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New records of *Bazzania* species (Marchantiophyta: Lepidoziaceae) in Peninsular Malaysia with identification key

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Abstract – This paper is the first attempt to understand the genus *Bazzania* Gray (Marchantiophyta: Lepidoziaceae) in Peninsular Malaysia. Eleven new records for Peninsular Malaysia are reported. They are *Bazzania albifolia* Horik., *B. angustitipula* N.Kitag., *B. asymmetrica* (Steph.) N. Kitag., *B. bicrenata* N.Kitag., *B. bidentula* (Steph.) Steph. ex Yasuda, *B. erosa* (Reinw., Blume & Nees) Trevis., *B. friabilis* N. Kitag. & T. Kodama, *B. horridula* Schiffner, *B. pseudovittata* N.Kitag. & T.Kodama, *B. serpentina* (Nees) Trevis. and *B. uncigera* (Reinw., Blume & Nees) Trevis. The first five species are new to the country, Malaysia. An identification key for all the *Bazzania* species reported for Peninsular Malaysia is provided.

Liverwort / *Bazzania* / Lepidoziaceae / Peninsular Malaysia / Identification key

INTRODUCTION

A total of 110 Lepidoziaceae taxa, representing 14.4% of the total liverworts and hornworts flora for Malaysia are listed in the liverworts and hornworts checklist for the country (Chuah-Petiot, 2011). Of the genera within family Lepidoziaceae, *Bazzania* Gray is the most dominant, with 52 species and 1 infra-specific taxon recorded (Chuah-Petiot, 2011).

The genus has approximately 140 accepted species worldwide, and is often referred to as one of the most prominent genera in the tropics (Meijer, 1960; Kitagawa, 1980; Engel, 2006; Zhou *et al.*, 2012a). Members of the genus are common in the forested area at all elevation. They are mostly epiphytic, growing on the bases, trunk or branches of trees and other plants and also on rotting logs. In the ever-wet mossy forest, they are even found thriving on humus, forming a thick cushion around the bases of tree.

Bazzania is easily recognized in the tropical forest because of its abundance and the conspicuous Y-shaped dichotomous branching. A total of 11 new *Bazzania* records for Peninsular Malaysia (indicated by *), including 5 new to Malaysia, (indicated by **) are enumerated in this paper. An identification key to all the *Bazzania* species reported for Peninsular Malaysia is also provided here, as a first attempt to understand the genus in the region. With these additions, 26 species of *Bazzania* are now known to occur in Peninsular Malaysia and a total of 55 in Malaysia.

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MATERIALS AND METHODS

Samples studied in this article were collected during the ecological survey to the forests in Genting Highlands, from August 2012 to May 2013. Identifications were made with reference to relevant literatures, in particular, Evans (1932), Gradstein (2011), Gottsche *et al.* (1845), Hattori & Mizutani (1958), Horikawa (1934), Kitagawa (1967, 1972, 1977, 1979, 1980), Kitagawa & Kodama (1975), Lindenberg & Gottsche (1851), Meagher (2008, 2010, 2011, 2015), Meijer (1954, 1960), Mizutani (1967, 1974), Pócs (1969), Piippo *et al.* (2002), Sande Lacoste (1857), Schiffner (1893), Stephani (1908, 1985) and Zhou *et al.* (2012a, 2012b). All of the specimens examined in present study are deposited in the Herbarium of University of Malaya (KLU), Kuala Lumpur.

KEY TO THE SPECIES OF *BAZZANIA* FROM PENINSULAR MALAYSIA

1a Lateral leaf apex entire or with indistinct lobes 2
1b Lateral leaf apex distinctly bilobed or trilobed 11

2a Lateral leaf margin serrulate-denticulate except near the base 3
2b Lateral leaf margin entire or repand 8

3a Lateral leaf and underleaf cells papillose, trigones indistinct .... *Bazzania horidula*
3b Lateral leaf and underleaf cells not papillose, trigones large, nodulose 4

4a Underleaves with hyaline margin 5
4b Underleaves without hyaline margin 7

5a Underleaves recurved at apex, distant ..... *Bazzania spiralis*
5b Underleaves plane, not recurved, closely appressed 6

6a Plant robust, approximately 3.5-5 mm wide; lateral leaves longer than its width ..... *Bazzania erosa*
6b Plant smaller, less than 3 mm wide; lateral leaves as long as its width ..... [A]*Bazzania loricata*

7a Underleaves subquadrate with plane margin, auricles presence at leaf base; lateral leaves oblong ovate ..... *Bazzania longicaulis*
7b Underleaves orbicular to reniform with recurved margin and apex, without auricles; lateral leaves triangular ovate, widest at base ..... *Bazzania recurva*

8a Plant often caducous; leaf apex mostly truncate; leaf cell asperous ..... *Bazzania pseudovittata*
8b Plant not caducous; leaf apex shallowly bi- or trilobed; leaf cell smooth 9

9a Median cells of underleaves hyaline, basal cells chlorophyllose ..... [B]*Bazzania intermedia*
9b Median cells of underleaves not hyaline, underleaf cells similar to those of lateral leaves 10

