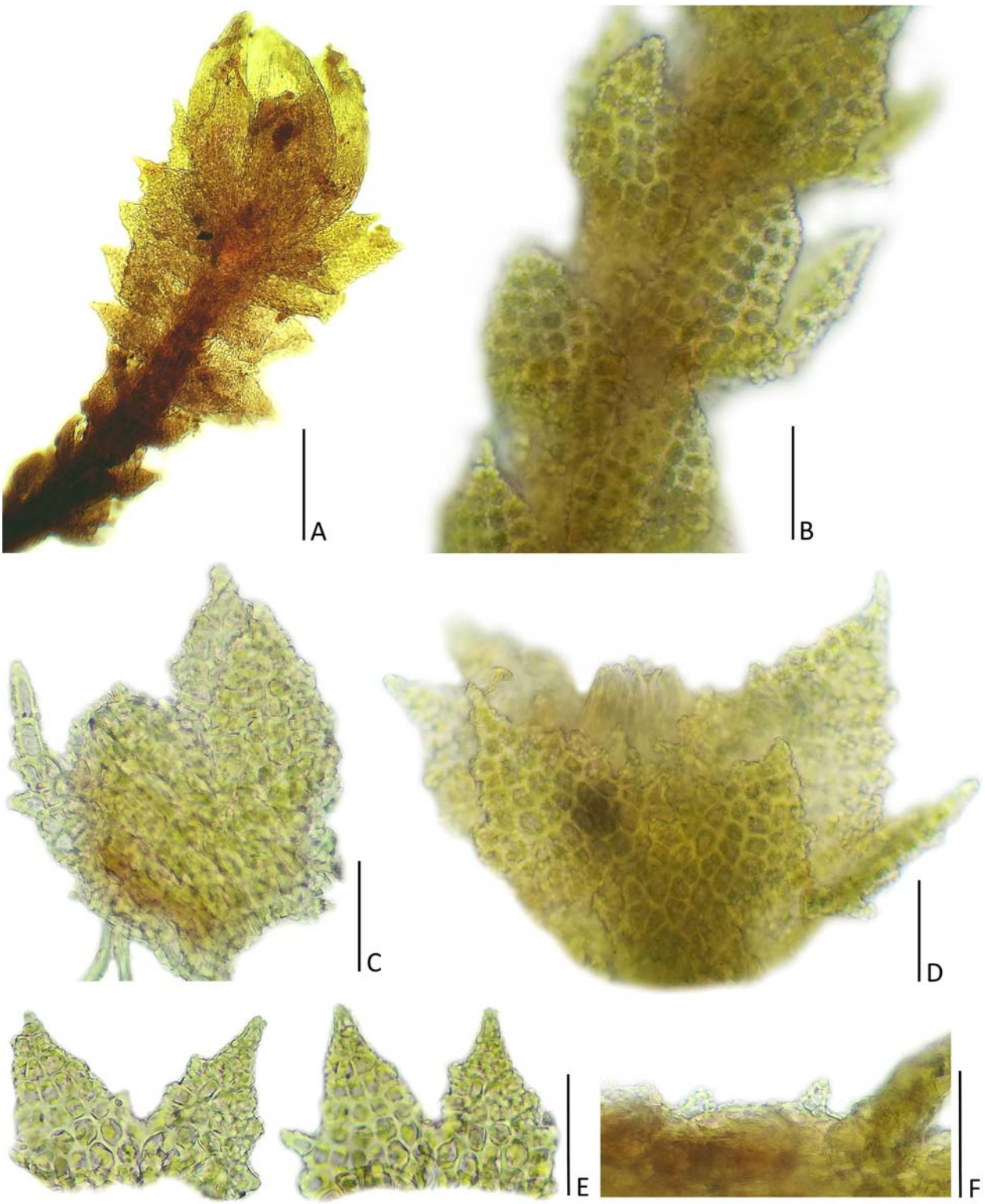

Fig. 3. *Cephaloziella aspericaulis* (from Kiebacher *2831*). A: Fertile shoot with perianth; B: Vegetative shoot, antical view; C: Part of a shoot, lateral view, with underleaf (left), lateral leaf (right) and rhizoids (bottom); D: Apex of fertile shoot with bracts and perianth mouth; E: Lateral leaves; F: Stem with teeth-like cellular outgrowth. Scales: A 200 µm; B–F 50 µm. Photos: T. Kiebacher,

With respect to the descriptions of *C. aspericaulis* in the protologue (Jørgensen, 1934), in Schuster (1988) and in Damsholt (2002) the Swiss collections exhibit some differences in size (shoots 0.15–0.25 vs. 0.25–0.36 µm wide), in colour (green [except gemmae] vs. usually secondarily pigmented), in leaf arrangement (±contiguous vs. distant) and in underleaf size (some nearly as long as lateral leaves vs. half the size). All these characters are notoriously very variable and the absence of pigmentation may be due to the little exposed microhabitat. In the Swiss plants the characters known to be relevant for the identification of the species in the genus *Cephaloziella* best fit the features reported in the protologue (Jørgensen, 1934) and in other literature, especially the excellent drawings by Annette Pagh (in Damsholt, 2002) based in part on the lectotype of the species and by Rudy Schuster (in Schuster, 1988). The most indicative key characters of *C. aspericaulis* differentiating it from *C. divaricata* are the outgrowths from the stem surface, the elongated apical cell of the leaf lobes and the coarse and abundant papillae. These are clearly demonstrable in the alpic population.

