

NEW RECORDS FOR THE LIVERWORT AND HORNWORT FLORA OF VIETNAM, 1

T. PÓCS^{1*}, N.-K.-T. TRAM², Q. HE³, T. KATAGIRI⁴, T.-T. LUONG^{2,5}

¹Botany Department, Institute of Biology, Eszterházy Károly University
H-3301 Eger, Pf. 43, Hungary; E-mail: *colura@upcmail.hu; corresponding author

²Department of Ecology-Evolutionary Biology, University of Science, Vietnam National
University, Ho Chi Minh City, Vietnam; E-mail: nguyenkhanhtrinhtram@gmail.com

³State Key Laboratory of Systematic and Evolutionary Botany, Institute of Botany
Chinese Academy of Sciences, Beijing, China; E-mail: heqiang@ibcas.ac.cn

⁴Hattori Botanical Laboratory, Obi 6-1-26, Nichinan, Miyazaki 889-2535, Japan
E-mail: tomoyuki-katagiri@hattorilab.org

⁵Herbarium, Biodiversity Unit, University of Turku, Turku, FI-20014, Finland
E-mail: thien-tam.luong@utu.fi

(Received: 21 May, 2019; Accepted: 16 August, 2019)

After the examination of the Cryptogam collection in the Herbarium of the University of Science, Vietnam National University Ho Chi Minh City (PHH), 25 species proved to be new to Vietnam, including one hornwort and 24 liverworts. Among them, four genera: *Denotarisia* Grolle, *Gongylanthus* Nees, *Leiomitra* Lindb. and *Lepicolea* Dumort. are new records for the country. Diagnostic characters and illustrations are given for some taxa, as well as locality notes and habitat descriptions are provided for each collecting area.

Key words: GBIF, hornwort, liverwort, new record, PHH Herbarium, Vietnam

INTRODUCTION

The first checklist of bryophytes, also the first checklist of Vietnam liverworts was published by T. Pócs in 1965, including 394 species of mosses and 162 species of liverworts and hornworts (Pócs 1965). Tixier (1966a) gave a detailed account on the epiphytic vegetation (including the bryophytes) of the Central Highlands of southern Vietnam, without floristical novelties. Fifty years later, Bakalin and Nguyen (2016) published the second checklist of 301 Vietnam liverwort and hornwort species (five species of hornworts) based on 45 literature sources. Recently, Bakalin *et al.* (2018) added 79 new records for Vietnam liverworts, in which 43 species are new to Indochina. The authors concluded that Vietnam liverwort flora currently has 379 species and infraspecific taxa and predicted that the total number of liverworts in Vietnam should be close to 500 species and infraspecific taxa. In the same year, Shu *et al.* (2017) revised Bakalin and Nguyen's (2016) checklist and added 100 new records, raising the total number of Vietnam liverwort and hornwort species

to 430 (except for 23 infraspecific taxa). There are differences in these author's opinions about the status of some species, which causes some discrepancies in the precise number of liverwort and hornwort taxa of Vietnam.

There has been a gap in liverwort studies in Vietnam for about 20 years since the late 1970s and the majority of publications on Vietnam liverworts and hornworts concentrated on floristical records. Studies on Vietnam liverworts began again in 1999, when Zhu and So reported a new *Cololejeunea* for Vietnam: *C. pseudoplagiophylla* P. C. Wu et J. X. Luo (Zhu and So 1999), which was not included in the Bakalin and Nguyen's (2016) checklist. Floristical studies with the participation of local bryologists have been restarted during the 21st century. In 2005, Pócs and Tran published 41 liverwort taxa in Vu Quang Nature Reserve (now it is a national park), of which *Cheilolejeunea streimannii* Pócs and *Cololejeunea vuquangensis* Pócs et Ninh were new to science, eight taxa were new to Indochina or Asia, while a further four were new to Vietnam (Pócs and Tran 2005). For the south of Vietnam, Pócs and Tran (2012) reported 21 epiphyllous species in Cat Tien National Park, in which *Colura ornata* K. I. Goebel were new to Vietnam. In 2013, Pócs, Luong and Ho described a new liverwort, *Drepanolejeunea bidoupensis* Pócs, among 54 epiphyllous species from 125 samples collected in Bidoup-Nui Ba National Park (Pócs *et al.* 2013). Three of them are also new to Vietnam. Bakalin and Vilnet (2018) announced a new *Mylia* to science: *Mylia vietnamica* Bakalin et Vilnet, which was also the first record of this genus for Southeast Asia. Recently, in 2019, Borovichev, Bakalin and Nguyen published a paper on the genus *Cyathodium*, which is poorly known in Vietnam. The authors provided morphological descriptions, ecology and distribution for three *Cyathodium* species present in the country (Borovichev *et al.* 2019).

In summary, the liverwort and hornwort floras of Vietnam have been studied for a long time but still insufficiently understood due to many disruptions. This paper belongs to a series of reports of new and noteworthy bryophytes of Vietnam, whereas specimen information is published and available on the Global Biodiversity Information Facility (GBIF) (www.gbif.org) database.

MATERIALS AND METHODS

The samples treated in this article were collected from 2011 to 2018 in 11 locations (1–11) of seven main localities (A–G) (Fig. 1), which are all described below. An overview on habitat and vegetation for each location is provided. Most of the specimens are from the Central Highlands of southern Vietnam and dominated by those in Bidoup-Núi Bà National Park.

The specimens were identified in connection with the project by the University of Science, VNUHCM, which aims to digitise and publish observations

of Vietnamese bryophyte and lichen specimens being held in the Herbarium of the University of Science, Vietnam National University Ho Chi Minh City (PHH) in the GBIF database. Until now, the dataset includes 851 records of which three species are hornworts and 154 species of liverworts (Luong *et al.* 2019). Identifications of specimens were done or confirmed by Tamás Pócs (EGR), Tomoyuki Katagiri (NICH) and Qiang He (PE). All specimens listed below are stored in PHH, with duplicates in EGR, NICH and PE.

Study locations

A). Bidoup-Núi Bà National Park located at the end of the Central Highlands, Lâm Đồng province. The Park has an average elevation of 1,500–1,700 m with the highest peaks at Bidoup 2,287 m, and Núi Bà (Lang Bian) 2,167 m.

– Loc. 1: the trail to Lang Bian peak, in needle-leaved forest (dominated by *Pinus kesiya*) and mixed forest (*Pinus kesiya*, Fagaceae, Melastomaceae). 12° 02' 24.4" N, 108° 25' 38.3" E. Alt.: 1500–1900 m. Date: 24 Nov. 2018.

– Loc. 2: the vicinity of Giang Ly station, in mixed forest (*Pinus krempfii*, *Podocarpus*, Fagaceae, Fabaceae, Lauraceae and Rubiaceae). 12° 11' 26.6" N, 108° 41' 14.3" E. Alt.: 1,480–1,500 m. Date: 2011 and 2015.

– Loc. 3: the vicinity of Hòn Giao station, in mixed forest (Fagaceae, Clusiaceae, Illiciaceae, Theaceae). 12° 11' 22.0" N, 108° 42' 48.5" E. Alt.: 1,500–1,800 m. Date: 2010, 2011 and 2015.

– Loc. 4: the vicinity of Cổng Trời station, in mixed forest (*Pinus kesiya*, Fagaceae). 12° 05' 55.0" N, 108° 22' 27.0" E. Alt.: 1,500–1,800 m. Date: 16 and 18 Nov. 2015.

B). Chư Yang Sin National Park, Đắk Lắk province, NW to Bidoup-Núi Bà National Park. Elevation: 800–2,442 m. The highest peak of the park and also of the province is Chư Yang Sin peak (2,442 m).

– Loc. 5: the forest along a stream in Subarea 1359 of the park, in mixed pine (*Pinus krempfii*, *P. dalatensis*, *Calocedrus macrolepis*, and *Fokienia hodginsii*) and evergreen forest (Fagaceae, Lauraceae, Meliaceae, Illiciaceae). 12° 24' 51.5" N, 108° 26' 49.5" E. Alt.: 1,600 m. Date: 29 Nov. 2015.