10a Lateral leaves ovate lingulate to lingulate, falcate; underleaves narrower than stem, apex of underleaves plane, often irregular retuse, not connate with both lateral leaves ..... *Bazzania pectinata*
10b Lateral leaves oblong ovate to sublinear ovate, not falcate; underleaves as wide as the stem, apex recurved, reflexed portion made up of thin walled and hyaline cells, underleaves in contact with both lateral leaves ..... *Bazzania densa*

11a Lateral leaves constantly bilobed 12
11b Lateral leaves always trilobed 15

12a Lateral leaves often deflexed ventrally; leaf cells verrucose; underleaves apex sinuate dentate ..... *Bazzania bicrenata*
12b Lateral leaves widely spreading not deflexed; leaf cells verrucose or smooth; underleaves different 13

13a Lateral leaves margin strongly crenulated; leaf cells verrucose, trigones bulging ..... *Bazzania friabilis*
13b Lateral leaves margin repand to subentire; leaf cells smooth, trigones distinctive but not bulging 14

14a Plant reddish brown, lateral leaves distant, triangular ovate; underleaves apex often bilobed ..... *Bazzania angustistipula*
14b Plant pale to yellowish green, lateral leaves contiguous, oblong ovate; underleaves apex truncate or weakly lobate ..... *Bazzania bidentula*

15a Vitta present and distinctive on lateral leaves, consist of 3-4 rows of longitudinal cells 16
15b Vitta absent, cells different only in size not longitudinal 17

16a Plant bluish green; leaf cells opaque due to verrucose surface; underleaves entire or crenulate at apex, made up of hyaline cells ..... *Bazzania vittata*
16b Plant olive green; leaf cells transparent and nearly smooth; underleaves irregular and deeply lobed, cells similar to those of leaves .... *Bazzania subtilis*

17a Lateral leaf apex tridentate with numerous accessory teeth; leaf cells distinctly to faintly verrucose 18
17b Lateral leaf apex tridentate without accessory teeth; leaf cells smooth 20

18a Lateral leaves strongly deflexed and postically connivent when dry; underleaves sub-orbicular to reniform with a narrow hyaline border .... *Bazzania erosa*
18b Lateral leaves not deflexed when dry; underleaves not as above 19

19a Lateral leaf oblong rectangular; underleaf plane, apex 5-6 lobed, margin bordered by hyaline cells ..... *Bazzania manillana*
19b Lateral leaf triangular ovate; underleaf often recurved, apex obtuse with scattered teeth, margin not hyaline ..... *Bazzania commutata*

20a Underleaves made up of hyaline cells, these cells uniformly thin-walled, without trigones, slightly bigger or more elongate compared to those cells on lateral leaves 21
20b Underleaves not hyaline, cells of underleaves similar to those of lateral leaves 23

21a Lateral leaf lobes sometimes serrulate; underleaves rectangular, hyaline to at least median leaf cells ..... *Bazzania intermedia*
21b Lateral leaf lobes with entire margin; underleaves different, almost hyaline entirely 22

22a Plant with whitish young shoots; lateral leaf oblong-rectangular, leaf cells verrucose with crystalline structure ..... *Bazzania albifolia*
22b Plant olive green to brownish green; lateral leaf ovate or oblong, leaf cells almost smooth ..... *Bazzania tridens*

23a Lateral leaves strongly deflexed to almost clasping even in moist condition; underleaves reflexed, with hyaline border ..... *Bazzania serpentina*

23b Lateral leaves wide spreading to falcate; underleaves plane, without hyaline border.....24
24a Lateral leaf triangular-ovate, widest at base, falcate.....25
24b Lateral leaf oblong-rectangular, not falcate.....26
25a Plant olive green; underleaves small, distant, semicircular to subquadrate, apex irregularly retuse, sometimes denticulate.....*Bazzania pectinata*
25b Plant yellowish brown; underleaves slightly wider than stem, contiguous, long-rectangular, bearing 4 principal apical lobes..... *Bazzania uncigera*
26a Underleaves orbicular-quadrate, margin often repand to shallowly lobed..... *Bazzania asymmetrica*
26b Underleaves dentate-laciniate, margin with accessory denticulations.....27
27a Underleaf bases with several teeth..... *Bazzania calcarata*
27b Underleaf bases forming auricles or appendage.....28
28a Lateral leaves oblong rectangular, widest at mid leaf; underleaves quadrate, as long as wide, shallow sinus between lobes ..... *Bazzania malaccensis*
28b Leaves oblong lanceolate, widest at leaf base; underleaves subquadrate, longer than wide, deep sinus between lobes ..... [C]*Bazzania paradoxa*

Annotations:

[A]According to Meijer (1960), *Bazzania distan* (Nees) Trevis., resembles a smaller and depauperate form of *Bazzania loricata.*

[B]*Bazzania wallichiana* (Lindenb.) Trevis. reported in Piippo *et al.* (2002) is key out here despite its occurrence at Singapore, south of Peninsular Malaysia. We agree to Mizutani (1967) with regards to *B. wallichiana* as a form of *Bazzania intermedia* (Lindenb. & Gottsche) Trevis.

