Acta Botanica Hungarica 66(1–2), pp. 105–118, 2024
DOI: 10.1556/034.66.2024.1-2.7

NEW RECORDS FOR THE BRYOPHYTE FLORA OF VIETNAM, 5
Epihyllous liverworts of Tam Đảo Mountains, Vietnam

T. Pócs

Institute of Biology, Eszterházy Károly Catholic University, H-3301 Eger, Pf. 43, Hungary; E-mail: pocs.tamas33@gmail.com

(Received: 3 January 2024; Accepted: 6 March 2024)

In November 1998, guided by Prof. Trần Ninh we revisited the Tam Đảo mountain range, extensively researched by him before. Since than it was converted into a National Park, with areas stretching to three provinces, Vĩnh Phúc, Thái Nguyên, and Tuyên Quang. The previous collections indicated that many more novelties can be expected from there. As a result, we collected 38 epiphyllous liverwort species. Among these 6 were new to the flora of Vietnam: *Cololejeunea fructu-marginata*, *C. papillosa*, *C. spathulifolia*, *Colura bisvoluta*, *Lejeunea dipterota* and *Microlejeunea sechuanensis.* One species is new to science: *Cololejeunea dinhensis*. Furthermore, *Cololejeunea rotundilobula* proved to be a new synonym of *Cololejeunea sigmoidea*.

Key words: *Cololejeunea*, endemism, Indochina, new species, new synonym

INTRODUCTION

In October 1963 I made a brief visit to the Tam Đảo Mountains, where I began collecting epiphylls. Only three records from that time were published (Pócs 1969). Even then, it was evident, that this humid area with relatively intact wet tropical forests harboured a very rich bryoflora. In the meantime, Trần Ninh from the Hanoi University of Science started to study its bryophytes, focusing especially on the mosses of the area, which is currently a national park, but he also collected liverworts. Trần Ninh published several papers, including the description of new species (Ninh 1980, 1981) and a comprehensive moss check list for the present Tam Đảo National Park (Ninh 1993). In 1999 two Hungarian botanists, Gabriella Kis and Erzsébet Fráter with her husband, Géza Kósa, guided by Vietnamese experts, visited shortly the mountains and collected 18 species of epiphylls at the foothills (Pócs 2023).

I revisited the area from 18 to 22 November 1998, with the guidance of Trần Ninh. We were accompanied by Dr Nguyễn Quốc Binh, a specialist of Zingiberaceae at the Botany Department of the Institute of Ecology and Biological Sciences (Vietnam) and by Géza Kósa, a dendrologist from the Institute of Ecology and Botany, Hungarian Academy of Sciences. We aimed to collect as many epiphyllous liverworts, as possible (20–30 host leaves per localities). In this paper I intend to publish the results after identifying them. The nomenclature fol-

lows Söderström *et al.* (2016). Voucher specimens are deposited in the herbarium of Hanoi University of Science (HNU) and in the herbarium of our university (EGR). The bryophyte specimens collected in Vietnam and incorporated into our herbarium until 2020 are enumerated in Lương *et al.* (2020). I changed in the title of the publication series from "liverworts and hornworts" to "bryophytes" following the renewed evolutionary concept (Bechteler *et al.* 2023), which suggests that bryophytes are monophyletic. Additionally, this change is practical as it allows for the publication of mosses in this series in the future.

MATERIAL AND METHODS

The epiphyllous collection

We collected epiphylls at the following places, as indicated by their locality numbers listed below. All identified epiphyllous liverworts are presented in Table 1.

No. 9897: Mossy elfin woodland with Melastomataceae, Ericaceae (*Vaccinium* sp.) and Theaceae shrubs and small (1–3 m) trees on the Đinh Rung Rinh summit at 1,335–1,345 m alt. 21° 28.76′ N, 105° 37.88′ E. Coll.: T. Pócs and Trấn Ninh, 18 Nov. 1998.

No. 9898: Montane rain forest NW from Tam Đảo town, NE slope of Mt Đinh Rung Rinh at 1,050–1,150 m alt. 21° 28.9′ N, 105° 38.2′ E. Coll.: T. Pócs and Trấn Ninh, 18 Nov. 1998.

No. 9899: Montane rain forest SE of Tam Đảo town, on the stony SW slopes of Mt Mỏ Quạ, at 910 m alt. 21° 26.9′ N, 105° 38.7′ E. Coll.: T. Pócs and Trấn Ninh, 19 Nov. 1998.

