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THE IDENTITY OF *PLECTOCOLEA UNISPIRIS* AMAKAWA (SOLENOSTOMATACEAE)

ЧТО ТАКОЕ *PLECTOCOLEA UNISPIRIS* AMAKAWA (SOLENOSTOMATACEAE)?

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Abstract

The study of living and authentic materials of *Plectocolea unispiris* Amakawa and *P. virgata* Mitt. has revealed their identity, so the former name is referred to synonymy of the latter one. The description based on type material for *P. virgata*, the photographs and line drawings for the species and related *P. erecta* Amakawa are provided. The distribution of *P. virgata* is clarified.

Резюме

Изучение живых и аутентичных материалов *Plectocolea unispiris* Amakawa и *P. virgata* Mitt. выявило отсутствие значимых различий, в связи с чем первое название сведено в синонимы *P. virgata*. Приводится описание *P. virgata*, основанное на типовом материале, фотографии и рисунки для этого вида и сходного с ним *P. erecta* Amakawa. Уточнено распространение *P. virgata*.

KEYWORDS: *Plectocolea*, Solenostomataceae, liverworts, taxonomy, East Asia.

INTRODUCTION

Plectocolea unispiris Amakawa was described from Miyazaki Prefecture of Japan by Amakawa (1954) as the species occupying marginal position in '*Virgata* group'. Indeed, it has rhizoids forming distinct fascicle decurrent down the stem along its ventral side (that is basic feature for the latter group). However, in ascending (versus commonly erect) growth it is dissimilar with other members of the group. Besides, unispiral elaters (that are very peculiar within genus) were declared as the main identification feature of the species. *P. unispiris* was regarded for a long time as relatively rare in Japan (Ohnishi *et al*., 2002). Yamada & Iwatsuki (2006) cited it for Honshu only, although the species was described from Miyazaki Prefecture that is in Kyushu, and later was also recorded from Hokkaido (Ohnishi *et al.*, 2002). The oil bodies of *P. unispiris* were unknown until very recently.

Some years ago Dr. Higuchi (TNS) and I have started the joint investigations on bryophytes around Sea of Japan (certainly, including also some areas in Japan). In the course of those explorations I several times found *Plectocolea* with unispiral elaters those were immediately and uncritically referred to *P. unispiris* (Bakalin *et al.*, 2013 and also several unpublished records). When microscopied, it was noted that although it is quite easy to identify the plants when they have sporophytes, the identification becomes quite difficult when sporophytes are absent. The main problem was the delimitation of *P. unispiris* from *P. virgata* Mitt. Therefore the main goal was to understand whether *P. unispiris* and *P. virgata* are different or not.

MATERIAL AND METHODS

To understand the differences between *Plectocolea virgata* and *P. unispiris* I attempted to involve large material from Japanese herbaria TNS, NICH, KYO, HIRO and CBM, as well as some other collections keeping in G, NY and VBGI and my own collections. In total over 110 specimens were studied, including holotypes and isotypes of the both taxa. The comparison was based on morphological study of dried and living materials. The obtained results were applied to descriptions and estimated differences between *P. virgata* and *P. unispiris* in literature sourcs (Amakawa, 1960; Ohnishi *et al*., 2002).

RESULTS AND DISCUSSION

If to compare the descriptions and keys in Amakawa (1960) and Ohnishi *et al*. (2002), the sterile plants of both 'taxa' may be supposedly distinguished in growth type that is ascending in *P. unispiris* and erect in *P. virgata* that correlates with slightly smaller leaf cells and thickened cell walls along leaf margin in the latter versus slightly larger and nearly thin-walled in *P. unispiris*. However, I found this differentiation is not universal and commonly could not be applied. The dwarf and ascending growth is characteristic for *P. unispiris* only when it is found in the sites experienced temporary impact of running water after strong rains (*e.g.*, along stream courses). In all other variants (*e.g.*, at the distance of 10–20 cm from watercourse) the normally developed plants are rather erect, with subtransversely oriented, obliquely to erect spreading leaves. Similarly, leaf margin cells of erect shoots (tentatively named as *P. virgata*) in favorable conditions become thin-walled, although commonly thicker