[C]*Bazzania caudata* (Steph.) Herz. as refers to Stephani (1985), also key out here as it agrees well and similar with *Bazzania paradoxa* (Sande Lac.) Steph. in its morphology.

Uncertain record: *Bazzania stonii* Inoue, which only been reported once for Peninsular Malaysia (Inoue, 1968) with no further information of the species.

NEWLY RECORDED *BAZZANIA* SPECIES OF FAMILY LEPIDOZIACEAE

****Bazzania albifolia*** Horik., *J. Sci. Hiroshima Univ., Ser. B, Div. 2, Bot. 2*: 195 (1934).

This medium-sized *Bazzania* species is characterized by an oblong-rectangular leaf with distinctive 3-lobed apex, verrucose leaf cells, and short-rectangular, hyaline underleaf with entire to truncate apex. The underleaves are hyaline in appearance because of thin-walled cells that generally lack chloroplasts even when fresh. The new shoot tip appears to be glossy whitish when dry and this is useful to recognize this species in the wild. The lateral leaf cells are verrucose, as pointed out by Zhou *et al.* (2012b), which is a character not described in the protologue (Horikawa, 1934). This serves as an useful character to distinguish this species from the morphologically similar, *Bazzania tridens* (Reinw, Blume & Nees)

Trevis., and particularly East Asian *B. tridens* var. *oshimensis* (Steph.) Pócs (Pócs, 1969) that also possesses long-rectangular underleaves, but has consistently smooth leaf cells on its lateral leaf. Nevertheless, careful examination of the leaf surface is necessary, because the verrucae are not always well-developed, so the surface can be weak to nearly smooth in some leaves, although there are always some leaves with distinctly verrucose cells. This study agrees with Zhou *et al.* (2012b) in treating the Thai species *B. semiopaca* N. Kitag. as a synonym of *B. albifolia*. Two other morphologically related species (*B. albicans* Stephani and *B. assamica* (Steph.) S. Hatt.) were either synonymized or recognized as a variety of *B. tridens* by Pócs (1969) and characterized by having smooth leaf cells.

Illustrations: Horikawa (1934: Plate 16, Figs 22-30), Zhou *et al.* (2012b: Fig. 3, A-I).

Specimens examined: Pahang, Genting Highland, *Y.H. Cheah 148, 149, 152, 162* (KLU).

Habitat: Found on tree trunks and ground at 1200-1500 m elevation.

Distribution: Taiwan (Horikawa, 1934), China, Thailand (Kitagawa, 1967; Zhou *et al.*, 2012b) and Peninsular Malaysia.

*****Bazzania angustistipula*** N. Kitag., *J. Hattori Bot. Lab.* 30: 268 (1967).

This delicate species was formerly known only from Thailand (Kitagawa, 1967) and Vietnam (Pócs, 1969). The plants collected from Peninsular Malaysia are not always reddish brown in colour as described by Kitagawa (1967) and Pócs (1969) for populations collected from Indochina. Plants are green when young but turn brownish green when mature. They have distantly arranged, triangular-ovate lateral leaves with the apex sometimes recurved. The leaf apices are variable even though the leaves are from the same branch. They are either acuminate, or asymmetrically bilobed or occasionally 3-lobed. It is noteworthy that this species often possesses caducous leaves and underleaves, which is distinctive from other *Bazzania* species reported for Peninsular Malaysia. This species may be confused with *B. bidentula* (Steph.) Yasuda and *B. bicrenata* N. Kitag., as they share many characters. The more imbricate leaf arrangement and consistently bidentate leaf apex in *B. bidentula* are perhaps the best characters to distinguish it from *B. angustistipula*. *B. bicrenata* can be separated from *B. angustistipula* by its oblong lanceolate lateral leaves, large trigones and thicker cell walls (Kitagawa, 1980) in the lateral leaf. In addition, the underleaves of *B. bicrenata* are orbicular and have a sinuate dentate apex, but in *B. angustistipula* the underleaves are ovate oblong, consistently longer than its width, often bilobed but occasionally entire. *B. fallax* (Sande Lac.) Schiffner, a species that is similar to *B. angustistipula* in many respects, is best distinguished from the present species by its underleaf shape. Pócs (1969) commented that *B. angustistipula* is possibly related to *B. minuta* (Aust.) Evans from Hawaii, but no specimen of that species was available for comparison during the preparation of this manuscript, so we prefer to retain the two as distinctive species owing to the geographical distance.

Illustrations: Kitagawa (1967: Fig. 7), Pócs (1980: Figs I-II, 1), Zhou *et al.*, (2012b: Fig. 5, A-I).

Specimens examined: Pahang, Mount Ulu Kali, *Y.H. Cheah 172, 174, 179, 180, 189* (KLU); *Y.H. Cheah & K.-T. Yong 183* (KLU).

Habitat: The samples were collected from tree trunks in upper montane forest at an elevation around 1700 m.