C). Hòn Bà Nature Reserve, southwest of Nha Trang city, Khanh Hoa province.

– Loc. 6: the trail from Dr Yersin's heritage house to Hòn Bà summit, in mixed coniferous and broadleaved forest (*Pinus krempfii*, *Fokienia hodginsii*, Fagaceae, Magnoliaceae, Rubiaceae and Lauraceae). 12° 07' 47.2" N, 108° 57' 37.7" E. Alt.: 1,550–1,560 m. Date: 23 Oct. 2015.

D). Đà Lạt city, a famous city for tourism in Lâm Đồng province, Central Highlands.

– Loc. 7: the Lâm Đồng Museum, liverworts on ornamental tree trunks. 11° 56' 26.9" N, 108° 27' 35.9" E. Alt.: 1,500 m. Date: 24 Nov. 2018.

E). Nam Ban Protected Forest, Lâm Đồng province, SW of Đà Lạt city.

– Loc. 8: a tropical montane forest along a shallow stream, next to a banana and coffee farm, including Euphorbiaceae, Lauraceae, Moraceae, Malvaceae with the understory dominated by Gesneriaceae. With the moisture from the stream, there are many Gesneriaceae leaves covered by epiphyllous liverworts. 11° 54' 59.5" N, 108° 10' 28.8" E. Alt.: 1,219 m. Date: 2 Dec. 2018.

F). Tân Phú Protected Forest, Đồng Nai Province, 40 km NW of Ho Chi Minh City.

– Loc. 9: along Mai Waterfall, characterised by tropical lowland forest vegetation, such as *Dipterocarpus*, *Ficus*, Fabaceae and Rubiaceae. It was shaded and semi-moist at the time we conducted the survey. 11° 06' 38.0" N, 107° 27' 10.0" E. Alt.: 76 m. Date: 25 Nov. 2018.

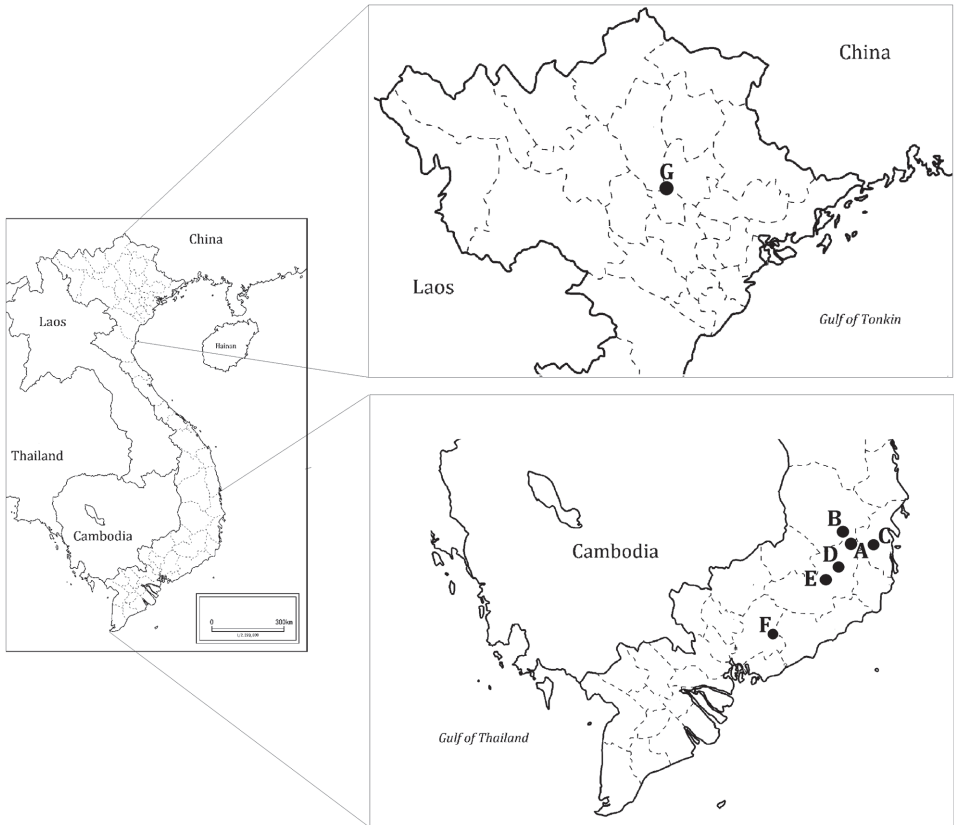


Fig. 1. The seven study locations in Vietnam. The letters refer to their description in the text

G). Tam Đảo National Park, Red River Delta, north Vietnam, 85 km NW of Hà Nội. Elevation: 700–1,300 m.

– Loc. 10: the trail to Rừng Rình peak, bamboo mixed forest, which possesses 30% cover of canopy. 21° 28' 06.3" N, 105° 37' 09.8" E. Alt.: 950–1,300 m. Date: 18 Nov. 2014.

– Loc. 11: a car road from a stilt house to the town, which runs through an evergreen forest, opened 70–100%. 21° 28' 27.6" N, 105° 38' 53.0" E. Alt.: 955 m. Date: 19 Nov. 2014.

RESULTS

A total of 25 species are newly recorded for the flora of Vietnam: one hornwort and 24 liverworts, in which four genera are new for the country: *Denotarisia* Grolle, *Gongylanthus* Nees, *Leiomitra* Lindb. and *Lepicolea* Dumort.

Acrolejeunea arcuata (Nees) Grolle et Gradst. (Figs 8–9). – Specimen examined: location 1, on bark, *Tram LBT-L-18003 p.p.* (PHH, EGR). – Distribution: a Malesian species, new to Vietnam; Java, Sumatra, Borneo (Sabah), Philippines, New Guinea. – Taxonomic notes: it can be distinguished by the lobule (more than 2.5 times long than wide with 1–2 teeth at its apex and by the suborbicular underleaves not wider than long (Gradstein *et al.* 2002).