No. 98100: Microphyllous forest on the rocky summit ridge of Mt Mỏ Quạ, E from Tam Đảo town, at 980–1,045 m alt. 21° 26.5′ N, 105° 38.8′ E. Coll.: T. Pócs and Trấn Ninh, 19 Nov. 1998.

No. 98102: Rocky montane rain forest above Quan Chu village, along Đuong Cai Keng tourist trail, dominated by *Cylindrokelupha alternifoliolata* and *Camellia* ssp., with bamboos and here and there with *Podocarpus neriifolius*, at 1030–1050 m alt. 21°28′N, 105°39′E., Coll. T. Pócs & Trấn Ninh, 20 Nov. 1998.

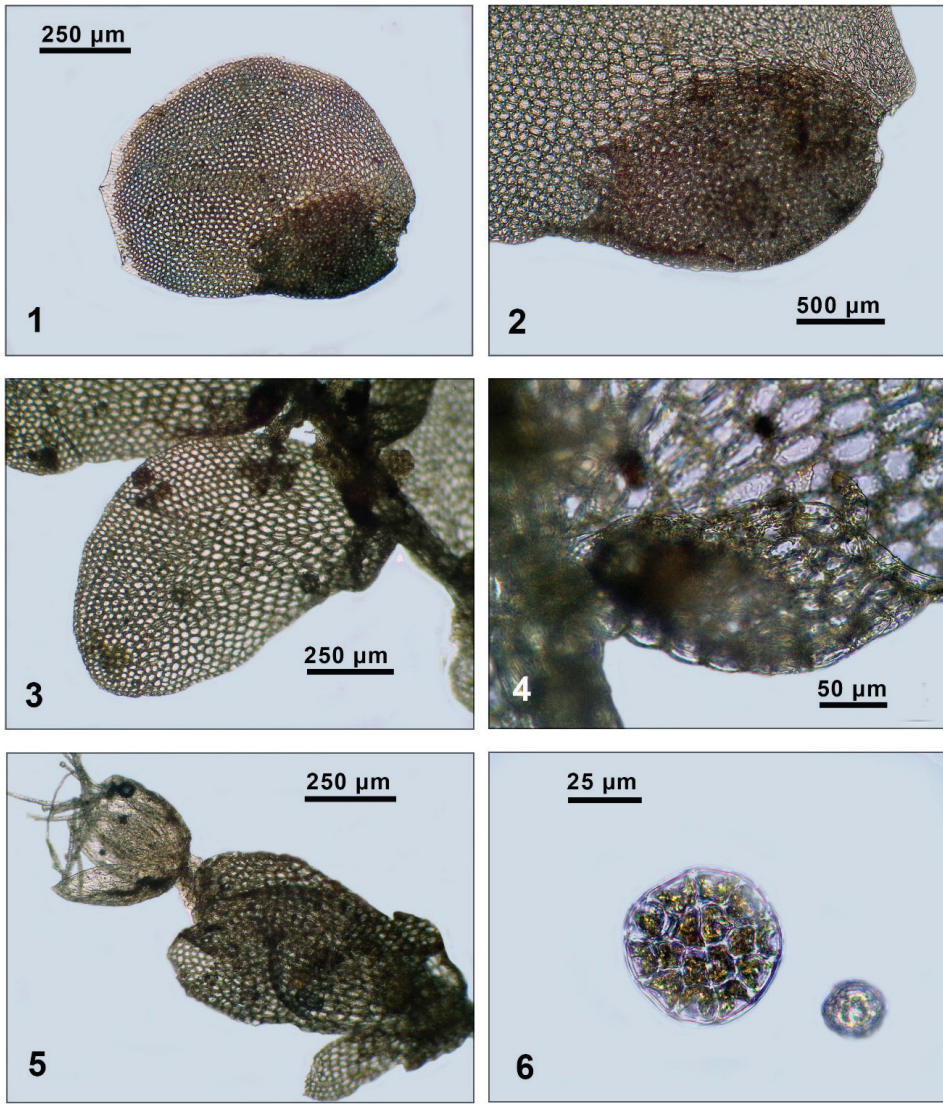
No. 98103: Mt Cái Keng N of Tam Dảo town. Montane rain forest on the S slopes between 1,015 and 1,185 m, with many *Cylindrokelupha alternifoliolata* trees, rich in bryophytes along streamlet. 21° 27.6′ N, 105° 38.8′ E. Coll.: T. Pócs and Trấn Ninh, 21–22 Nov. 1998.

No. 98105: Montane rain forest in the valley E from Thác Bạc waterfalls, SW of Tam Đảo town, at 870–940 m alt. 21° 27.23′ N, 105° 39.05′ E. Coll.: T. Pócs, 22 Nov. 1998.