Distribution: Northern Thailand (Kitagawa, 1967), Northern Vietnam (Pócs, 1969), China, India, Nepal, Bhutan (Zhou *et al.*, 2012b) and Peninsular Malaysia.

*****Bazzania asymmetrica*** (Steph.) N. Kitag., *Bull. Nara Univ. Educ., B* 28: 77 (1979).

This species is robust in size with densely arranged and imbricate leaves and appears worm-like when dry. The lateral leaves are consistently 3-lobed, the lamina asymmetric with a crescentic sinus and distinctive auricles. The underleaves are quadrate-orbicular, 3 times as wide as the stem, with conspicuous basal auricles. The apex and margin of the underleaves are variously lobate but usually shallow or just appear undulate. The lateral and underleaf cells are persistently smooth with conspicuously large, nodulose, and longitudinally confluent trigones. *Bazzania asymmetrica* is morphologically related to *B*. *appendiculata* (Mitt.) S. Hatt., however the latter species is characterized by having rotund underleaves with elaborate basal auricles and strongly verrucose leaf cells. The robust form of *B*. *asymmetrica* somewhat resembles *B*. *longicaulis* (Sande Lac.) Schiffner, but the distinctly 3-lobed leaf apex and entire lateral leaf margin distinguish it from the latter species, which has weakly to indistinctly 3-lobed apex and minute denticulate to serrulate lateral leaf margin. It is interesting to note that the species is thus far only known from Papua New Guinea (Kitagawa, 1979), Hainan Island, China (Zhou *et al.*, 2012b), and now Peninsular Malaysia, which is a very disjunct distribution.

Illustrations: Kitagawa (1979: Fig. 4, 1-12), Stephani (1985: Plate 7167), Zhou *et al.* (2012b: Fig. 7, a-f).

Specimens examined: Pahang, Genting Highland, forested area near Amber Court apartment, *Y.H. Cheah 154, 159* (KLU).

Habitat: The plants were collected from tree trunks and ground at an elevation around 1500 m.

Distribution: New Guinea (Kitagawa, 1980), China (Zhou *et al.*, 2012b) and Peninsular Malaysia.

*****Bazzania bicrenata*** N. Kitag., *J. Hattori Bot. Lab.* 47: 127 (1980).

Prior to this study, this species was only known from the type collected in western New Guinea (Kitagawa, 1980). The diagnostic features of this species are the ovate-triangular leaves which are always recurved ventrally. Like other members in section Bidentatae, *B*. *bicrenata* also possesses a bilobed leaf apex, but with the anterior tooth larger than the posterior. Specimens collected in present study show faintly verrucose leaf cells, agree well with the description in the protologue (Kitagawa, 1980). Due to its small size, this species could easily be misidentified as *B*. *friabilis* N. Kitag. & T. Kodama, but the latter has lateral leaves with distinct crenulate margin, whereas the lateral leaf margin is entire in *B*. *bicrenata*. The other related species is *B*. *angustistipula*; differences between the two species have been addressed in the earlier part of this paper. This is the first record of *B. bicrenata* in Western Malesia. This disjunct distribution suggests the possible discovery of this species at the islands in between Peninsular Malaysia and New Guinea.

Illustration: Kitagawa (1980: Fig. 1, 1-11).

Specimen examined: Pahang, Mount Ulu Kali, *Y.H. Cheah 156, 158, 181* (KLU).

Habitat: The plants were found on tree trunks in both lower montane and upper montane forest at 1500-1700 m elevation.

Distribution: New Guinea (Kitagawa, 1980) and Peninsular Malaysia.

*****Bazzania bidentula*** (Steph.) Steph. ex Yasuda, *Shokub. Kak*. 711 (1911).

This small *Bazzania* species is usually found mingled with other liverworts and mosses in the wild. It is recognizable by its ovate-oblong, bilobed lateral leaves

but quadrate and weakly toothed to truncate underleaves. Lateral leaves wide-spreading when moist but strongly deflexed when dry. This species somehow resembles *B*. *bicrenata* but the latter possesses faintly verrucose lateral leaf cells and a ventrally curved leaf lobe. It is also notable that *B*. *bidentula* is often caducous, and there are always some denuded shoot tips among the collection. This serves as a good character to distinguish it from *B*. *bicrenata* which is not caducous. Zhou *et al*. (2012b) commented that *B*. *angustistipula* shares many characters with *B. bidentula*, but differs in having triangular-ovate lateral leaves that are distantly arranged on branch and stem. The underleaves of *B*. *angustistipula* are always shallowly bilobed, instead of weakly irregularly toothed to nearly entire as in *B*. *bidentula*. *Bazzania bidentula* is fairly common in East Asian and west to the Himalaya region. The present record is the southernmost distribution of the species, indicating that the species has at least dispersed to the tropical highlands.

Illustrations: Hattori & Mizutani (1958: Fig. IV, 17-31), Zhou *et al*. (2012b: Fig. 8, a-l).

Specimens examined: Pahang, Mount Ulu Kali, *Y.H. Cheah 169, 190, 191* (KLU).

Habitat: These plants were collected from tree trunks and ground in the upper montane forest at an elevation of about 1700 m.

