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Marchantia L. (Marchantiaceae-Marchantiophyta) in Taiwan

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ABSTRACT: Floristic study of *Marchantia* L. in Taiwan has been presented in this paper. Six taxa, namely, *M. emarginata* subsp. *tosana*, *M. formosana*, *M. paleacea* subsp. *paleacea*, *M. paleacea* subsp. *diptera*, *M. pinnata* and *M. polymorpha* are confirmed in Taiwan. Among them, *M. formosana* is endemic, *M. pinnata* is shared by Japan and Taiwan, *M. paleacea* subsp. *diptera* is distributed in China, Japan and Taiwan, while the remainings are more or less widespreading. Key for taxa in Taiwan is provided for convenience of identification, and descriptions, photos and distribution maps are also provided for each taxon as a basic materials for further studies.

KEY WORDS: Flora, Liverworts, *Marchantia*, Marchantiaceae, Taiwan.

INTRODUCTION

Liverworts of *Marchantia* accompanied with *Bucegeia* and *Preissia* are members of Marchantiaceae, which can be distinguished from others by bearing compound air pores plus ventral scales with appendages (Crandall-Stotler *et al.*, 2009). *Bucegeia* and *Preissia* are monotypic and differ from *Marchantia* by not bearing cupules on the dorsal thalli. *Buceigia* contains more than one layer of air chamber inside thalli while *Preissia* with only one layer. Hence *Marchantia* is distinguished by bearing cupules on the dorsal thalli and with only one layer of air chamber (Hayne, 1915; Haupt, 1926; Bischler-Causse, 1989). Although Both *Bucegeia* and *Preissia* have been reduced to subgeus *Preissia* (Long *et al.*, 2016), it is only one of the option based on molecular phylogeny. Thus we still hold the traditional view of *Marchachia* at present.

Marchantia is composed of 37 species plus 7 subspecies (Soderstrom *et al.* 2016) and is distributed worldwide (Bischler-Causse, 1989), although new species has been published from Yunnan, China, recently (Xiang *et al.*, 2016). Taiwan is situated among Japan, China, and the Philippines, which is considered as one of the most diverse area of liverworts (von Konrat *et al.*, 2008). Horikawa (1934) is the first researcher to revise the genus *Marchantia* in Taiwan and recognized five species, *i.e.*, *M. polymorpha*, *M. diptera* (= *M. paleacea* subsp. *diptera*), *M. tosana* (= *M. emarginata* subsp. *tosana*), *M. cuneiloba* (= *M. pinnata sensu* Taiwan, fide Bischler, 1987) and *M. formosana*. Lai and Wang-Yang (1976) listed six taxa by adding *M. paleacea* var. *paleacea* (= *M. paleaceae* subsp. *paleacea*) as new record. Since then six taxa are followed by later checklists (Kuo and Chiang, 1988; Pippo, 1990; Wang *et al.*, 2011). *Marchantia paleacea* subsp. *diptera* was first reported in Taiwan by Horikawa (1934) by citing many specimens throughout the island and it may rightly be assigned to *M. paleacea* subsp. *paleacea* since its existence in Taiwan was not confirmed by Bischler-Causse (1989) because no specimens from Taiwan were ever cited. However, Bischler-Causse (1989) noted that subsp. *diptera* is distributed at lower altitude, usually below 500m, and subsp. *paleacea* at higher altitude. During the course of this study, we collected specimens from Shitoushan, Miaoli County, below 500m in elevation, and confirmed the existence of the subspecies in Taiwan. This paper is to present a floristic study of *Marchantia* in Taiwan. Descriptions, photos and distribution maps are then given for each taxon.

MATERIALS and METHODS

Specimens were collected throughout Taiwan proper and they were deposited in the Department of Applied Science, National Hsinchu University of Education (tentative acronym, NHCUE). For preparing photos of scanning electronic microscope (SEM), fresh materials were collected and fixed with 70% alcohol, and then dehydrated in alcohol series, dried in a critical point dryer, coated with gold and were examined with Hitachi S-3000N, installed at the Department of Applied Science, National Hsinchu University of Education.

Herbarium acronym is added where the specimens are deposited, but specimens deposited at NHCUE is not added in this paper for saving space.

TAXONOMIC TREATMENT

Marchantia L., Sp. Pl. 1137, 1753; Horikawa in J. Sci. Hiroshima Univ., ser. B. Div. 2: 2(2): 119, 1934; Bischler in Bry. Bibl. 38: 13, 1989.

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This genus is characterized by complex thalli with one layer of air chamber in cross section, compound air pores on dorsal thalli and long-stalked gametangiaphores housing antheridia and archegonia respectively.