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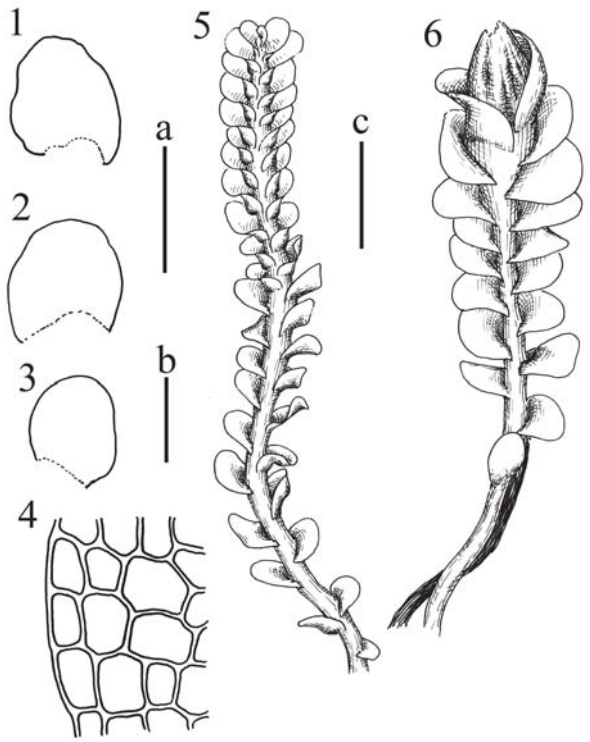

Fig. 1. *Plectocolea virgata* Mitt.: 1–3 – leaves; 4 – cells along leaf margin; 5 – male plant habit; 6 – perianthous plant habit (all from holotype, NY). Scales: a – 1 mm, for 1–3; b – 50 μm, for 4; c – 1 mm, for 5, 6.

in well-exposed and drier habitats. The last circumstance was also noted by Ohnishi *et al*. (2002).

Within *Plectocolea*, both *P. virgata* and *P. unispiris* has very unique spherical, very finely papillose to almost smooth (although looking as crumpled paper with time) oil-bodies. The difference in number (1–3 versus 1–5) estimated in Ohnishi *et al*. (2002) hardly deserve attention because of variation even within one leaf of some plants.

Thus, the only stable feature between two taxa might be elaters type that was recorded as bispiral in *P. virgata* and unispiral in *P. unispiris* (Amakawa, 1960; Ohnishi *et al.*, 2002). Therefore I tried to find 'true' *P. virgata* with bispiral elaters. However, despite continuous search I was unable to find living material characterized by 'virgata' oil body type and having bispiral elaters. After I checked all available material of *P. virgata* in the largest Japanese herbaria such as NICH, TNS, HIRO and KYO and nevertheless I did not find specimens those are not the misidentifications for other species (*e.g.*, *P. erecta*) and would have bispiral elaters. In any way, an unambiguous confirmation that *P. virgata* elaters are bispiral could be based on study of type of the latter.

The holotype of *Plectocolea virgata* is in NY (as the most of other Mitten's types). The type specimen (Japan, Challenger Expedition, NY 02265836!) contains both sterile, male and female branches, but unfortunately no sporophytes. Noticeable that the cell size along leaf margin is 16–24 μm that is quite larger than in Amakawa's description (Amakawa, 1960). Moreover, the cell walls along leaf margin are thin, with moderate in size, slightly convex trigones(!), and the only slightly thickened external wall, that evidently contradict to literature data (Amakawa, 1960). Since I did not find the elaters in holotype I took an attempt to find them in isotype in G (G00281173!), where very fortunately I found several unispiral elater fragments in rhizoids fascicle of *P. virgata* shoots (thus most probably although not 'certainly' belong to the plants from whose rhizoids they were taken). Therefore there are not any robust features separating *P. virgata* and *P. unispiris* and these two names need to be synonymized:

Plectocolea virgata Mitt., Trans. Linn. Soc. London, Bot. 3: 197, 1892 (NY 02265836!, isotype G00281173!) = *Plectocolea unispiris* Amakawa J. Jap. Bot. 29: 178. f. 1. 1954. (NICH 47429!, isotype in HIRO!) **syn. nov.**

Description (based on cited type material and specimens listed below). Plants brownish green to yellowish brownish (due to age), semi-erect, 1.0–1.6 mm wide and 10–15 mm long, forming loose mats, from rhizomatous base with frequent geotropic leafless rhizogenous stolons. Rhizoids numerous, originated from the ventral side of stem and decurrent down in very distinct fascicle of the same diameter with the stem (and easily detaching from the stem as compact bundle), purple to (rarely, probably due to age) purplish in color. Stem 200–300 μm in diameter, brownish, branching rarely occurs, ventral. Leaves more or less distant to contiguous, obliquely inserted and obliquely to (rarer) subtransversely oriented, slightly concave-canaliculate, loosely sheathing the stem in the base and erect spreading and obliquely to very obliquely oriented above, nearly ovate, ca. 800–1200×700–1100 μm. Midleaf cells 22–30×20–30 μm, thin-walled, trigones moderate in size, mostly slightly convex or triangular, cuticle smooth; cells along leaf margin 16–24 μm, thin-walled, with moderate in size, triangular to slightly convex trigones, external wall slightly thickened, cuticle smooth or finely striolate-papillose. Dioicous. Androecia intercalary, although branch commonly become depauperate after, with 10–12 pairs of bracts, bracts of similar size with leaves or slightly smaller, strongly inflated in lower 1/3. Perianth conical, exerted for 2/3 of its length, pluriplicate, gradually narrowed to not beaked mouth; perigynium ca. 1/3 of perianth length, with two pairs of bracts; bracts closely sheathing the perianth in the lower 1/3 and erect spreading above. Elaters unispiral (present as fragments only), 7–9 μm thick.

Distribution: *P. virgata* is warm-temperate to subtropical East Asian species distributed in the areas under strong influence of Pacific Ocean (the record from Nepal is based on tiny admixture to *P. truncata* (Nees) Herzog and may represent another species, *e.g.* so-called "*Jungermannia viridis*" Kashyap, *n. illeg.*). It occurs from Hokkaido in the north (where it is uncommon), becoming then more and more frequent southward, and finally is the most