The type material is sterile (Jørgensen, 1934; cf. Schuster, 1980; Damsholt, 2002) and although Schuster (1988) reports to have seen male plants, neither him nor Damsholt (2002, 2013) provide a description or figure of them. According to Konstantinova (in litt.), there are specimens from Russia with perianths and androecia but none with sporophytes. As we could not find any report of sporophytes elsewhere, our alpic population is the first fertile one ever found. The discovery of *C. aspericaulis* in the Alps is furthermore a substantial expansion of the known distribution range of the taxon. The population in the Alps represents a disjunct location with respect to the nearest occurrences in Scandinavia and in the Caucasus (Hodgetts & Lockhart, 2020; Konstantinova & Bakalin, 2009).

Among the species associated with *C. aspericaulis* at the collection site in Switzerland *Amphidium, Eremonotus,* and *Blindia* indicate some content of bases in the substrate. Such habitats and this set of species are not uncommon (except maybe *T. repandum*) in the siliceous parts of the Alps, although not always easy to access. Furthermore, according to the relatively few collections of the genus in Z+ZT, the genus is significantly undercollected, at least in Switzerland. Consequently, it seems likely that further occurrences of *C. aspericaulis* can be found in the siliceous parts of the Alps if specifically searched for.

Acknowledgments

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Literature cited

DAMSHOLT, K. 2002. Illustrated flora of Nordic liverworts and hornworts. – *Lund, Nordic Bryological Society, 837 pp.*

DAMSHOLT, K. 2013. The liverworts of Greenland. – *Lund, Nordic Bryological Society, 626 pp.*

HODGETTS, N., M. CÁLIX, E. ENGLEFIELD, N. FETTES, M. GARCÍA CRIADO, L. PATIN, A. NIETO et al. 2019. A miniature world in decline: European Red List of Mosses, Liverworts and Hornworts. – *Brussels, IUCN, 87 pp.*

HODGETTS, N. & N. LOCKHART. 2020. Checklist and country status of European bryophytes – Update 2020. – *Irish Wildlife Manuals* **123**: *1–214.*

JØRGENSEN, E. 1934. Norges Levermoser. – *Bergens Museums Skrifter* **16**: *1–343, maps I–XXV.*

KIEBACHER, T., J. STEFFEN, M. MEIER, A. BERGAMINI, H. HOFMANN, N. MÜLLER, M. REIMANN, N. SCHNYDER, & E. URMI. 2017. Missionen, Dauerflächen und verschollene Arten – Neues von der Roten Liste der Moose. – *Meylania* **60**: *8–14.*

KÖCKINGER, H. 2017. Die Horn- und Lebermoose Österreichs (Anthocerotophyta und Marchantiophyta). Catalogus Florae Austriae, Teil II, 2. Heft. – *Wien, Österreichische Akademie der Wissenschaften, Wien, 382 pp.*

KONSTANTINOVA, N. A. & V. A. BAKALIN. 2009. Checklist of liverworts (Marchantiophyta) of Russia. – *Arctoa* **18**: *1–64.*

MAMONTOV, Y.S. & A.A. VILNET. 2017. *Cephaloziella konstantinovae* (Cephaloziellaceae, Marchantiophyta), a new leafy liverwort species from Russia and Mongolia identified by integrative taxonomy. – *Polish Botanical Journal* **62**: *1–19.*

MÜLLER, K. 1957. Die Lebermoose Europas. 2 Abth. – *In: L. Rabenhorst's Kryptogamen-Flora von Deutschland, Oesterreich und der Schweiz, 3 Aufl., 6 Band, Leipzig, Akademische Verlagsgesellschaft Geest & Portig, pp. 757–1365.*

PATON, J.A. 1999. The liverwort flora of the British Isles. – *Colchester, Harley Books, 626 pp.*

[POTEMKIN, A.D., & E.V. SOFRONOVA] ПОТЁМКИН А.Д., Е.В. СОФРОНОВА. 2009. Печеночники и антоцеротовые России. – [*Liverworts and hornworts of Russia. 1*]. *СПб-Якутск, Бостон-Спектр* [*St. Petersburg-Yakutsk, Boston-Spektr*]: *368 pp.*

SCHUMACKER, R. & J. VÁŇA. 2005. Identification keys to the liverworts and hornworts of Europe and Macaronesia (distribution and status). 2nd revised edition. – *Poznań, Sorus, 211 pp.*

SCHUSTER, R.M. 1971. Studies on Cephaloziellaceae. – *Nova Hedwigia* **22**: *121–265*.