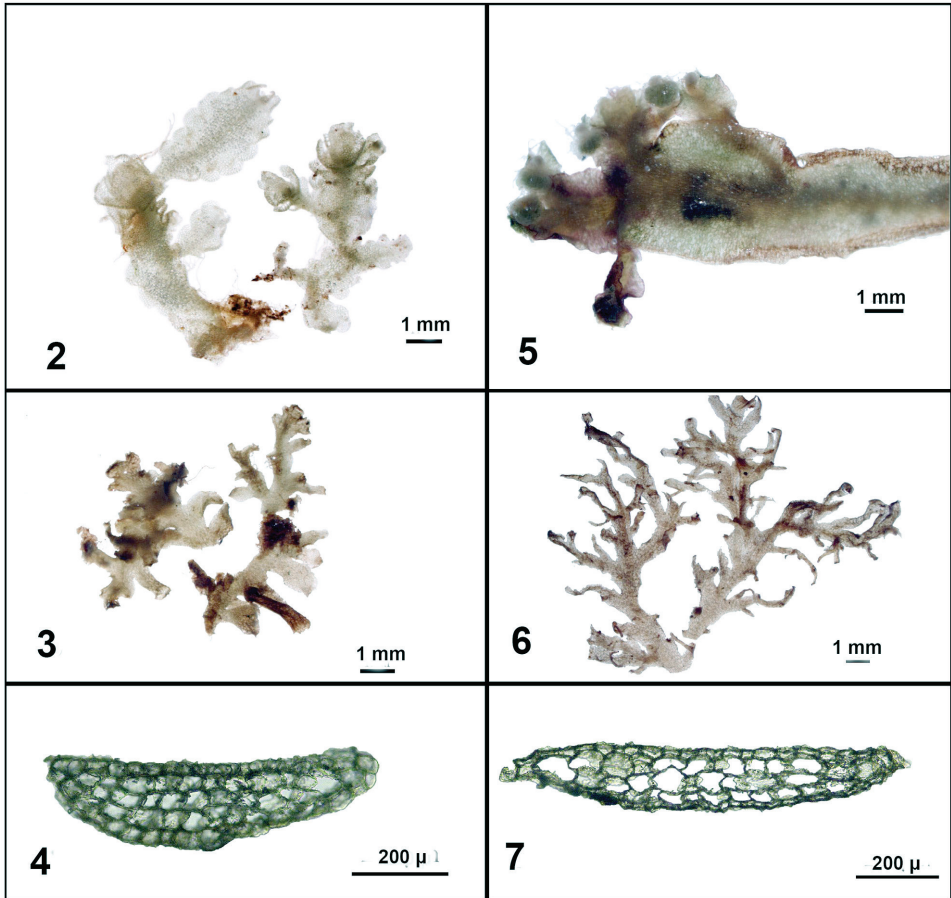
Acromastigum herzogii Grolle (Figs 10–12). – Specimens examined: location 1, on bark, *Pócs 1827/J* (PHH, EGR); location 2, on decaying log, *Luong & Ho BD-511-056* (PHH); location 3, on bark, *Luong & Ho BD-810-052-b* (PHH). – Distribution: hitherto known only from Borneo (Sarawak); new to Vietnam. A plant published and illustrated by Kitagawa (1978, fig. 2) from Thailand under the name of *Acromastigum curtilobum* A. Evans, may be the same species (*A. curtilobum* has truncate leaf lobe apices). – Taxonomic notes: the species is related to *A. filum* (Steph.) A. Evans and to *A. capillare* (Steph.) A. Evans. It differs from *A. filum* by its J shaped (not square) leaf insertion, and from *A. capillare* by its more elongated leaves and underleaves (Grolle 1964).

Anthoceros bharadwajii Udar et A. K. Asthana – Specimen examined: location 4, on soil, *Luong & Duong 15579* (PHH, PE). – Distribution: a Sino-Himalayan species, new to Vietnam; India, Nepal, S-China (Peng and Zhu 2013). – Taxonomic notes: the species is characterised by 1) thallus orbicular to fan-shaped; 2) small spores, 35–54 µm in diameter; 3) spores with spinulate blunt projections forming a pseudolamellate pattern (Peng and Zhu 2013).

Asterella mussuriensis (Kashyap) Verd. – Specimens examined: location 11, on rock, *Luong & Dinh 14622* (PHH, PE) and *14623* (PHH, PE). – Distribution: a Sino-Himalayan species, new to Vietnam; N India, Nepal, Bhutan, China and Pakistan (Jia and He 2013, Singh *et al.* 2016). – Taxonomic notes: the species is characterised by 1) sexual condition ventral-autoicous, both androecia and archegoniophores on very small ventral branches; 2) spores dark

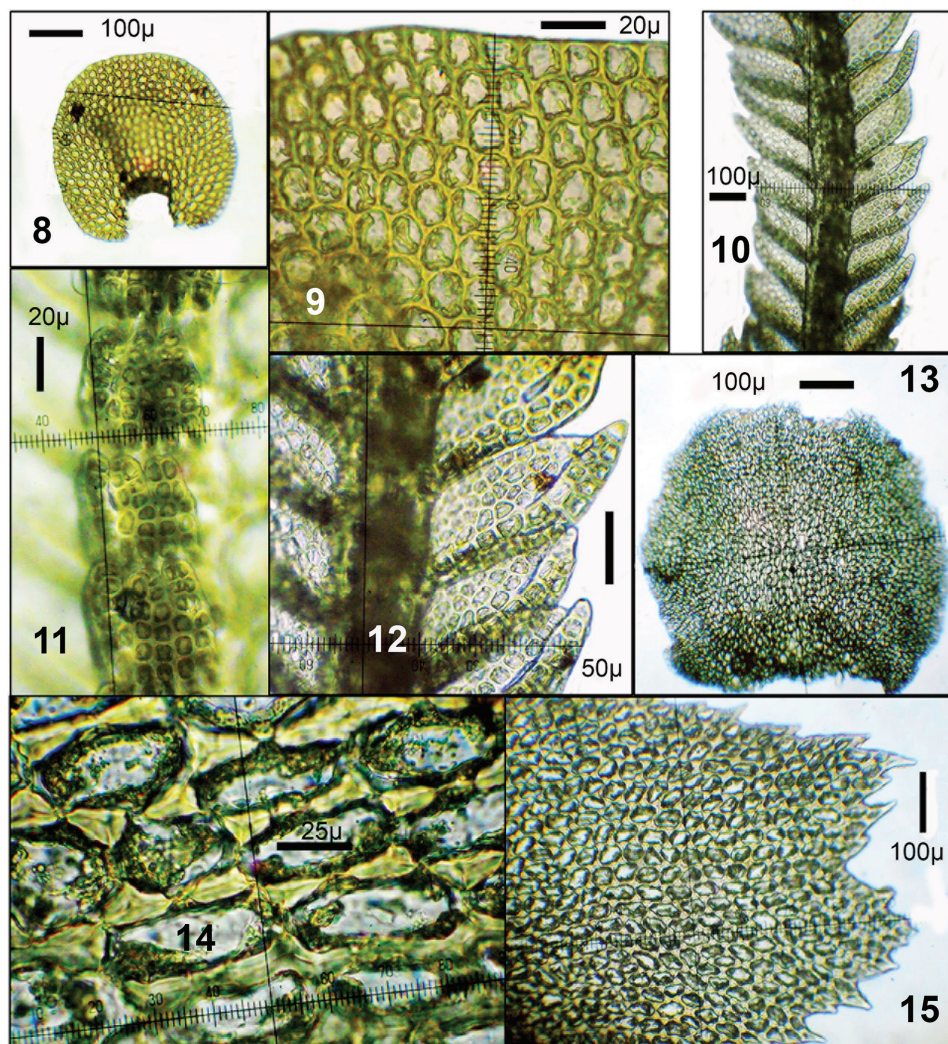
red-brown, 80–110 μm diam.; 3) elaters 130–195 \times 12.5–20 μm , mostly bispiral (Long 2006).

Bazzania serrulatooides Horik. – Specimen examined: location 3, on bark, Luong BD-0111-027 (PHH). – Distribution: a Malesian species, new to Vietnam, known from Sumatra, China (Hainan), Taiwan and Thailand. – Taxonomic notes: the combination of the serrulate leaf apex and narrow underleaves with hyaline margins distinguishes it from all other Vietnamese and South Chinese species (Zhou *et al.* 2012).