Distribution: China, Japan, Korea, Taiwan (Hattori & Mizutani, 1958; Mizutani & Chang, 1986), Bhutan, India, Nepal (Zhou *et al.*, 2012b) and Peninsular Malaysia.

****Bazzania erosa*** (Reinw., Blume & Nees) Trevis., *Mem. Reale Ist. Lombardo Sci., Ser. 3, Cl. Sci. Mat.* 4: 415 (1877).

The robust plant size, triangular-ovate lateral leaf with less distinctly 3-lobed apex, dentate-serrulate on the whole leaf margin, large leaf cells with nodulose trigones, and large, ovate-reniform underleaf, bordered by rows of hyaline and thin-walled cell, are the characters that served to distinguish this species from the others. The lateral leaves are often yellowish brown in colour and deflexed ventrally to almost clasping when dry, hence the plant often appears worm-liked in the field. This species is morphologically related to *B*. *longicaulis* (Sande Lac.) Schiffner and *B*. *spiralis* (Reinw., Blume & Nees) Meijer, and *B*. *longicaulis* was erroneously identified as *B*. *erosa* in the account of the *Bazzania* from Sumatra by Evans (1932), as pointed out by Meijer (1960) and Kitagawa (1977). *Bazzania longicaulis* is different from present species only by its longer lateral leaves and subquadrate underleaves which lack of hyaline border, whereas *B*. *spiralis* can be distinguish from *B*. *erosa* by having shorter lateral leaves and reniform underleaves with a recurved apex. Even though the underleaves of both *B*. *spiralis* and *B*. *erosa* are similar in shape and are bordered by hyaline cells, the underleaves in *B*. *erosa* are always plane and not recurved. It is useful to mention here two other species, *B*. *insignis* (De Not.) Trevis. and *B*. *loricata* (Reinw., Blume & Nees) Trevis., that are more similar to *B*. *spiralis*, but might sometimes be confused with *B*. *erosa* as well. However, in those two species the hyaline border of the underleaves is either lacking or poorly developed (as noted by Kitagawa, 1977), which readily separates from *B*. *erosa*. It is worth remarking here that *B*. *serrulatioides* Horik., which is restricted to the East Asia region (Horikawa, 1934; Mizutani & Chang, 1986) but recently reported for Indonesia and Thailand (Zhou *et al.*, 2012b), might be conspecific with *B. erosa*. The original description and illustration (Horikawa, 1934) agrees well in all details with *B*. *erosa*. None of the authors mentioned above has compare the species with *B*. *erosa*, but information from the protologue (Horikawa,

1934), as well as the latter publication (Zhou *et al.*, 2012b) do suggest a possible conspecific of *B. serrulatoides* and *B. erosa*.

Illustrations: Lindenberg & Gottsche (1851: Plate 16, Figs 1-10), Kitagawa (1977: Fig. 1, 1-13), Meagher (2015: Fig. 2).

Specimens examined: Pahang, Mount Ulu Kali, *Y.H. Cheah 155, 168, 173, 186, 193* (KLU); *Y.H. Cheah & K.-T. Yong 176, 182* (KLU).

Habitat: The plants were found on tree bases and ground in the upper montane forest at elevation around 1700 m.

Distribution: Sabah, Sarawak (Menzel, 1988; Frahm *et al.*, 1990), Sumatra (Kitagawa, 1977), New Guinea, Caroline Islands and Samoa (Kitagawa, 1980), New Caledonia, Australia and Borneo (Meagher, 2015) and Peninsular Malaysia.

****Bazzania friabilis*** N. Kitag. & T. Kodama, *J. Hattori Bot. Lab.* 39: 67 (1975).

Prior to this study, this peculiar and delicate *Bazzania* was known only from the type gathered from Mount Kinabalu, Borneo. This species is characterized by having bidentate lateral leaves, with a distinctively crenulate leaf margin, and the presence of large and bulging trigones. In addition to that, the leaf cells are always verrucose in both lateral and underleaves. The underleaves are bifid, but with additional shorter teeth next to each lobe, so that sometimes they are irregularly toothed in appearance. Specimens collected from Peninsular Malaysia agree in all details with the type description (Kitagawa & Kodama, 1975) except that the trigones are sometimes undeveloped or indistinct in some specimens. This species somewhat resembles *Acromastigum* species because of the small size, the similar branching pattern, and is often found intermingled with *Acromastigum* species.

Illustrations: Kitagawa & Kodama (1975: Fig. 1, 1-14).

Specimens examined: Pahang, Mount Ulu Kali, *Y.H. Cheah 151, 166* and *Y.H. Cheah & K.-T. Yong 184* (KLU).

Habitat: The plants were collected from tree trunk and ground at 1500-1700 m elevation.

Distribution: Sabah (Menzel, 1988; Frahm *et al.*, 1990) and Peninsular Malaysia.