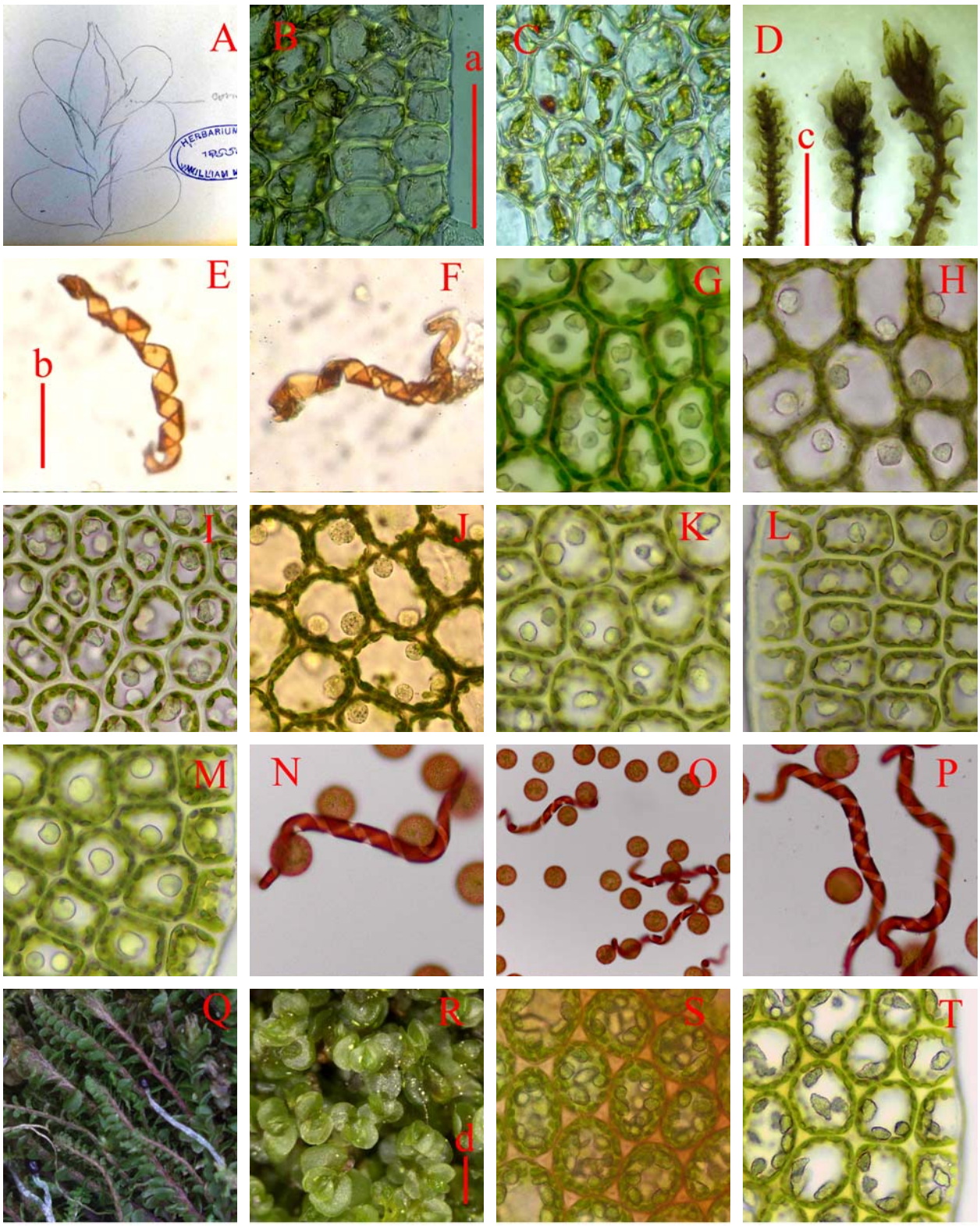

Fig. 2. *Plectocolea virgata* Mitt.: A – Mitten's hand drawing in holotype envelope (NY); B – leaf margin cells, holotype (NY); C – midleaf cells, holotype (NY); D – plant habit, male and female plants, isotype (G); E – elater fragment, isotype (G); F – elater fragment, isotype (G); G – midleaf cells, Furuki 28.II.2014, Yakushima (CBM); H – midleaf cells, j-5-13-13 (VBGI); I – midleaf cells, j-5-27-13 (VBGI); J – midleaf cells, j-91-64-15 (VBGI); J – midleaf cells, kor-29-5-15 (VBGI); K – cells along leaf margin, kor-29-5-15 (VBGI); L – cells along leaf margin, kor-30-47-15 (VBGI); M – elater, j-5-27-13 (VBGI); N – spores and elaters, j-5-27-13 (VBGI); O – elaters, j-7-12-13 (VBGI); P – plant habit, j-5-27-13 (VBGI); Q – plant habit, kor-29-5-15 (VBGI). *Plectocolea erecta* Amakawa: R – midleaf cells, j-43-8-14 (VBGI); S – cells along leaf margin, kor-23-6-15 (VBGI). Scales: a – 50 μm, for B, C, G-N, P, S, T; a – 130 μm, for O; b – 20 μm, for E, F; c – 2 mm, for D, Q; d – 1 mm, for R.