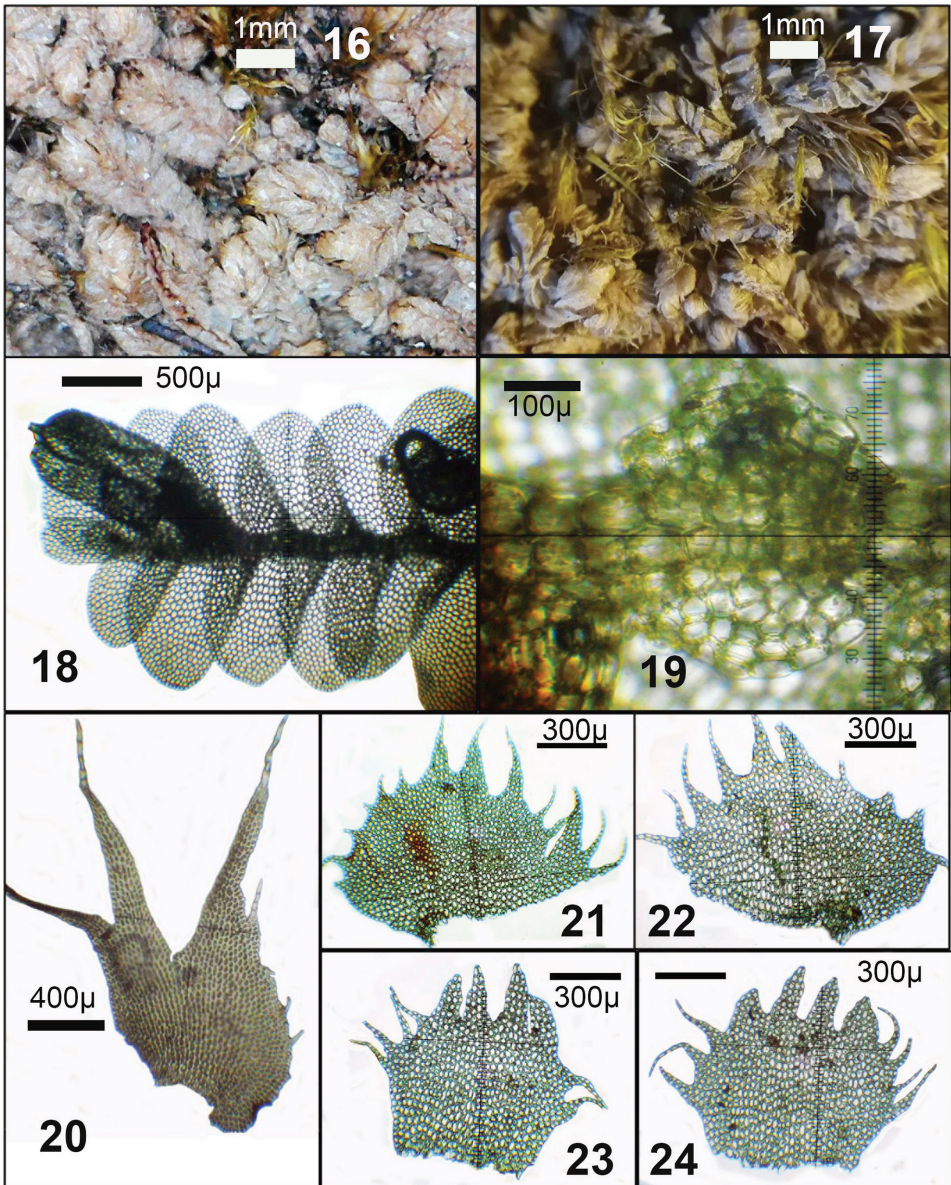


Figs 2–7. Fig. 2. *Schiffneria yunnanensis* C. Gao et W. Li, part of plant with perianth, dorsal view (from Luong & Duong 15760). – Figs 3–4. *Riccardia latifrons* (Lindb.) Lindb.: 3 = part of plant with calyptrae; 4 = cross section of thallus (from Luong & Dinh 14646). – Fig. 5. *Aseterella mussuriensis* (Kashyap) Verd., part of plant with ventral branches, dorsal view (from Luong & Dinh 14623). – Figs 6–7. *Riccardia nagasakiensis* (Steph.) S. Hatt.: 6 = part of plant; 7 = cross section of thallus (from Luong BD0111-005)

Cheilolejeunea intertexta (Lindenb.) Steph. – Specimen examined: location 9, on rock, Pócs 1829/A (PHH, EGR). – Distribution: widespread in the Palaeotropics, new to Vietnam (Zhu *et al.* 2002). – Taxonomic notes: the species is distinguished from the related *C. rigidula* (Nees ex Mont.) R. M. Schust. by its autoicy, pycnolejeuneoid innovation and by its very small trigones (Grolle 1979).



Figs 8–15. Figs 8–9. *Acrolejeunea arcuata* (Nees) Grolle et Gradst.: 8 = underleaf; 9 = lobe cells (from Tram LBT-L-18003). – Figs 10–12. *Acromastigum herzogii* Grolle: 10 = habit, ventral view; 11 = underleaves; 12 = leaves, ventral view (from Pócs 1827/J). – Figs 13–15. *Bazzania serrulatioides* Horik.: 13 = underleaf; 14 = leaf basal cells; 15 = leaf apex (from Luong BD-0111-027)



Figs 16–25. Figs 16–17. *Gongylanthus himalayensis* Grolle: 16 = habit in dry state; 17 = in wet state (from Tram NBT-L-1813). – Figs 18–19. *Lejeunea compressiuscula* (Steph.) G. E. Lee et Heinrichs: 18 = habit, ventral view, with perianth; 19 = underleaf (from Luong & Duong 15429). – Fig. 20. *Lepicolea yakusimensis* (S. Hatt.) S. Hatt. (from Luong BD-0111-021), leaf. – Figs 21–24. *Lepidozia borneensis* Steph.: 21–22 = lateral leaves; 23–24 = underleaves (from Luong BD-0111-036)

Cheilolejeunea khasiana (Mitt.) N. Kitag. – Specimen examined: location 1, on bark, *Pócs 1827/T p.p.* (PHH, EGR). – Distribution: a Southeast Asian species, new to Vietnam; S China, Japan, India (Assam), Nepal, Philippines. – Taxonomic notes: it is distinguished by its subacute leaves with short lobule and relatively large underleaves with rounded segments, and by its obovate perianth with weakly-developed keels (Zhu *et al.* 2002).

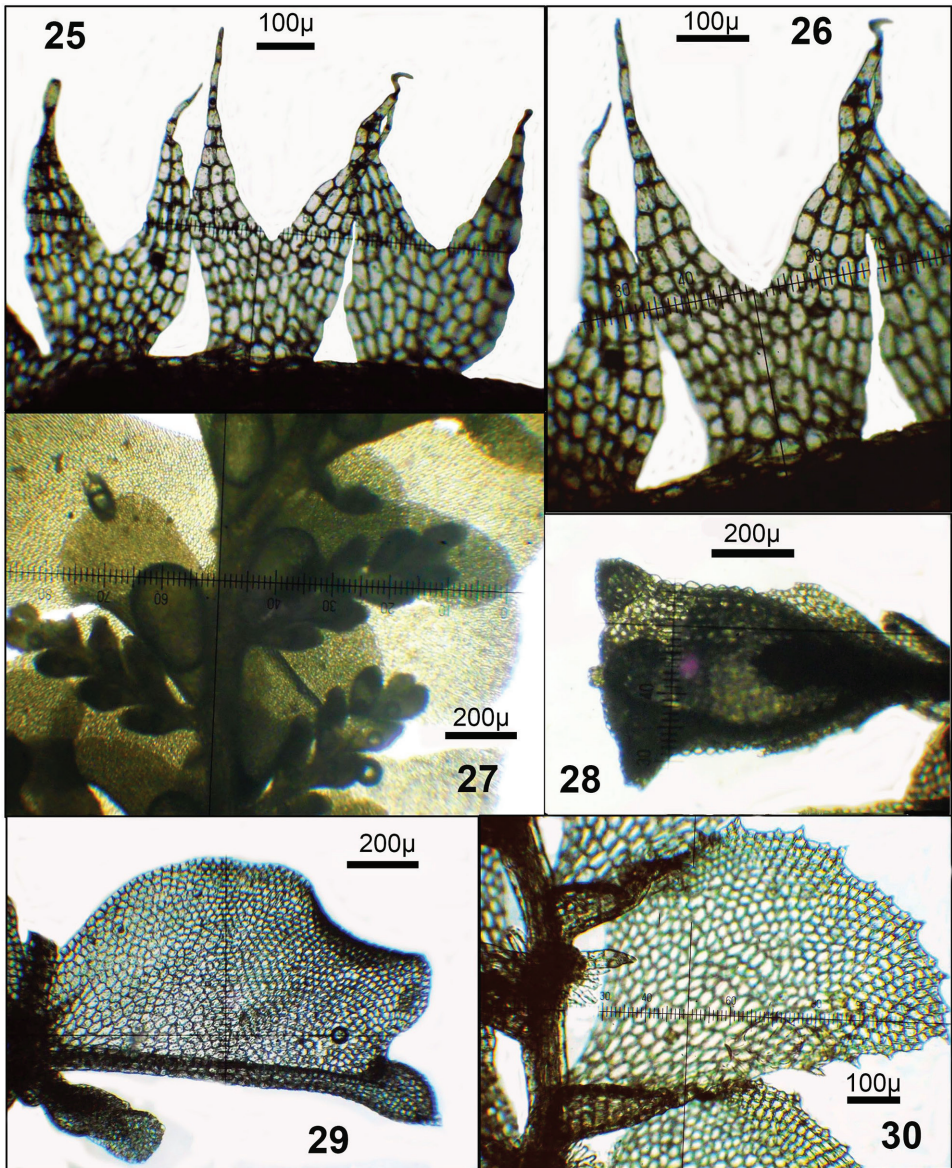
Colura speciosa Jovet-Ast (Fig. 29). – Specimen examined: location 5, epiphyllous, *Luong & Duong 15949-b* (PHH). – Distribution: known only from Indonesian Borneo and from Papua New Guinea, new to Vietnam (Pócs 2013). – Taxonomic notes: the characteristic feature of species is the entire lobe margin, the rare occurrence of lobulated leaves and the sharply apiculate lobule sac (Jovet-Ast 1954).