RESULTS

Species new to the bryoflora of Vietnam

The following list enumerates the species new to the bryoflora of Vietnam, including those reported only once before, as documented in the check-



Figs 1–2. Cololejeunea fructu-marginata Tixier, leaf and lobule, ventral view (from 98102). – *Figs 3–6. Cololejeunea spathulifolia* (Steph.) H. A. Mill., 3: leaf; 4: lobule, ventral view; 5: gynoecium with sporophyte; 6: gemma (from 98102)

Table 1
The occurrence of collected species in the different localities (Loc. 9897–9898 and 9899–98100 are united, as they are very close to each other). The numbers in the five columns are the traditional dominant values according to Braun-Blanquet (1964). In the last column frequency values are indicated

Species/Locality no.	9897–9898	9899–98100	98102	98103	98105	FR
Cheilolejeunea turgida (Mitt.) W. Ye et R. L. Zhu	+	–	–	–	–	I
Cheilolejeunea trapezia (Nees) R. M. Schust.	1	1	–	–	–	II
Cheilolejeunea xanthocarpa (Lehm. et Lindenb.) Malombe	+	1	–	–	–	II
Cololejeunea appressa (A. Evans) Benedix	1	+	–	+	–	III
Cololejeunea dinhensis sp. n.	2	3	–	2	–	III
Cololejeunea fructu-marginata Tixier	–	–	+	1	–	II
Cololejeunea haskarliana (Lehm. et Lindenb.) Schiffn.	–	–	2	–	–	I
Cololejeunea inflata Steph.	–	2	–	–	–	I
Cololejeuna lanciloba Steph.	–	–	–	–	2	I
Cololejeunea papillosa (K. I. Goebel) Mizut.	1	–	–	–	–	I
Cololejeunea peraffinis (Schiffn.) Schiffn.	1	–	–	+	–	II
Cololejeunea sigmoidea Ast et Tixier	1	–	2	2	–	III
Cololejeunea spathulifolia (Steph.) H. A. Mill.	–	–	+	–	–	I
Cololejeunea tenella Benedix	+	–	–	–	–	I
Cololejeunea trichomanis (Gottsche) Besch.	–	–	3	+	2	III
Colura bisvoluta Herzog et Ast	+	–	–	–	–	I
Diplasiolejeunea cobrensis Gottsche ex Steph.	+	–	–	–	–	I
Diplasiolejeunea rudolphiana Steph.	+	–	–	–	–	I
Drepanolejeunea commutata Grolle et R. L. Zhu	2	–	–	+	–	II
Drepanolejeunea erecta (Sateph.) Mizut.	2	2	+	1	+	V
Drepanolejeunea foliicola Horik.	1	–	–	–	–	I
Drepanolejeunea spicata (Steph.) Grolle	1	–	–	–	3	II
Drepanolejeunea tenera K. I. Goebel	1	–	–	–	–	I
Frullania alstonii Verd.	–	1	+	–	–	II
Lejeunea adpressa Nees	+	–	–	–	+	II
Lejeunea cf. *dipterota* (Eifrig) G. E. Lee	–	–	–	–	+	I
Lejeunea parva (Sw.) Nees	–	1	–	+	+	III

Table 1 (continued)

Species/Locality no.	9897–9898	9899–98100	98102	98103	98105	FR
Leptolejeunea maculata (Mitt.) Schiffn.	1	–	–	2	–	II
Leptolejeunea subacuta A. Evans	2	1	2	1	–	IV
Metzgeria consanguinea Schiffn.	1	–	–	–	–	I
Metzgeria furcata (L.) Corda	–	–	–	2	–	I
Microlejeunea punctiformis (Taylor) Steph.	–	1	+	1	–	III
Microlejeunea szechuanensis P. C. Chen	–	–	–	1	–	I
Myriocoleopsis minutissima (Sm.) R. L. Zhu et Pócs	+	–	–	–	–	I
Radula acuminata Steph.	–	–	2	1	–	II
Radula gedena Gottsche ex Steph.	1	–	–	+	–	II
Radula tjibodensis K. I. Goebel	+	–	–	–	–	I
Tuyamaella molischii (Schiffn.) S. Hatt.	–	1	–	–	–	I
Number of species	24	11	10	16	7	

lists of Bakalin and Sinh (2016) and Shu *et al.* (2017). Voucher specimens are deposited in HNU and their duplicates in EGR.