****Bazzania horridula*** Schiffner, *Nova Acta Acad. Caes. Leop.-Carol. German. Nat. Cur.* 60: 258 (1893).

This *Bazzania* species is readily distinguished from others in Peninsular Malaysia by its imbricate, triangular-ovate lateral leaf, strongly reflexed and bluntly pointed apex, denticulate-serrulate margin, and unipapillose leaf cells. The papillae are distinctive and large, at least on the dorsal side of cells. In particular, those on the leaf margin are often sharply pointed, resulting in a coarse leaf margin. The laminal cells are thick-walled but because of the large cell papillae the trigones are usually indistinct and difficult to observe. It is interesting to note that the often recurved semicircular underleaves of this species sometimes appear to be plane, especially in young plants. It is also notable that the underleaves are not always connate on both sides of the lateral leaves, as opposed to the descriptions in Kitagawa (1967) and Schiffner (1894). Kitagawa (1967) suggested a new section, *Papillatae* to cater for *Bazzania* species with papillose protrusions on the leaf cells, *viz.*, *B. horridula* and *B. angustisedens* (Steph.) N. Kitag. The latter species is known only from Java (Kitagawa, 1972) and has a very different leaf form from *B. horridula*. Because of the papillose protrusions on the dorsal surface of leaves, *B. horridula* resembles *Chiloscyphus muricatus* (Lehm.) J.J. Engel & R.M. Schust.. However, the

latter has a succubous leaf arrangement which should not be confused with any *Bazzania* where the leaves are always incubous.

Illustrations: Schiffner (1893: Figs 12-22), Kitagawa (1967: Fig. 1, 1-14).

Specimens examined: Pahang, Genting Highland, *Y.H. Cheah 146, 147, 161* (KLU).

Habitat: The plants were found growing on tree trunks at 800-1500 m elevation.

Distribution: Sabah (Menzel, 1988; Frahm *et al.*, 1990); Ambon, Java, Philippines, Thailand (Kitagawa, 1967) and Peninsular Malaysia.

****Bazzania pseudovittata*** N. Kitag. & T. Kodama*, J. Hattori Bot. Lab*. 39: 69 (1975).

This species resembles *B. vittata* in various aspects: the minute plant size, oblong lateral leaves that are always widely spreading and nearly perpendicular to the stem, hyaline underleaves that are appressed to the stem, and verrucose laminal cells. Nonetheless, it can be distinguished from *B. vittata* and its related species by the absence of vitta on the lateral leaf, the crenulate leaf margin because of the projecting leaf cells and presence of the large and bulging trigones in most of the lateral leaves. Just like the *B. friabilis*, this species was previously known only from Mount Kinabalu and its adjacent area in Borneo, but appears to have a wider distribution that includes Peninsular Malaysia. Kitagawa & Kodama (1975) considered this species to be a xerophyte, and noted that the caducous and easily fragmented leaves, verrucose leaf cells and large and bulging trigones that characterized the species are the result of adaptation. It is noteworthy to mention that some specimens collected from the humid lower montane forest in the present study do not have large trigones between the laminal cells, even though the cells are relatively thick-walled and have a verrucose surface.

Illustrations: Kitagawa & Kodama (1975, Fig. 2, 1-14).

Specimens examined: Pahang, Mount Ulu Kali, *Y.H. Cheah 160, 163, 171, 177* (KLU).

Habitat: The samples were collected from tree trunks and ground in the lower and upper montane forest, at 1500-1700 m elevation.

Distribution: Sabah (Kitagawa & Kodama, 1975) and Peninsular Malaysia.

****Bazzania serpentina*** (Nees) Trevis., *Mem. Reale Ist. Lombardo Sci., Ser. 3, Cl. Sci. Mat*. 4: 415 (1877).

The large size plant and the strongly deflexed, falcate and triangular-ovate leaves in both dry and moist conditions make this species readily distinguishable from other *Bazzania* species. The lateral leaf is widest at its base and narrow gradually towards the asymmetrical tridentate apex. Both lateral and underleaves consist of large laminal cells with smooth surfaces and nodulose trigones. The reflexed apex of the underleaves is bordered by 1-2 rows of hyaline cells. *Bazzania praerupta* (Reinw., Blume & Nees) Trevis. is similar, but the former has larger and less deflexed leaves and underleaves with a plane apex, and the underleaves lack a hyaline margin.

This species might also be confused with *B. zollingeri* (Lindenb.) Trevis. which also possesses falcate and deflexed leaves. According to Meijer (1960) *B. zollingeri* has lateral leaves with a blunt or indistinctly lobed apex. Gradstein (2011) remarked that the trigones in *B. zollingeri* are relatively small which would be sufficient to differentiate *B. serpentina* from *B. zollingeri*. It is important to note that the hyaline border in the underleaves of *B. serpentina* might be overlooked if the specimen is old and the margin has disintegrated.

Illustrations: Lindenberg & Gottsche (1851: Plate 19, Fig. 1-5), Kitagawa (1977: Fig. 3, 1-15).

Specimens examined: Pahang, Genting Highland, *Y.H. Cheah 150, 153, 157* (KLU); also at Mount Ulu Kali, *Y.H. Cheah 164, 187* (KLU) and *Y.H. Cheah & K.-T. Yong 188* (KLU).