Denotarisia linguifolia (De Not.) Grolle – Specimen examined: location 1, on *Pinus kesiya* bark, *Pócs 1828/B* (PHH, EGR). – Distribution: Malesian-Pacific, genus and species new to Vietnam; known from Ceylon to Fiji and to the Society Islands. – Taxonomic notes: apart from its subfalcate leaves with incurved margins, the best character of the genus and species are the star-like marks in the largely nodulose trigones of the cell walls (Grolle 1971).

Drepanolejeunea levicornua Steph. (Figs 28 and 30). – Specimens examined: all specimens epiphyllous: location 2, *15055-a* (PHH), *15057-c* (PHH) and *15061-c* (PHH); location 3, *Luong 15032-c* (PHH); location 5, *Luong & Duong 15948-b* (PHH) and *15949-a* (PHH). – Distribution: a Malesian species, new to Vietnam; known from Borneo, Java, Peninsular Malaysia and Sarawak, Seram and New Guinea (Lee *et al.* 2018). – Taxonomic notes: within the *D. thwaitesiana* group the species is characterised by the lack of median leaf ocelli and by the highly mamilliose perianth wall (Mizutani 1990).

Gongylanthus himalayensis Grolle (Figs 16–17). – Specimen examined: location 8, on soil, *Tram NBT-L-1813 p.p.* (PHH, EGR). – Distribution: a Sino-Himalayan species, genus is new to Vietnam; known from India: Nilgiri Hills, Sikkim and Assam; Nepal; Bhutan; China: Sichuan and Yunnan, in an altitudinal range of 1710 to 5070 m (Váňa *et al.* 2012). – Taxonomic notes: similar to *G. ericetorum* (Raddi) Nees, but clearly differs from the latter by 1) the smooth cuticle of leaf cells; 2) the rather concave leaves with upper margin recurved (Grolle 1966).

Heteroscyphus aselliformis (Reinw., Blume et Nees) Schiffn. – Specimen examined: location 1, on bark, *Tram LBT-L-18003 p.p.* (PHH, EGR). – Distribution: a Malesian-Pacific species, new to Vietnam; known from Indonesia, Malaysia, Philippines, Japan, Taiwan, New Guinea, Solomon Islands, New Caledonia, Fiji (Grolle and Piippo 1984, Hürlimann 1998). – Taxonomic notes: a robust plant with clasping leaves, and usually occurs together with a similar species *Heteroscyphus splendens* (Lehm. et Lindenb.) Grolle. It morphologically differs from *H. splendens* by its acutely bilobed and ciliate leaf apex (Piippo 1985, 1989).



Figs 25–30. Figs 25–26: *Metahygrobiella acuminata* (Herz.) R. M. Schust.; 25. Habit, side view (from T. T. Luong BD-410-091-b). 26. Leaf. – Fig. 27: *Radula amentulosa* Mitt.; Part of shoot with amentulose branches, ventral view (from T. T. Luong 15031-b). – Figs 28 and 30: *Drepanolejeunea levicornua* Steph.; 28. Perianth. 30. Part of shoot, ventral view (from T. T. Luong 15032-c). – Fig. 29: *Colura speciosa* Jovet-Ast; Leaf, ventral view (from T. T. Luong & B. H. Duong 15949-b)

Leiomitra merrillana (Steph.) T. Katag. (Figs 31–33). – Specimens examined: location 3, on bark, *Luong & Ho* BD-511-041 (PHH, NICH) and BD-810-037 (PHH, NICH). – Distribution: widely distributed in SE Asia (Thailand, Malaysia, Philippines, Indonesia, Papua New Guinea); new genus to Vietnam. – Taxonomic notes: *Leiomitra* Lindb. is distinguished from *Trichocolea* Dumort. by the lack of regularly pinnate branching and from *Eotrichocolea* R. M. Schust. by succubous leaves. *Leiomitra merrillana* is characterised by irregularly pinnate branching, leaf cilia with (3–)6–10(–12) cells long and thick-walled cells with dilated septa. More distinguishing characters are discussed in Katagiri and Deguchi (2012).

Lejeunea cf. *dipterota* (Eifrig) G. E. Lee – Specimen examined: location 7, on bark, *Pócs* 1824/C (EGR). – Distribution: a Malesian species known from Java, Borneo (Sabah), new to Vietnam (Lee 2013). – Taxonomic notes: the vegetative characters are the well-developed cell wall trigones and intermediate thickenings of lobe, the fully incurved margin and large disc cell below the apical tooth of lobule and the large, reniform underleaves (Lee 2013). Sterile, perianth not seen.

Lejeunea compressiuscula (Steph.) G. E. Lee et Heinrichs (Figs 18–19). – Specimens examined: both epiphyllous, location 2, *Luong* 15061-*b* (PHH), location 4, *Luong & Duong* 15429 (PHH). – Distribution: a Malesian species known from Sri Lanka and Java, new to Vietnam (Lee *et al.* 2018). – Taxonomic notes: the distinguishing characters are the ovate-oblong leaves with rounded apices, the straight ventral margin of keel, the leaf cells with trigones, the small leaf lobules and the distant, small, suborbicular underleaves (Lee *et al.* 2018). Eifrig (1937) described it as *Taxilejeunea compressiuscula* Lindenb. ex Steph. nom. nudum, but did not separate it well from specimens of the later described *L. micholitzii* Mizut.

Lepicolea yakusimensis (S. Hatt.) S. Hatt. (Fig. 20). – Specimen examined: location 3, on bark, *Luong* BD-0111-021 (PHH). – Distribution: a South-east-Asian species, the genus is new to Vietnam; known from Japan, Taiwan, Malaysia: Cameroon Highlands, Sabah (Kitagawa and Kodama 1973, Wang *et al.* 2011). – Taxonomic notes: characters of the species are the absence of stem paraphyllia and the leaf segments ending in a long, hyaline, uniseriate tip (Piippo 1988).

Lepidozia borneensis Steph. (Figs 21–24). – Specimens examined: both on decaying log: location 2, *Luong & Ho* BD-511-054 (PHH) and location 3, *Luong* BD-0111-036 (PHH). – Distribution: Malesian, hitherto known only from Borneo, the Philippines and New Guinea, new to Vietnam (Piippo 1984, Tan and Engel 1986). – Taxonomic notes: a large, pinnately branching plant. It differs from the related species, like *Lepidozia brotheri* Steph. or *L. cladorhiza* (Reinw. *et al.*) Gott *et al.* by several, long, setose teeth 2–6 cells wide at base on the margin of very asymmetric leaves and underleaves (Mizutani 1968, Piippo 1984).