common in Kyushu. Westward it reaches southern tip of Korean Peninsula and is quite common in Jeju Island. Distribution in China seems to be poorly understood. It was recorded for Zhejiang and Hunan in subtropical East China (Piippo, 1990), eastern spoors of Himalaya in Yunnan (Gao & Bai, 2001) and Guizhou. Aside of China mainland it is known in Taiwan (Váňa & Inoue, 1983). I expect wider distribution of *P. virgata* in China, although ecological character of this species in China may be different from that in Japan. The only tropical record aside of East Asian floristic province is within Paleotropis in Malaysian floristic province (Luzon), although the identity of Luzon material with East Asian one should be verified using living and spore-bearing material.

Ecology: *Plectocolea virgata* is obviously an acidophilic hygrophyte. It prefers partly shaded (rarely growing in full shade or, contrary, in open sites) rocky substrates as well as dense fine soils along stream courses. Quite rarely this species grows aside of temporary impact of running water and covers moist to wet cliffs. *Plectocolea virgata* is the 'forest' species, occurring in broadleaved deciduous forests (Korea and northern Japan) in cool temperate zone to semi- and evergreen forests in warm temperate zone. In its 'oceanic' part of area the species distinctly avoids upper elevations of the mountains and the most of records in Japan and Korea are below 700 m a.s.l., with only limited number of localities as high as up to 900 m a.s.l. However, in South and South-East China the species occurs in much higher elevations starting from 1200 in Taiwan and reaching 1570 m a.s.l. in Yunnan, with the only record at 800 m a.s.l. in Hunan. I see several possible reasons for this fact, with the most appropriate are: 1) warmer climate in southern China, than in southern Japan, 2) drier climate in the mainland of China that does not permit the survival of this highly 'moisture-depending' taxon in low elevations where it cannot catch additional amount of moisture from wet monsoon air masses, 3) occupancy of suitable habitats in low elevations of southern China by other taxa that, therefore, supersede *P. virgata* from low elevations.

Specimens examined: (other than types):

CHINA. Guizhou Prov., Duyun Municipality, Doupeng Mountains, Xiniu Waterfall area (26°22'23"N 107°21'21"E), 1300 m alt., broadleaved (mostly evergreen) forest, wet cliffs in open place in spray zone of waterfall, *Bakalin V., China-56-81a-13* (VBGI); Hunan Prov., Yanling Co., Tianxinli (26°28' N 114°03'E), 760-800 m alt., cliffs in mid-subtropical forest, *Koponen T., 55182* 11.X.1998 (NY, s.n.; MO 6169096; HIRO, s.n.), Daozhen, Dashahe, 1500 m. alt., on stone, *Wang M., 59204*, 03.VIII.2003 (PE 01072903); Yunnan Prov., Gongshan County (27°46'05" N 98°38'14"E), 1570 m alt., rock slab at the base of cliff, in river gorge with evergreen broadleaved forest on steep N-facing slope above river, *Long D.G. & J. Shevock, 37096* 25.IX.2007 (MO 6231193, sub *Solenostoma appressifolium*).