Habitat: The plant was found growing on ground, tree trunk and base of tree, at 1500-1700 m elevation.

Distribution: Sabah (Frahm *et al.*, 1990), Java, Sumatra (Meijer, 1960), New Guinea, Solomon Island (Kitagawa, 1980) and Peninsular Malaysia.

****Bazzania uncigera*** (Reinw., Blume & Nees) Trevis., *Mem. Reale Ist. Lombardo Sci.,* Ser. 3, *Cl. Sci. Mat*. 4: 415 (1877).

The diagnostic features of this *Bazzania* species are its large size, up to 10 cm in length. It often appears rigid in the field and forms a yellowish brown mat. The falcate, sublinear lateral leaves gradually narrow to a long-slender apex that is occasionally bilobate, but more often trilobate. In addition, the long-rectangular underleaves, have sinuate-dentate margins and irregularly lobed apices, and are patently inserted on the stems and branches. This species is also characterized by the presence of large, nodulose and often confluent trigones on the leaves and underleaves. Kitagawa (1967) noted that *B*. *uncigera* is very similar to *B*. *sumatrana* (Sande Lac.) Steph. and *B*. *fauriana* (Steph.) S. Hatt. in morphology, and all these species might be conspecific. However, our present finding support Meijer (1960), who said that *B*. *sumatrana* is more robust plant with less falcate lateral leaf in relative to *B*. *uncigera* whereas, *B*. *fauriana*, a species known only to the East Asian and northern Vietnam, is more related to the *B*. *sumatrana* in term of plant size and leaf shape, as described and illustrated in Hattori & Mizutani (1958), Pócs (1969) and Zhou *et al.* (2012b). *Bazzania fauriana* is different from *B*. *uncigera* by having more quadrate underleaves, and occasionally a hyaline margin at its apex (Pócs, 1969). Conversely, we note the high similarity of *B*. *linguiformis* (Sande Lac.) Schiffn., a species known from Java and Sumatra, to *B*. *uncigera*. *Bazzania linguiformis* is believed to be different from *B*. *uncigera* by having broader lateral leaves, underleaf with recurved apex, and the presence of auricles at the base of the underleaf (Meijer, 1960). The last character is occasionally seen in some of the *B*. *uncigera* collected in the present study. Meanwhile, *B*. *angustifolia* Horik., another morphologically related species, displays smaller and less falcate lateral leaves, together with the distinctive dentate-laciniate underleaves and lack of auricles at its base, which serve as the main characters to distinguish it from *B*. *uncigera*.

Illustrations: Lindenberg & Gottsche (1851: Plate 19, Figs 6-10), Stephani (1985: Plate 7220 & Plate 7221).

Specimens examined: Pahang, Mount Ulu Kali, *Y.H. Cheah 165, 167, 170, 175, 178* (KLU); *Y.H.Cheah & K.-T. Yong 185, 192* (KLU).

Habitat: The samples were collected from tree bases and ground in the upper montane forest at elevation around 1700 m.

Distribution: Sabah (Menzel, 1988; Frahm *et al.*, 1990), Java and Sumatra (Meijer, 1960), Thailand, New Guinea and Fiji (Kitagawa, 1967), The Philippines, Nepal (Hattori, 1975) and Peninsular Malaysia.

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REFERENCES

CHUAH-PETIOT M.S., 2011 — A checklist of Hepaticae and Anthocerotae of Malaysia. *Polish Botanical Journal,* 56: 1-44.

ENGEL J.J., 2006 — Austral Hepaticae 41. *Bazzania exempta* Engel, an interesting new species from New Zealand, belonging to a new section, *Bazzania* sect. Exemptae Engel. *Journal of the Hattori Botanical Laboratory,* 99: 197-205.

EVANS A.W., 1932 — Some representative species of *Bazzania* from Sumatra. *Papers of the Michigan Academy of Science, Arts & Letters,* 17: 69-118.

FRAHM J.-P., FREY W., KÜRSCHNER H., & MENZEL M., 1990 — *Mosses and liverworts of Mt. Kinabalu,* Sabah, Sabah Parks Publication, 91 p.

GOTTSCHE C.M., LINDENBERG J.B.G., & NEES VON ESENBECK C.G., 1845 — *Synopsis Hepaticarum, fasc. 2,* Hamburg, pp. 214-233 (*Mastigobryum*).

GRADSTEIN S.R., 2011 — *Guide to the Liverworts and Hornworts of Java,* Bogor, Southeast Asian Regional Centre for Tropical Biology, 146 p.

HATTORI S., 1975 — Bryophyta, Anthocerotae and Hepaticae: Flora of Eastern Himalaya, 3rd report (compiled by Hiroyoshi Ohashi). *The University Museum, The University of Tokyo, Bulletin* 8: 206-242.

HATTORI S., & MIZUTANI M., 1958 — A revision of the Japanese species of the family Lepidoziaceae. *Journal of the Hattori Botanical Laboratory,* 19: 76-118.

HORIKAWA Y., 1934 — *Monographia Hepaticarum Australi-Japonicarum,* Japan, Hiroshima University, pp. 102-325.