Lepidozia cf. *quadridens* (Nees) Nees – Specimen examined: location 1, on bark, Pócs 1827/V (PHH, EGR). – Distribution: known from Java and New Guinea, new to Vietnam (Mizutani 1968, Piippo 1984). – Taxonomic notes: medium sized, pinnately branched plants with asymmetrical, widely spreading or convex, imbricate leaves with a few short teeth on their dorsal margin with verruculose cuticle. Underleaves 4 lobed with sinuses to their half length (Mizutani 1968, Piippo 1984).

Metahygrobiella acuminata (Herzog) R. M. Schust. (Figs 25–26). – Specimen examined: location 3, on soil, Luong BD-410-091-b (PHH). – Distribution: hitherto known from Borneo: Sarawak, Sabah and from the Philippines, new to Vietnam (Váňa 1993, Schuster 2002). – Taxonomic notes: the main features of the species are the nearly lanceolate, long acuminate leaf lobes with 2–6 cells long uniseriate tips (Váňa 1993). The species is well illustrated by Herzog (1950, fig. 10) under the name of *Hygrobiella acuminata* Herzog.

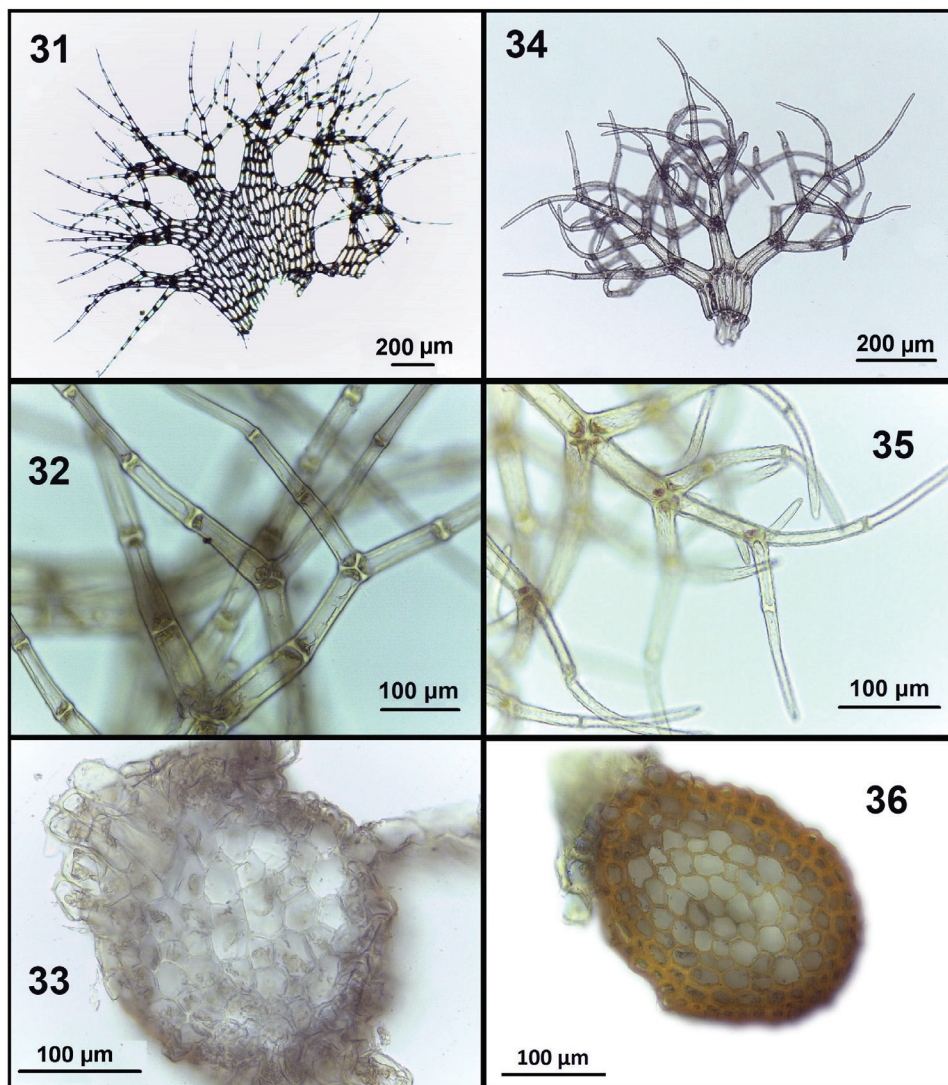
Radula amentulosa Mitt. (Fig. 27). – Specimen examined: location 3, epiphyllous, Luong 15031-b (PHH). – Distribution: a widespread Malesian-Pacific species distributed from Ceylon to Tahiti (So 2006), new to Vietnam. – Taxonomic notes: as a member of section Amentulosae, differs from all species previously known from Vietnam, by the amentulose branches shorter than a normal leaf, composed of reduced, fusiform lobes. *R. amentulosa* has ca 2 mm wide shoots and leaves with obovate lobules ca 2/3 of lobe length (Yamada 1979).

Radula formosa (C. F. W. Meissn. ex Spreng.) Nees – Specimen examined: location 3, on bark, Luong & Ho BD-511-030-a (PHH). – Distribution: a Malesian-Pacific species known from Ceylon to Tahiti, new to Vietnam (So 2006, Yamada 1979). – Taxonomic notes: Another member of sect. Amentulosae, differs from the previous species by its concave leaves with strongly incurved apex and by smaller, subquadrate lobules (Yamada 1979).

Riccardia latifrons (Lindb.) Lindb. (Figs 3–4). – Specimen examined: location 11, on concrete, Luong & Dinh 14646 (PHH, PE). – Distribution: Wide distribution in the Northern Hemisphere (Furuki 1991), new to Vietnam. – Taxonomic notes: the species is characterised by 1) medium size (0.7–1.0 × 20 mm), fresh green thalli when alive; 2) crystalline structures secreted on the surface of thallus; 3) Massula-type oil bodies (drop-like oil bodies, 1–2.5 µm in diameter and numerous in each cell); 4) paraphyses of female branches long and hair-like.

Riccardia nagasakiensis (Steph.) S. Hatt. (Figs 6–7). – Specimen examined: location 2, on rock, Luong BD-0111-005 (PHH). – Distribution: Japan (Furuki 1991), China (Piippo 1990 as *R. jackii* Schiffn.), new to Vietnam. – Taxonomic notes: the species is characterised by 1) blackish and brown thalli when dried; 2) small epidermal cells of median part of thallus; 3) epidermal cells of median part of thallus lacking oil bodies; 4) narrow lobes of ultimate pinules; 5) dioicous plants (Furuki 1991).

Schiffneria yunnanensis C. Gao et W. Li (Fig. 2). – Specimen examined: location 6, on decaying log, *Luong & Duong 15760* (PHH, PE). – Distribution: China (Li *et al.* 2006), new to Vietnam. – Taxonomic notes: the species is characterised by 1) archegoniophores at the apex of the dorsal sides of thallus; 2) bracts dense, 2–4 pairs; 3) lobe of bracts with rounded apex.



Figs 31–36. Figs 31–33. *Leiomitra merrillana* (Steph.) T. Katag.: 31 = leaf, 32 = leaf cilia, 33 = cross section of stem (from Luong & Ho BD-810-037). – Figs 34–36. *Trichocolea mollissima* (Hook. f. et Taylor) Gottsche: 34 = leaf, 35 = cilia, 36 = cross section of stem (from Luong 15013)

Trichocolea mollissima (Hook. f. et Taylor) Gottsche (Figs 34–36). – Specimens examined: both on bark, location 3, *Luong 15013* (PHH) and location 10, *Luong & Dinh 14618* (PHH, NICH). – Distribution: Oceania (Australia, New Zealand) to SE Asia (Philippines, Malaysia, Indonesia), new to Vietnam, also new for continental Asia. – Taxonomic notes: *T. mollissima* can be diagnosed by 2–3 pinnate branching, lack of superficial cilia on leaf disc, and the curved terminal cells of cilia. SE Asian specimens of this species have been often kept in herbaria under the name of *T. tomentella* var. *javanica* (Reinw., Blume et Nees) Gottsche, Lindenb. et Nees, but it is just an extreme variation of *T. pluma* (Reinw., Blume et Nees) Mont. (Katagiri *et al.* 2013).