JAPAN. Aomori Pref., Hakkoda Mt., below Kayano-chaya, 400 m alt., *Kitagawa N., 6396* 03.IX.1961 (KYO, s.n.), Towada-shi, Okuse, Goryo-no-taki Falls (40°29'08"N 140°56'50"E), 400 m alt., bottom of falls in deciduous forest, *Ota M. & T. Furuki, 23389*, 29.IX.2013 (CBM, s.n.), [no exact locality], *Faurie U., 118*, IV.1898 (KYO, s.n., sub *Jungermannia fusiformis*), [no exact locality], *Faurie U., 126*, 16.V.1898 (KYO, s.n., sub *Jungermannia fusiformis*), [no exact locality], *Faurie U., 128, 140*, 20.V.1898 (KYO, both sub *Jungermannia fusiformis*); Chiba Pref., Awa-gun, Kiyosumi Mt., 150 m alt., on wet rock in shaded place, *Takamiya H., 80,* 03.VIII.1987 (CBM 4538), Futtsu-shi, Nokogiri Mt., 150-250 m alt., cliff (tufa), along trail in the forest, *Furuki T., 8244*, 15.VI.1989 (CBM 17601); Fukuoka Pref., Tagama-gun, Soeda-machi, Hiko-san Mt., along upper course of Shioi River (33°28'20"N 130°54'07"E), 770 m alt., broadleaved-coniferous forest along stream, cliff in partial shade, in mesic conditions. *Bakalin V., J-7-49-14* (VBGI), moist cliff in partial shade, Bakalin V., J-6-48-14 (VBGI), Ubaga-futukoro (33°27'33"N 130°53'48"E), 570 m alt., broadleaved-coniferous mixed forest, moist boulder near stream, in partial shade, *Bakalin V., J-4-29-14* (VBGI), moist cliff on slope, in open place, *Bakalin V., J-4-56-14* (VBGI); Kagoshima Pref., Ohguchi City, North of Motokoyama, 700 m alt., *Inoue H., 21172*, 21.II.1974 (TNS 28717), Ohsumi Pen., Hetsuka small ravine along sea coast, *Inoue H., 21082*, 20.II.1974 (TNS 28658), Yakushima Isl., 300 m alt., moist boulders along logging railway, *Takaki N.*, 08.IX.1968 (SAP, published in Hepaticae Japonicae Exsiccatae ser. 16 (1969) n. 779); Kochi Pref., Ohnomi-mura, 400 m alt., on wet rock, *Inoue H., 2218* 24.III.1952 (NICH 61246); Kumamoto Pref., Kikuchi-shi, *Iijima M.*, 13.XI.1974 (TNS 37578, chromosome number = 9, counted by M. Iijima); Mie Pref., between Owase and Yanoko Pass, 600 m alt., *Inoue H., 24759*, 27.VII.1976 (TNS 54995), Nagashidani, Komono-cho, 650 m alt., on bank, *Kodama T., 10054*, 10.VIII.1955 (NICH 47120); Miyazaki Pref., Nichinan, Sakatani, waterfall in Kobuse Stream Valley (31°38'15"N 131°14'46"E), 180 m alt., broadleaved-coniferous mixed forest in the valley, moist to wet cliffs (white pumice deposits of acid reaction), in part shade, *Bakalin V., J-2-4-14* (VBGI), Okue Mt., 900 m alt., on thin soil of rock Amakawa T., 1134 01.IV.1953 (NICH 47429, holotype of *Plectocolea unispiris* Amakawa; HIRO, s.n., isotype), Obi, 100 m alt., rupicola, sciophila, *Hattori S.*, VII.1945 (SAP, published in Hepaticae Japonicae Exsiccatae ser. 1 (1946) n. 10), Kagamizu, Kaeda Stream Valley (31.780278°N 131.374722°E), 200 m alt., evergreen broadleaved forest in the valley, moist cliff in part shade, *Bakalin V.*, J-91-64-15, 07.X.2015 (VBGI); Niigata Pref., Toyano, on ground, *Ikegami Y., 7215*, 28.VI.1946 (NICH 10677); Oita Pref., Fuka-yabakei, shaded rocks, *Noguchi A.*, VII.1950 (SAP, published in Hepaticae Japonicae Exsiccatae ser. 4 (1951) n. 186); Shiga Pref., Ashibidani, Katada-cho, 500 m alt., rock along stream, *Kodama T., 22802*, 23.XI.1963 (KYO, s.n.; NICH 73592); Shizuoka Pref., Ashitaka Mt., 500 m alt., *Hirano H.*, 03.XII.1977 (TNS 43188); Tottori Pref., Tottori-shi, Aoya-cho, Tawaradani, Fudo Water Fall (35°28'41.3"N 133°58'20.7"E), 115 m alt., Broadleaved-coniferous forest, moist cliff in part shade in stream valley. *Bakalin V., J-5-23-13, J-5-26-13* (VBGI), Iwatsubo (35°24'09.6"N 134°06'0.9,4"E), 239 m alt. Broadleaved forest, moist to wet cliffs along stream. *Bakalin V., J-7-11-13* (VBGI)