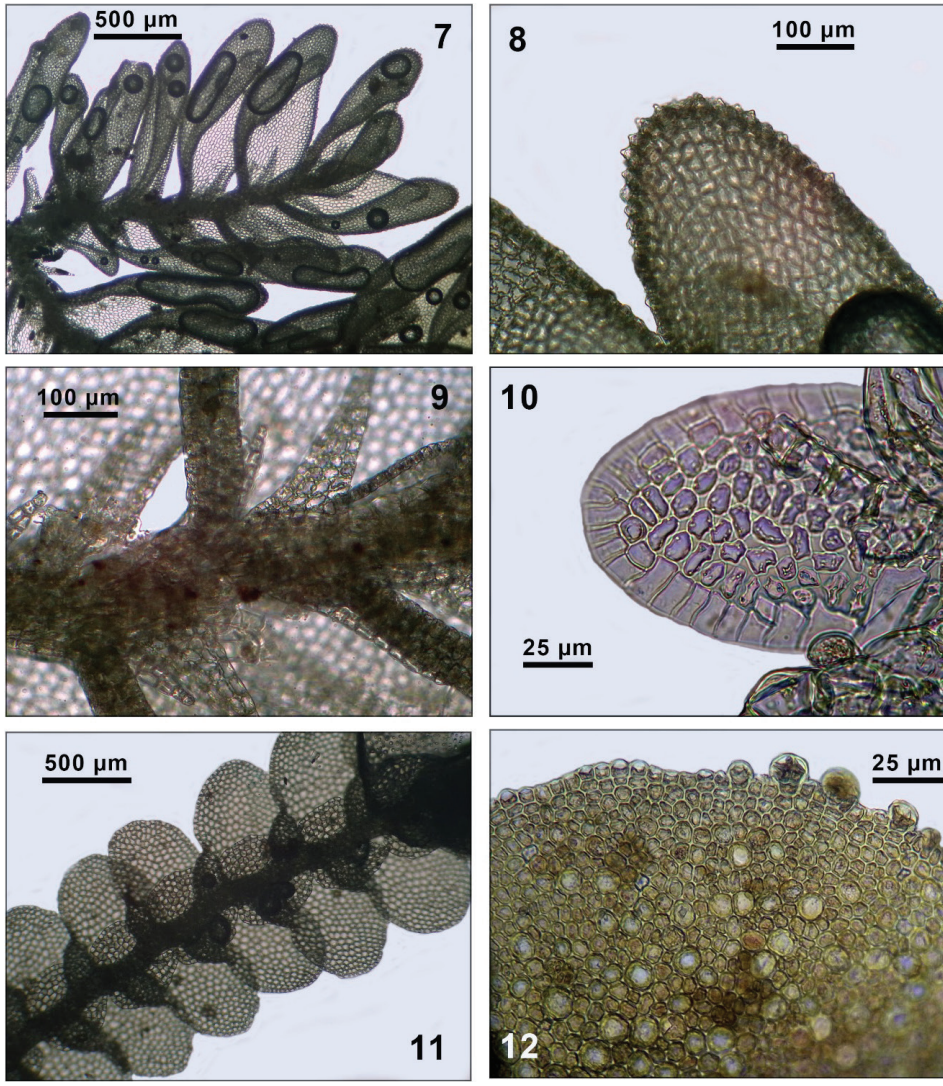
Cololejeunea fructu-marginata Tixier – Nos 98102, 98103 (EGR, HNU) (Figs 1–2) – A well-defined species of subgenus *Pedinolejeunea* Benedix ex Mizut. 1961. It has two unequal lobule teeth and lobe margin formed by two or more rows of hyaline cells at the apex. New to Vietnam, hitherto known from Thailand and Malaysia (Tixier 1985).

Cololejeunea papillosa (K. I. Goebel) Mizut. (Syn. *Aphanolejeunea papillosa* (K. I. Goebel) Herzog) – No. 9898 (HNU) – It is a tiny species of subgen. *Aphanolejeunea* characterised by many reduced, linear leaves formed by cells in two rows with smooth (not dentate) margin. A rare tropical American–Asian–Australasian disjunct, new to Vietnam (distributional data by Pócs and Piippo (1999), under the name of *Aphanolejeunea borneensis* (Herzog) Pócs).

Cololejeunea spathulifolia (Steph.) H. A. Mill. – No. 98102 (HNU, EGR only microslide) (Figs 3–6) – Species characteristic by its leaf shape and lobule with one tooth, the smooth leaf cells and the very short bracts of perianth. Gemmae 16 cells (new observation). Hitherto is known only from the Solomon Islands and Thailand, new to Vietnam. The reference of Chantanaorrapint and Pócs (2014) to Tixier (1985) of its presence in Réunion, Vietnam, New Caledonia and Hawaii was by mistake.