INOUE H., 1968 — Chromosome numbers of some Malayan and Taiwan liverworts. *Bulletin of the National Science Museum, Tokyo,* 11: 397-403.

KITAGAWA N., 1967 — Studies on the Hepaticae of Thailand. I. The genus *Bazzania*, with general introduction. *Journal of the Hattori Botanical Laboratory,* 30: 249-270.

KITAGAWA N., 1972 — Miscellaneous notes on little-known species of Hepaticae, 1-25. *Journal of the Hattori Botanical Laboratory,* 36: 444-454.

KITAGAWA N., 1977 — Studies on Asian species of *Bazzania*, Hepaticae, I. *Bulletin of Nara University of Education,* 26: 73-82.

KITAGAWA N., 1979 — Studies on Asian species of *Bazzania*, Hepaticae, II. *Bulletin of Nara University of Education,* 28: 71-83.

KITAGAWA N., 1980 — New Guinean species of the genus *Bazzania*, I. *Journal of the Hattori Botanical Laboratory,* 47: 127-143.

KITAGAWA N., & KODAMA T., 1975 — Two new species of *Bazzania* with an unusual habitat in Sabah (North Borneo). *Journal of the Hattori Botanical Laboratory,* 39: 67-70.

LINDENBERG J.B.G., & GOTTSCHE C.M., 1851 — *Species Hepaticarum,* Vol. 3, Fasc. 8-11: i-xii, Bonn, pp. 1-119 (*Mastigobryum*).

MEAGHER D., 2008 — Studies on *Bazzania* 1. Some new and little known species from Australasia. *Nova Hedwigia,* 86: 477-495.

MEAGHER D., 2010 — Studies on *Bazzania* 2. Seven poorly known species from Australia. *Nova Hedwigia,* 90: 395-411.

MEAGHER D., 2011 — Studies on *Bazzania* (Lepidoziaceae, Marchantiophyta) 3. Four new species from Australia. *Nova Hedwigia,* 92: 487-495.

MEAGHER D., 2015 — Studies on *Bazzania* (Marchantiophyta: Lepidoziaceae) 8. *Bazzania wooroonooran* sp. nov. and seven other rare species from tropical Australia. *Nova Hedwigia,* 100: 535-552.

MEIJER W., 1954 — Collecting bryophytes in Borneo. *The Bryologist,* 57: 261-272.

MEIJER W., 1960 — Notes on the species of *Bazzania* (Hepaticae) mainly of Java. *Blumea,* 10: 367-384.

MENZEL M., 1988 — Annotated catalogue of the Hepaticae and Anthocerotae of Borneo. *Journal of the Hattori Botanical Laboratory,* 65: 145-206.

MIZUTANI M., 1967 — Studies of the Himalayan species of *Bazzania*. *Journal of the Hattori Botanical Laboratory,* 30: 71-90.

MIZUTANI M., 1974 — Lepidoziaceae, subfamily Lepidozioideae from Sabah (North Borneo). *Journal of the Hattori Botanical Laboratory,* 38: 371-385.

MIZUTANI M., & CHANG K.C., 1986 — A preliminary study of Chinese Lepidoziaceae flora. *Journal of the Hattori Botanical Laboratory,* 60: 419-437.

PIIPPO S., HE X.-L., JUSLÉN A., TAN B.C., MURPHY D.H., & PÓCS T., 2002 — Hepatic and hornwort flora of Singapore. *Annales Botanici Fennici,* 39: 101-128.

PÓCS T., 1969 — A short survey of the *Bazzania* of North Viet-Nam. *Journal of the Hattori Botanical Laboratory,* 32: 79-94.

SANDE LACOSTE C.M.V.D., 1857 — Synopsis Hepaticarum Javanicarum, adjectis quibusdam speciebus Hepaticarum novis extra-Javanicis. *Verhandelingen der Koninklijke Akademie van Wetenschappen. Aldeeling Natuurkunde,* 5: 1-112.

SCHIFFNER V.F., 1893 — Ueber exotische Hepaticae, hauptsächlich aus Java, Amboina und Brasilien, nebst einigen morphologischen und kritischen Bemerkungen über *Marchantia*. *Nova Acta Academiae Caesareae Leopoldino-Carolinae Germanicae Naturae Curiosorum,* 60: 220-316.

STEPHANI F., 1908 — *Species Hepaticarum,* 3, Genève & Bale, George & Cie, pp. 517-693.

STEPHANI F., 1985 — *Icones Hepaticarum,* Leiden, International Documentation Company.

ZHOU L.-P., ZHANG L., & XING F.-W., 2012a — The genus *Bazzania* in China and adjacent regions. 1. *Bazzania dulongensis* L.-P.Zhou & L.Zhang *sp. nov.* and *Bazzania hainanensis* L.-P.Zhou & L.Zhang *sp. nov. Journal of Bryology,* 34: 22-31.

ZHOU L.-P., ZHANG L., & XING F.-W., 2012b — Taxonomical review of *Bazzania* (Lepidoziaceae, Marchantiophyta) in China. *Journal of Fairylake Botanical Garden,* 11: 1-62.