DISCUSSION

The greater part of the above species was collected in the Bidoup-Nui Ba National Park in the Lang Bian Mountains, Central Highlands of southern Vietnam. As the area, both in altitudinal regions and in its variable substrates, provides a high diversity of habitats along favourable climatic conditions, it is no wonder that its bryoflora is so rich. Here an important substrate is the acidic bark of *Pinus kesiya*, occurring both in pure stands or mixed among broadleaved trees. Pine bark is especially rich in members of Lepidoziaceae family. Epiphylls are more common in the broadleaved forests of the area.

As far as the phytogeographical composition of the bryoflora is concerned, the number of Indo-Malesian and Malesian-Pacific elements increases going southward in Vietnam, as was previously shown by Tixier (1966a, b). At the same time the ratio of Sino-Himalayan elements decreases southwards. Belonging to the former group, in our collection, they are for example *Acrolejeunea arcuata*, *Acromastigum herzogii*, *Bazzania serrulatoides*, *Colura speciosa*, *Denotarisia linguifolia*, *Lepidozia borneensis*, *Metahygrobiella acuminata* and *Radula formosa*, while to the later group are *Asterella mussuriensis* and *Gongylanthus himalayensis*. Southeast Asian species add a special feature to the bryoflora, like *Lepicolea yakusimensis* and *Riccardia nagasakiensis*. The rest of species are more widespread Palaeotropical or northern temperate elements.

To gain a more complete knowledge of the flora a more detailed phytogeographical analysis should be done. But currently based on our collection of 103 species, 24 proved to be new to Vietnam and much more species of the area yet to be investigated, we can conclude that the very rich liverwort flora of the country is still very imperfectly known. We can also confirm the statements of Bakalín and Nguyen (2016) and of Shu *et al.* (2017) in this respect, that to obtain a fairly complete knowledge of the bryoflora of Vietnam further thorough researches are needed.

*

Acknowledgements – We would like to express our gratitude to managers, staff and forest guards of Bidoup-Núi Bà National Park, Chư Yang Sin National Park, Tam Đảo National Park, Hòn Bà Nature Reserve and Nam Ban Protected Forest for their kindest helps in our fieldtrips. We are also very grateful to Ministry of the Environment, Government of Japan for funding us under the project BIFA3_32. Thanks are due to Ms Judit Havasi assisting of collecting and preserving specimens from locations 1 and 9; Mr Cheng-Wei Chen for inviting us to join the botanical fieldtrip in Nam Ban. This work was partly supported by JSPS KAKENHI Grant Number JP16K18604 and Grant-in-Aid for Scientific Research (Specially Designated Research Promotion) of Japan Society for the Promotion of Science (JSPS). We are grateful to Dr Christine Cargill (CANBR) for the very careful review of our manuscript.

REFERENCES

- Bakalin, V. A. and Nguyen, V. S. (2016): The checklist of liverworts (Hepaticae) and hornworts (Anthocerotae) of Vietnam update based on literature survey. – *Tạp chí Sinh học* **38**(4): 481–491. <https://doi.org/10.15625/0866-7160/v38n4.8771>
- Bakalin, V. A. and Vilnet, A. (2018): A new *Myliia* Gray (Myliaceae, Hepaticae) species from North Vietnam extends the range of the genus to the Paleotropics. – *Phytotaxa* **348**(1): 41–48. <https://doi.org/10.11646/phytotaxa.348.1.5>
- Bakalin, V. A., Nguyen, V. S. and Borovichev, E. A. (2018): New liverwort records for Vietnam. – *J. Bryol.* **40**(1): 68–73. <https://doi.org/10.1080/03736687.2017.1393140>
- Borovichev, E., Bakalin, V. and Nguyen, V. S. (2019): Note on *Cyathodium* (Hepaticae). – *Bot. Pacifica* **8**(1): 1–4. <https://doi.org/10.17581/bp.2019.08103>
- Eifrig, H. (1937): Monographische Studien über die indomalayischen Arten von *Taxilejeunea*. – *Ann. Bryol.* "1936" **9**: 73–114.
- Furuki, T. (1991): A taxonomical revision of the Aneuraceae (Hepaticae) of Japan. – *J. Hattori Bot. Lab.* **70**: 293–397.
- Gradstein, S. R., He, X., Piippo, S. and Mizutani, M. (2002): Bryophyte flora of the Huon Peninsula, Papua New Guinea. LXVIII. Lejeuneaceae subfamily Ptychanthoideae (Hepaticae). – *Acta Bot. Fenn.* **174**: 1–88.
- Grolle, R. (1964): Über neue bemerkenswerte Acromastigum-Arten. – *Österr. Bot. Z.* **111**(2–3): 240–256. <https://doi.org/10.1007/BF01373767>
- Grolle, R. (1966): Die Lebermoose Nepals. – *Ergeb. Forsch.-Unternehm. Nepal Himalaya* **1**(4): 262–298.
- Grolle, R. (1971): *Jamesoniella* und Verwandte. – *Feddes Repert.* **82**: 1–100. <https://doi.org/10.1002/fedr.19710820102>
- Grolle, R. (1979): *Miscellanea Hepaticologica* 191–200. – *J. Hattori Bot. Lab.* **46**: 337–355.
- Grolle, R. and Piippo, S. (1984): Annotated catalogue of Western Melanesian bryophytes. I. Hepaticae and Anthocerotae. – *Acta Bot. Fenn.* **125**: 1–86.
- Herzog, T. (1950): Hepaticae borneenses (Oxford University expeditions to Sarawak, 1932). – *Trans. Brit. Bryol. Soc.* **1**(4): 275–326. <https://doi.org/10.1179/006813850804878680>
- Hürlimann, H. (1995): Hepaticae aus dem Gebiete des südlichen Pazifik. XIII. – *Bauhinia* **11**: 159–175.
- Jia, Y. and He, S. (2013): *Species catalogue of China*. Vol. 1. Plants, Bryophytes. – Beijing: Science Press, 525 pp. [in Chinese].
- Jovet-Ast, S. (1954): Le genre *Colura*, Hepatiques, Lejeuneacees, Diplasiae. – *Rev. Bryol. Lichénol.* "1953" **22**: 206–312.