Colura bisvoluta Herzog et Ast – No. 9897 (HNU, EGR only microslide) (Figs 7–10) – In Tam Šảo only one well developed specimen occurred in our collection. It agrees in all properties with the Malaysian and Thai specimens

illustrated and described by Jovet-Ast (1954) and Sangrattanaprasert *et al.* (2018). But it differs from them by the inner valve cells, which have much larger, almost confluent trigones (Fig. 10). It was known from Sumatra, Thailand, Malaysia and Australia, new to Vietnam.



Figs 7–10. Colura bisvoluta Herzog et Ast, 7: habit, ventral view; 8: lobule apex; 9: underleaves, ventral view; 10: valve (all from 9897). – *Fig. 11. Lejeunea* cf. *dipterota* (Eifrig) G. E. Lee, habit, ventral view (from 98105). – *Fig. 12. Radula gedena* Gottsche ex Steph., lobe cells (from 98103)

Lejeunea cf. *dipterota* (Eifrig) G. E. Lee – No. 98105 (EGR, only microphoto) (Fig. 11) – The sterile specimen was very similar to the one described and illustrated by Eifrig (1936 under *Taxilejeunea dipterota*) and by Lee (2013), but without seeing a perianth I could not confirm its identity with certainty. The circular-reniform underleaves almost covering the lobules with fully incurved margin refer to this species. This case would be new to Vietnam, known from Java and Malaysia (Sabah) before.

Microlejeunea szechuanensis P. C. Chen – No. 98103 (EGR) – It is a taxon of a bit uncertain position. It is differentiated from the widespread *Microlejeunea punctiformis* (Taylor) Steph. by its asymmetric, falcato-ovate leaf, broadening upwards and by the 3–5 cells long underleaf segments. Previously only known from Sichuan, SW China, new to Vietnam (Miller *et al.* 1967).

Species reported previously only from one locality in Vietnam

Cheilolejeunea turgida (Mitt.) W. Ye et R. L. Zhu – No. 9898 (only microslide) – This generally rare species is known in Vietnam only from Tam Đảo, which we could confirm. It was first reported by Zhu and Lai (2003), under the name of *Leucolejeunea turgida* (Mitt.) Verd. (Shu *et al.* 2017). It is distributed from Sri Lanka and the Himalayas to southern China and Thailand (Kitagawa 1968, Ye and Zhu 2010, Zhu and So 1999 with map;).

Radula gedena Gottsche ex Steph. – No. 9898 (HNU); No. 98103 (EGR) (Fig. 12) – Rare among the epiphyllous species of *Radula.* Easy to recognise by the uneven size of lobe cells, a good number of them being larger (12–16 μm) than the average (8–10 μm). In addition, numerous small discoid gemmae are all around the lobe margin. It was known before only from the Central Highland of Lâm Đồng Province in southern Vietnam (Pócs *et al.* 2013) and from the Hoang Lien Mountains in northern Vietnam (Bakalin *et al.* 2023). It is known to be scattered from Java to Japan and Thailand (Yamada 1979).

NEW SPECIES

Cololejeunea dinhensis Pócs, *spec. nova*
(Figs 13–18)

The new species belongs to Sectio Leonidentes *Benedix, Feddes Rep. Spec. Nov. Beiheft 134: 38, and is related to* Cololejeunea ensifera *Tixier (1968) and to* Cololejeunea ocelloides *(Horik.) Mizut. (1961, syn.:* Cololejeunea leonidens *Benedix 1953). It differs from both, with its first lobule tooth being much larger than the second tooth, which is narrow and, in most cases, much shorter, consisting of only a few cells.*

Type: Vietnam, Vinh-Phuc Prov., Tam-Đảo Mts, montane rain forest NW from Tam-Đảo town, on the NE slope of Mt Rung Rinh at 1,050–1,150 m elevation. 21° 28.9′ N, 105° 38.2′ E. Epiphyllous. Coll.: T. Pócs and Trấn Ninh, 18 November 1998. Holotype: 9898/AB (EGR); isotype (HNU); paratypes: 9898/A, 9899/V, 98103/BQ (EGR).

Etymology: The Vietnamese meaning of Đinh is a nail, peak or any pointed object (and rung rinh means 'moving' or 'vibrating'). The new species is named after the summit Đinh Rung Rinh and the long, pointed first lobule tooth.