SCHUSTER, R.M. 1980. The hepaticae and anthocerotae of North America east of the hundredth meridian, Volume IV. – *New York, Columbia University Press, 1334 pp*.

SCHUSTER, R.M. 1988. The hepaticae of South Greenland. – *Beihefte zur Nova Hedwigia* **92**: *1–255.*

SÖDERSTRÖM, L., E. URMI & J. VÁŇA. 2002. Distribution of Hepaticae and Anthocerotae in Europe and Macaronesia. – *Lindbergia* **27**: *3–48.*

SÖDERSTRÖM, L., S. HAGBORG, M. VON KONRAT, SH. BARTHOLOMEW-BEGAN, D. BELL, L. BRISCOE, E. BROWN ET AL. 2016. World checklist of hornworts and liverworts. – *PhytoKeys* **59**: *1–821.*

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Table 1. Comparison of character states of *Cephaloziella aspericaulis* Jørg. and the similar taxa: *C. divaricata* (Sm.) Schiffn. var. *scabra* (M.Howe) Haynes (fide Damsholt, 2002), *C. konstantinovae* Mamontov & Vilnet (fide Mamontov & Vilnet, 2017). *C. mammillifera* R.M.Schust. & Damsh (including *C. varians* (Gottsche) Steph. var. *scabra* (S.W. Arnell) Damsh.) (fide Damsholt, 2002), *C. massalongi* (Spruce) Müll.Frib. (fide Damsholt, 2002), *C. nicholsonii* Douin & Schiffn. (fide Paton, 1999), *C. phyllacantha* (C.Massal. & Carestia) Müll.Frib. (fide Damsholt, 2002), *C. polystratosa* (R.M.Schust. & Damsh.) Konstant. (fide Damsholt, 2013), *C. spinicaulis* Douin (fide Schuster, 1980), *C. uncinata* R.M.Schust. mamillose morphotype (C. *uncinata* var. *mammillosa* R.M. Schust. & Damsh. nom. inval.; fide Damsholt, 2013).

Species or morphotype	Lateral leaves	Leaf cell walls	Cuticle	Apical cell of leaf lobes	Stem surface	special feature / comment
C. aspericaulis	towards base bistratose and with conical projections on the abaxial surface, margin ±dentate	usually incrassate	nearly always coarsely papillose	elongate, distinctly longer than wide	rough from cellular projections often forming longitudinal ridges	often so densely covered by projections and papillae that the cell structure is difficult to discern
C. divaricata* var. *scabra	with conical or branched projections on the abaxial surface, margin dentate	incrassate, at least those of marginal cells	papillose	short, not longer than wide	smooth	sporophytes rare, with strikingly small spores, 5–6 µm
C. konstantinovae	with 1- to 4-celled projections on the abaxial surface, margin entire or with few teeth	thin	smooth	short, not longer than wide	smooth, but longitudinal rows of somewhat inflated cells	margin of lobes bent backwards, perianth campanulate, capsule spherical
C. mammillifera (incl. ***C. varians* var. *scabra***)	at base bistratose and with conical or spherical projections on the back, margin ±entire	thin to incrassate	smooth or ±papillose	short, not longer than wide	usually smooth, sometimes towards apex rough from mamillae or spinosely protuberant cells	leaf cells often relatively small, 8–10(–13) µm, underleaves indistinct
C. massalongi	at base mostly 2- to 3-stratose with conical projections on the back, margin usually dentate	incrassate	papillose, at least on the apex of the lobes and on the teeth	mostly longer than wide	smooth	leaves loosely conduplicate, the lobes often slightly concave (seen from the abaxial side)
C. nicholsonii	with or without conical projections on the abaxial surface, margin dentate, rarely entire	±incrassate	smooth or papillose	indistinctly elongate	smooth	some of the rather rare gemmae irregulary shaped
C. phyllacantha	at base mostly 2-stratose and with spiny projections on the back, margin spinosely dentate	incrassate	papillose, at least on the apex of the lobes and on the teeth	ca twice as long as wide	smooth	leaves somewhat convex (seen from the abaxial side), lobes often bent towards the stem
C. polystratosa	abaxial surface smooth, margin entire	thin	smooth	short, not longer than wide	smooth	leaves towards base 2- to 3-stratose, lobes wide, at base 10–13(–15) cells wide
C. spinicaulis	with spiny teeth on the whole abaxial surface, spinosely dentate	thin	smooth	somewhat elongate	the whole length with spiny teeth arranged in longitudinal rows	the whole plant densely covered with spines, except the adaxial surface of leaves
Mamillate morphotype of ***C. uncinata***	with mamillose projections on the abaxial surface, margin usually entire	thin to incrassate	coarsely papillose	somewhat elongate	smooth	underleaves mostly indistinct