- Katagiri, T. and Deguchi, H. (2012): Taxonomic studies of the Trichocoleaceae in south-east Asia I. The genus *Leiomitra* Lindb. – *Bryologist* **115**(4): 475–493. <https://doi.org/10.1639/0007-2745-115.4.475>
- Katagiri, T., Sadamitsu, A., Miyauchi, H., Tsubota, H. and Deguchi, H. (2013): Taxonomic studies of the Trichocoleaceae in Southeast Asia. III. The genus *Trichocolea* Dumort. – *Hattoria* **4**: 1–42. https://doi.org/10.18968/hattoria.4.0_1
- Kitagawa, N. (1978): The Hepaticae of Thailand collected by Dr. A. Touw (I). – *Acta Phytotax. Geobot.* **29**(1–5): 47–64. <https://doi.org/10.18942/bunruichiri.KJ00001078284>
- Kitagawa, N. and Kodama, T. (1973): Enumeration of Hepaticae collected by Drs. S. Kokawa and M. Hotta in Sabah (North Borneo) I. – *Bull. Osaka Mus. Nat. Hist.* **27**: 11–21.
- Lee, G. E. (2013): A systematic revision of the genus *Lejeunea* Lib. (Marchantiophyta: Lejeuneaceae) in Malaysia. – *Cryptogamie, Bryol.* **34**(4): 381–484. <https://doi.org/10.7872/cryb.v34.iss4.2013.381>
- Lee, G. E., Bechteler, J. and Heinrichs, J. (2018): A revision of unrevised taxon names in the former genus *Taxilejeunea* (Marchantiophyta: Lejeuneaceae) from Asia. – *Phytotaxa* **358**(1): 26–48. <https://doi.org/10.11646/phytotaxa.358.1.2>
- Li, W., Gao, C. and Wu, Y.-H. (2006): Studies on the genus *Schiffneria* Steph. (Hepaticae). – *Bull. Bot. Res.* **26**(4): 389–391.
- Long, D. G. (2006): Revision of the genus *Asterella* P. Beauv. in Eurasia. – *Bryoph. Bibl.* **63**: 1–299.
- Luong, T. T., Nguyen, T. L., Tram, N. K. T. and Vo, P. G. (2019): *Bryophytes of Vietnam (PHH Herbarium, Cryptogam Collection)*. Version 1.10. – University of Science, Vietnam National University, Ho Chi Minh City. Occurrence dataset <https://doi.org/10.15468/je1esr> (Accessed via GBIF.org on 17-05-2019).
- Mizutani, M. (1968): Studies of little known Asiatic species of Hepaticae in the Stephani Herbarium. 6. On some, interesting tropical species of Lepidozia. – *J. Hattori Bot. Lab.* **31**: 176–188.
- Mizutani, M. (1990): Notes on the Lejeuneaceae. 16. *Drepanolejeunea thwaitesiana* and its related species from Asia. – *J. Hattori Bot. Lab.* **68**: 367–380.
- Peng, T. and Zhu, R.-L. (2013): A revision of the genus *Anthoceros* (Anthocerotaceae, Anthocerotophyta) in China. – *Phytotaxa* **100**(1): 21–35. <https://doi.org/10.11646/phytotaxa.100.1.3>
- Piippo, S. (1984): Bryophyte flora of the Huon Peninsula, Papua New Guinea. VI. Lepidoziaceae subfam. Lepidozioideae, Calypogeiaceae, Adelanthaceae, Cephaloziaceae subfam. Cephalozioideae and subfam. Odontoschismatoideae and Jubulaceae (Hepaticae). – *Ann. Bot. Fenn.* **21**(4): 309–335.
- Piippo, S. (1985): Bryophyte flora of the Huon Peninsula, Papua New Guinea. XII. Geocalycaceae (Hepaticae). – *Acta bot. Fenn.* **131**: 129–167.
- Piippo, S. (1988): Bryophyte flora of the Huon Peninsula, Papua New Guinea. XXI. *Lepicolea norrisii* (Lepicoleaceae, Hepaticae). – *Ann. Bot. Fenn.* **25**(1): 55–57.
- Piippo, S. (1989): The bryophytes of Sabah (North Borneo) with special reference to the Bryotrop transect of Mount Kinabalu. III. Geocalycaceae (Hepaticae). – *Willdenowia* **18**(2): 513–527.
- Pócs, T. (1965): Prodrome de la bryoflore du Vietnam. – *Acta Acad. Paed. Agriensis*, n. ser. **3**: 453–495.
- Pócs, T. and Ninh, T. (2005): Contribution to the bryoflora of Vietnam, VI. On the liverwort flora of Vu Quang Nature Reserve. – *Acta Bot. Hung.* **47**(1–2): 151–171. <https://doi.org/10.1556/abot.47.2005.1-2.14>

- Pócs, T. and Ninh, T. (2012): New or little known epiphyllous liverworts, XVII. Records from the Cát Tiên National Park, southern Vietnam. – *Acta Biol. Plant. Agriensis* **2**: 11–19.
- Pócs, T. (2013): The genus *Colura* (Lejeuneaceae) in New Guinea and in the neighboring areas. – *Chenia* **11**: 12–38.
- Pócs, T., Luong, T.-T. and Ho, B.-C. (2013): New or little known epiphyllous liverworts, XVIII. Records from the Bidoup-Núi Bà National Park, Vietnam, with the description of *Drepanolejeunea bidoupensis*, sp. nov. – *Cryptogamie, Bryol.* **34**(3): 287–298. <https://doi.org/10.7872/cryb.v34.iss3.2013.287>
- Schuster, R. M. (2002): Austral hepaticae. Part II. – *Beih. Nova Hedwigia* **119**: 1–606.
- Shu, L., Xiang, Y.-L., Cheng, X.-F., Wei, Y.-M., Wang, J., Zhang, L.-N., Li, W., Yin, X.-B., Zhang, W.-P., Zhao, C.-X., Peng, T., Do, T. V., Lu, T. N. and Zhu, R.-L. (2017): New liverwort and hornwort records for Vietnam. – *Cryptogamie, Bryol.* **38**(4): 411–445. <https://doi.org/10.7872/cryb/v38.iss4.2017.411>
- Singh, D. K., Singh, S. K. and Singh, D. (2016): *Liverworts and hornworts of India. An annotated checklist*. – Botanical Survey of India, Ministry of Environment, Forest & Climate Change, Kolkata, 439 pp.
- So, M.-L. (2006): *Radula* (Radulaceae, Marchantiophyta) in the South Pacific. – *J. Hattori Bot. Lab.* **99**: 207–232.
- Tan, B. C. and Engel, J. J. (1986): An annotated checklist of Philippine Hepaticae. – *J. Hattori Bot. Lab.* **60**: 283–355.
- Tixier, P. (1966a): *Flore et végétation orophiles de l'Asie tropicale. Les épiphytes du flanc méridional du Massif Sud Annamitique*. – SEDES, Paris, 240 pp.
- Tixier, P. (1966b): Bryophytes du Vietnam. Récoltes de A. Petelot et V. Demange au Nord Vietnam (Relictae Henryanae). – *Rev. Bryol. Lichénol.* **34**(1–2): 127–181.
- Váňa, J. (1993): The bryophytes of Sabah (North Borneo) with special reference to the Bryotrop transect of Mount Kinabalu. XVIII. Cephaloziaceae (Hepaticopsida, Jungermanniales). – *Willdenowia* **23**: 245–255.
- Váňa, J., Grolle, R. and Long, D. (2012): Taxonomic realignments and new records of *Gongylanthus* and *Southbya* (Marchantiophyta: Southbyaceae) from the Sino-Himalayan region. – *Nova Hedwigia* **95**(1):183–196. <https://doi.org/10.1127/0029-5035/2012/0042>
- Wang, J., Lai, M. J. and Zhu, R.-L. (2011): Liverworts and hornworts of Taiwan: an updated checklist. – *Ann. Bot. Fenn.* **48**: 369–395. <https://doi.org/10.5735/085.048.0501>
- Yamada, K. (1979): A revision of Asian taxa of *Radula*, Hepaticae. – *J. Hattori Bot. Lab.* **45**: 201–322.
- Zhou, L.-P., Zhang, L. and Xing, F.-W. (2012): Taxonomical review of *Bazzania* (Lepidoziaceae, Marchantiophyta) in China. – *J. Fairlake Bot. Garden* **11**(2): 1–62.
- Zhu, R. L. and So, M.-L. (1999): New records of *Cololejeunea* (Lejeuneaceae, Hepaticae) for China and Vietnam. – *Bot. Bull. Acad. Sin.* **40**: 165–171.
- Zhu, R.-L., So, M.-L. and Wang, Y.-F. (2002): The genus *Cheilolejeunea* (Hepaticae, Lejeuneaceae) in China. – *Nova Hedwigia* **75**(3–4): 387–408. <https://doi.org/10.1127/0029-5035/2002/0075-0387>

Open Access statement. This is an open-access article distributed under the terms of the Creative Commons Attribution 4.0 International License (<https://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited, a link to the CC License is provided, and changes – if any – are indicated. (SID_1)