Description: Relatively large species with 1.2–1.8 mm wide, pale green shoots form roundish colonies of 1.2–1.8 cm, appressed to the host leaf surface of shrubs or *Pandanus* sp. A 2–3 cell wide broad vitta can be seen even by a hand lens. The 60–80 μm thick stem irregularly branching and composed of 1 medullary and 6 cortical cells, of one is the ventral merophyte. Cortical cells are rectangular, about 40 × 20 μm, the ventral, merophyte cells irregular in shape and size. The leaves are ovate-oblong, asymmetric, reniform, slightly falcate, up to 720 × 560 μm size, leaf insertion angle to the stem 30°, ventral margin forms an angle of 140–150° with the keel. Lobe cells mostly square or rhomboid (8–18 × 6–12 μm), thin walled without trigones, each with a small papilla on both sides. Marginal cells just smaller (4–8 × 6–8 μm), hardly differentiated from the other lobe cells, rarely rectangular, perpendicular to the margin. The vitta is striking, honey yellow and shining under stereo microscope, always much exceeding the lobule in length, composed of two rows of 6–7 larger (up to 180 × 40 μm) cells diminishing toward the end. A third, smaller row accompanies them with sometimes scattered and obliquely located cells. The vitta cell walls have bulbous trigones and 2–3 intermediate thickenings. The lobule is of ⅓–¼ of lobe length and width, ovate and evenly inflate with a long, linear-lanceolate, first tooth consisting of 3–6 uniseriate cells and the usually shorter triangular second tooth, crossing each other. The second tooth usually small and consists only of 1–4 cell, sometimes obsolete and is always overgrown by the first tooth, crossing each other. An ellipsoidal, translucent hyaline papilla of 16 × 18 μm is between them, attached to the distal margin of lobule. The first tooth is at 2(–3) cells distance from the keel. Stylus bicellular, 40 × 15 μm.

I could not observe any gametangia on the investigated, more than 120 individuals. But on the other hand, the vegetative propagation is enhanced by the many discoid, endogenous gemmae of brownish colour, developing mostly on the ventral side of the lobes (generally 10–30, up to 50 per leaf). Normally the gemmae consist of 20–24 cells, round or very slightly reniform, 40–45 μm in diameter.

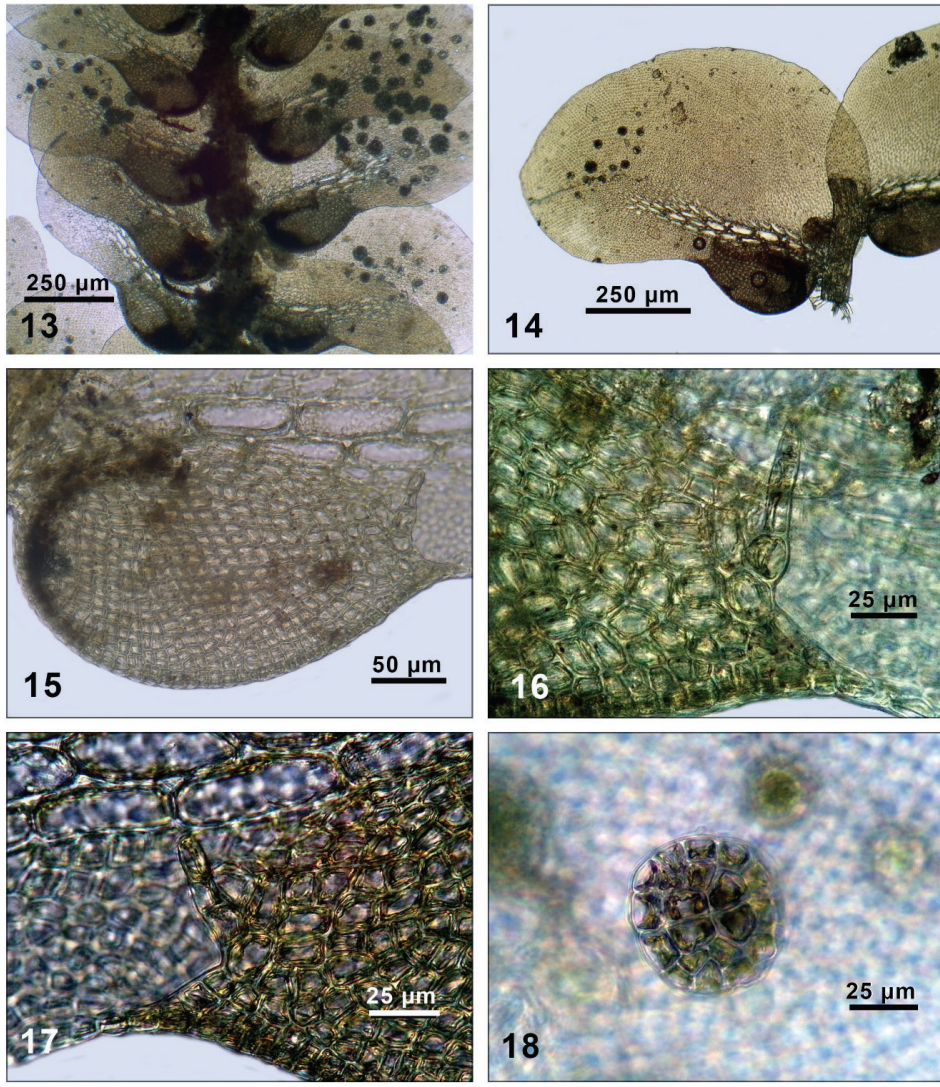
Several differences distinguish it from the related species of Leonidentes section. It differs from *C. bachmaensis* Tixier (1968), by the much longer vitta consisting of 2 or more rows of ocelli and in its small lobule; from *C. ensifera*