NEPAL. Western Nepal, Pokhara, Phewa Lake, 800 m alt., on soil, *Higuchi M., 15481*, 06.IX.1988 (TNS 110057, tiny admixture to *Plectocolea truncata* (Nees) Herzog, identified with some doubts).

PHILLPPINES. Luzon, Pulong Mt. (16°36'N 120°54'E), *Jacobs M., B296*, 06.II.1968 (NY, s.n.)

REPUBLIC OF KOREA. Jeju Prov., Halla Mt., 700 m alt., rocks, *Hong W.S., 1876*, 03.VIII.1960 (NICH 226849), ibidem, 1870 m a.s.l. (NICH 226942), Seogwipo-city, Hyodon stream (33.306306°N 126.556111°E), 484 m alt., *Choi S., 7686-a,* 7.08.2010 (JNU, VBGI), (33.306444°N 126.556194°E), 484 m alt., *Choi S., 111259*, 29.X.2011 (JNU, VBGI); Jeollabuk-do Prov., Musu, Deokgyu National Park, Sasgak Stream (35.782472°N 129.712806°E), 809 m alt., broadleaved forest, rocks along stream, *Bakalin V., Kor-16-5-08* (VBGI); Jeonnam Prov., Cheongoan Mt., peak area (34°32'08"N 126°54'43 "E), 731 m alt., mostly *Weigela-Quercus mongolica* with admixture of broadleaved trees and *Chamaecyparis* forest, wet cliffs near stream in part shade, *Bakalin V., Kor-17-19-11* (VBGI), Oinarodo Island, Bongryae Mt. (34°26'09"N 127°30'21"E), 413 m alt., broadleaved deciduous-evergreen forest with dense shrub understory and some admixture of planted *Cryptomeria* and *Chamaecyparis*, wet cliffs near stream, *Bakalin V., Kor-18-38-11* (VBGI); Kangwon Prov., Seorak Mt., the road from Jungcheong Peak to Sinheungsa Temple along Cheonbuldong Valley (38°08'11"N 128°28'24"E), 900 m alt., wet cliffs, *Bakalin V., Kor-11-21-11*, *Kor-12-07-11* (VBGI); KyongNam Prov., lower course of Simwon Stream, (35.352778°N 127.570278°E), 981 m alt., broadleaved forest, wet cliffs along stream, *Bakalin V., Kor-18-46-09* (VBGI).

TAIWAN. Nantou Co., Chitou, 1200 m alt., rocks near stream, *Yamada K., 439,* 27.VII.1979 (NICH 426665), Hohuanshan Mt., *Lai M.J., 13019*, 25.III.1982 (NICH 407915).

Comparison: Two other species seems to be most closely related to *Plectocolea virgata* in the sense of the present account. The first one is *P. erecta* Amakawa that differs from *P. virgata* in mostly large and convex trigones of leaf cells that commonly loosely confluent in tangential walls of leaf margin cells (and then looks as strongly unequally thickened cell walls), subtransversely inserted, but mostly obliquely oriented leaves and, especially, in more numerous (3–7 per cell) rounded to ellipsoidal granulate oil bodies. Another taxon with which *P. virgata* may be related is *P. prostrata* (Steph.) S. Hatt. (recently re-circumscribed and illustrated by Bakalin, 2014), the poorly investigated taxon of unclear rank, somewhat similar to *P. erecta* in large trigones in leaf cells, but having rhizoids initial cells in ventral leaf base – the feature uncharacteristic in the group. Unfortunately oil bodies and sporophytes of the latter are not known and the relationships of *P. prostrata* and *P. virgata* should be further investigated.

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