Table 2

Comparison of the morphological differences among *Cololejeunea dinhensis*, and related species of Sect. *Leonidentes*. (Species without true hyaline margin, with vitta much exceeding the length of lobule and with lobule teeth crossing each other)

Properties	*C. dinhensis* sp. n.	*C. bachmaensis*	*C. ensifera*	*C. crassipapillata*	*C. gresicola*	*C. ocelloides*
Leaf shape	subsymmetric ovate, slightly falcate, ventral margin forming an angle of 150–170° to the keel	rotundato-ovate, dorsal margin strongly arched, ventral margin almost straight	shortly obtuse-ovate, dorsal margin strongly arched, ventral margin almost straight	rotundato-ovate, asymmetric, ventral margin forming an angle of 160–170° with the keel	subsymmetric ovate with rounded apex, ventral margin almost straight	subsymmetric ovate, slightly falcate, ventral margin forming an angle of 160–170° with the keel
Angle of leaf insertion	30°	30°	30°	70°	70°	60–70°
Lobe margin cells	square, rarely rectangular and perpendicular to margin	rectangular or square	rectangular or square	rectangular, perpendicular to margin, rarely square	rectangular	rectangular, perpendicular to margin
Lobule/lobe length %	25–30	40–50	50–60	40–50	50–60	40–50
Lobule shape	broadly ovate. inflated	broadly ovate. inflated	elongate, inflated	ovate, inflated	ovate, inflated	ovate, inflated
Vitta	6–7 cell long, 2+1 rows	6–7 cells long,1 (+1) row	6–7 cells long, 2 rows	6 cell long, 2+1 rows	–11 cells long, 3 rows	4–10 cells long, 2–4 rows
Style cells	2	2	2–3	1	1	1
1st lobule tooth	long, linear-lanceolate, consisting of 3–6 uniseriate cells, much longer than the 2nd tooth	linear-lanceolate, formed by 2–3 cells, not exceeding the 2nd tooth	long, linear-lanceolate, consisting of 4–5 uniseriate cells	linear-lanceolate, 1–2 cells long, shorter than the 2nd tooth	linear-lanceolate, 2 cells long with thick walls, shorter than the 2nd tooth	linear-lanceolate, 2–4 cells long, much shorter than the 2nd tooth
2nd lobule tooth	small, narrow triangular to lanceolate or reduced to 0–few cells	narrow triangular, 2–3 cells broad at its base	triangular, as long as the 1st tooth, 3–4 cells broad at base	large, broad triangular, 3–5 cells broad at base	large, broad triangular, 3–4 cells broad at base	large, triangular, 2–4 cells broad at its base
Cells between 1st tooth and lobe margin	1–3	4	4	1–3	2	2–4

Tixier (Tixier 1968) by the smaller second tooth and the much shorter, ovate lobule and the vitta having a third row; from *C. crassipapillata* Tixier (Tixier 1968) by its bicellular stylus and much longer first and smaller second tooth; from *C. gresicola* Tixier (Tixier 1968) and from *C. ocelloides* (Horik.) Mizut. (Mizutani 1961) by its other leaf shape, smaller lobule and longer first lobule tooth. These differences are summarised in Table 2.



Figs 13–18. Cololejeunea dinhensis sp. n., 13: habit; 14: leaf; 15: lobule; 16–17: lobule teeth; 18: gemma (all ventral view, from the holotype, 9898/AB)

NEW SYNONYM

The format of this section follows Söderström *et al.* (2012).

Cololejeunea sigmoidea Ast et Tixier, Rev. Bryol. Lichenol. 31 (1/2): 273 (Jovet-Ast and Tixier 1962). – Type: Vietnam, Benom da Treu, forêt dense 1,800 m alt., leg. P. Tixier (holotype PC!).

= *Cololejeunea rotundilobula* (P. C. Wu et P. J. Lin) Piippo, J. Hattori Bot. Lab. 68: 134 (Piippo 1990). = *Pycnolejeunea rotundilobula* P. C. Wu et P. J. Lin, Acta Phytotax. Sin. 16: 69 (Wu and Lin 1978). – Type: China, Hainan, Jianfengling, Tianchilinchang, 1,150 m, on the leaves of *Symplocos viridissima* Brand, 6 Feb. 1962, P. C. Chen et al. 456 (holotype IBSC, isotype: HSNU), *syn. nova.*

Although I have not seen the type of *Pycnolejeunea rotundilobula*, I have seen many large populations in the Tam Đảo material, which have shown all transitions from specimens without saccate lobule to populations, which have saccate lobules on the majority of leaves and reduced lobules only on the rest. Populations completely without saccate lobules are rare; in most cases one can find a few leaves with lobule sacks. Asthana and Srivastava (2003: 99, Plate 15) illustrated also this kind of specimen, as *C. sigmoidea*. Usually well-developed, larger specimens have more saccate lobules. The variation of saccate and reduced lobules is also known by other *Cololejeunea* species, such as *Leptolejeunea epiphylla* (Mitt.) Steph. The difference between *C. sigmoidea* and *C. rotundilobula* in leaf shape given by Wu and Lin (1978) and referred to them by Zhu and So (2001: 249, 254), after examination of many specimens, is not existing. Therefore, these properties are inadequate to separate the two species.

DISCUSSION

The Tam Đảo range has even within Vietnam high bryophyte diversity. Several species are endemic to this mountain or at least for the northernmost part of Vietnam. Trấn Ninh (1993) enumerates the formerly published *Campylopus eberhardtii* Par., *Leucoloma tonkinense* Broth. et Par., *Callicostella eberhardtiana* Broth. et Par. and *Heterophyllium microalare* (Broth. et Par.) Broth. He himself (Ninh 1981) described several new moss species, which seems to be restricted to this area (*Calymperopsis vietnamensis* Ninh, *Calyptrochaeta pocsii* Ninh and *Distichophyllum duongii* Ninh). Concerning liverworts, there are no old records of endemics from the Tam Đảo Mountains (Pócs 1965). More recently was described *Cololejeunea tamdaoensis* Tixier (Tixier 1968).

After the original delimitation of section *Leonidentes* (Benedix 1953), Tixier (1968) dealt in details with this species group. From the section only 2 more widespread species were known from the Indo-Malesian region (Tixier 1978), and he added 17 new taxa from the Southeast Asian tropics. It can be

questioned whether these new species are distinct or not. Taking into account their differentiating characters in leaf shape and insertion, lobe margin, vitta, lobule shape and dentition and their quite restricted distribution in certain mountainous areas of Vietnam, Cambodia, Thailand, and the Philippines, it seems that Indochina and the surrounding area is a real hot spot of their biodiversity and allopatric speciation. The recently described *Cololejeunea dinhensis* Pócs joins this group and well differs from *C. tamdaoensis* Tixier described from the same mountains.

Renner (2020) emphasises the importance of the investigation of cryptic bryophyte species, analysing in detail the results of widespread research in this field, both by refined morphological and molecular methods. Therefore, related species, distinguished even by little but important morphologic differences, should be kept apart until molecular methods clarify their evolutionary status. This is valid also for such species group as the Indochinese members of the *Leonidentes* section of *Cololejeunea.*

*

Acknowledgements – Thanks are due to the Hungarian and to the Vietnamese Academies of Sciences for sponsoring and supporting this research within the frame of scientist exchange between these countries. I am very grateful for organising the fieldwork to Prof. Trần Ninh (HNU) and for accompanying and helping in the collection to Dr Nguyễn Quốc Binh and to Géza Kósa. I am also grateful to Thiện Tâm Lương and to Nguyễn Khánh Trình Trầm (HNU) for providing me with important references, and to the two anonymous reviewers for their useful advises and corrections.

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