Key to the taxa of *Marchantia* in Taiwan

1a. Cupule lobes broadly triangular, more than 4 cells at base, ciliate at margin ……. 2
1b. Cupule lobes linear or narrowly triangular, 1~3 cells at base, entire at margin …….. 4
2a. Thalli strongly wavy at margin; disks of archegoniophore deeply divided and rays terete ……..5. ***M. polymorpha***
2b. Thalli weakly wavy or not at margin; disks of archegoniophore shallowly divided and rays flat …… 3
3a. Appendages of ventral median scales ovate, acuminate at apex …… 3a. ***M. paleacea*** subsp. ***paleacea***
3b. Appendages of ventral median scales orbicular, rounded at apex …… 3b. ***M. paleacea*** subsp. ***diptera***
4a. Cupule lobes usually narrowly triangular, 3-7 cells long ……..
…… 2. ***M. formosana***
4b. Cupule Lobes usually linear, 1-4 cells long ……..…….. 5
5a. Thalli with distinctive median line; appendages of ventral scale pinnatified; cupule lobes evenly 1-2 cells long ……..... 4. ***M. pinnata***
5b. Thalli with indistinctive or without median line; appendages of ventral scale serrate; cupule lobes unevenly 1-4 cells long ……
…….…… 1. ***M. emarginata*** subsp. ***tosana***

Marchantia emarginata Reinw. Blume & Nees subsp. *tosana* (Steph.) Bischl. in Crypt. Bryol. Lichénol. 10: 77, 1989; Bischler in Bry. Bibl. 38: 195, 1989; Lin, The Liverwort Flora of Taiwan. 235, 2000.

Figs. 1A & 2. 土佐地錢

Marchantia tosana Steph., Bull. Herb. Boissier 5: 99. 1897; Horikawa in Sci. Rep. Tohoku Imp. Univ. Ser. 4, Biol. 5: 632, 1930.
Marchantia cuneiloba Steph., Bull. Herb. Boissier 5: 98. 1897. (fide Bischler, 1987).
Marchantia radiata Horikawa in Sci. Rep. Tohoku Imp. Univ., Ser. 4, Biol. 5: 629, 1930.
Preissia quadrata auct. non (Scop.) Nees.: Yang & Lee in Taiwania 5: 186, 1964. (*KF-1670*, TAI!)

Thalli green or deep green, divaricate, relatively slender, entire at margin; on dorsal surface: median line indistinct or absent; compound air pores distinctive; cupules cup-shaped; lobe usually linear, uneven, 1-4 cells long, without serration at margin; on ventral surface: rhizoids present, pale yellowish; scales new-moon-shaped; its appendages rhomboidal with serrate margins. Dioicous. Disk of archegoniophores fist-like at first, becoming disk-like when mature, deeply divided; rays finger like, 8-10, abruptly broadened at apex; stalk 1.1-2.3 cm long. Disk of antheridiophore disk-like, shallowly divided; rays 8-10; stalks 1.1-2.0 cm long. Spores globular, 18.3-26.8 um in diameter, irregularly verrucate; trilets distinctive; elaters 2-spirally thickened.

Distribution: India, Sri Lanka, Andaman islands, China, Japan, the Ryukyus, Taiwan, southeastern Asia, New Guinea, Solomon islands (Bischler-Causse, 1989).

Habitat: On damp soils below 1800 m in elevation throughout Taiwan.

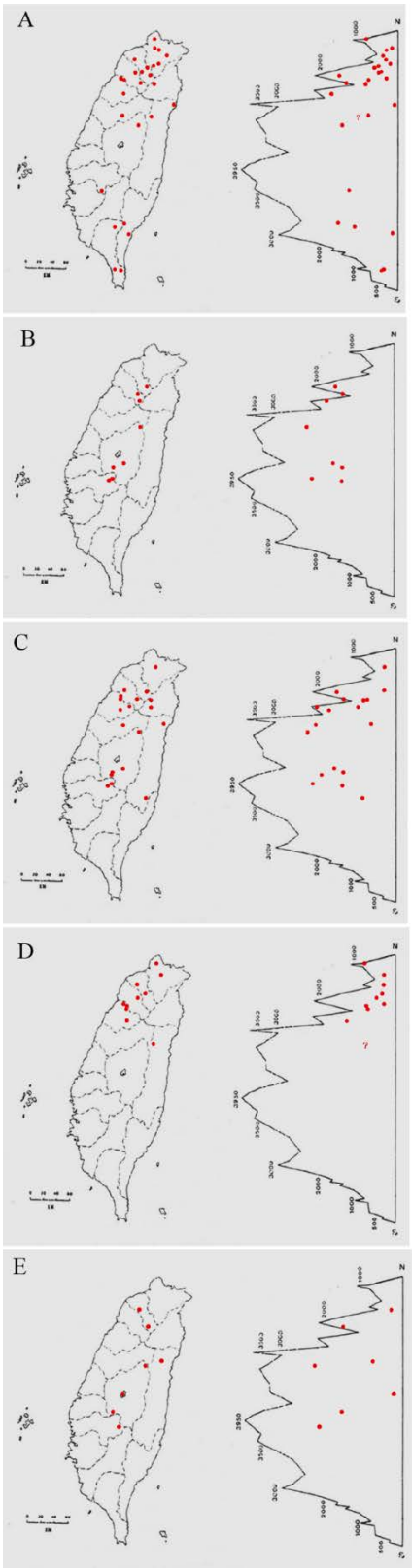


Fig. 1. Distribution maps of ***Marchantia*** in Taiwan. **A**: ***M. emarginata*** subsp. ***tosana***, **B**: ***M. formosana***, **C**: ***M. paleacea*** subsp. ***paleacea***, **D**: ***M. pinnata*** , **E**: ***M. polymorpha*** L.. **?**: elevation unknown.

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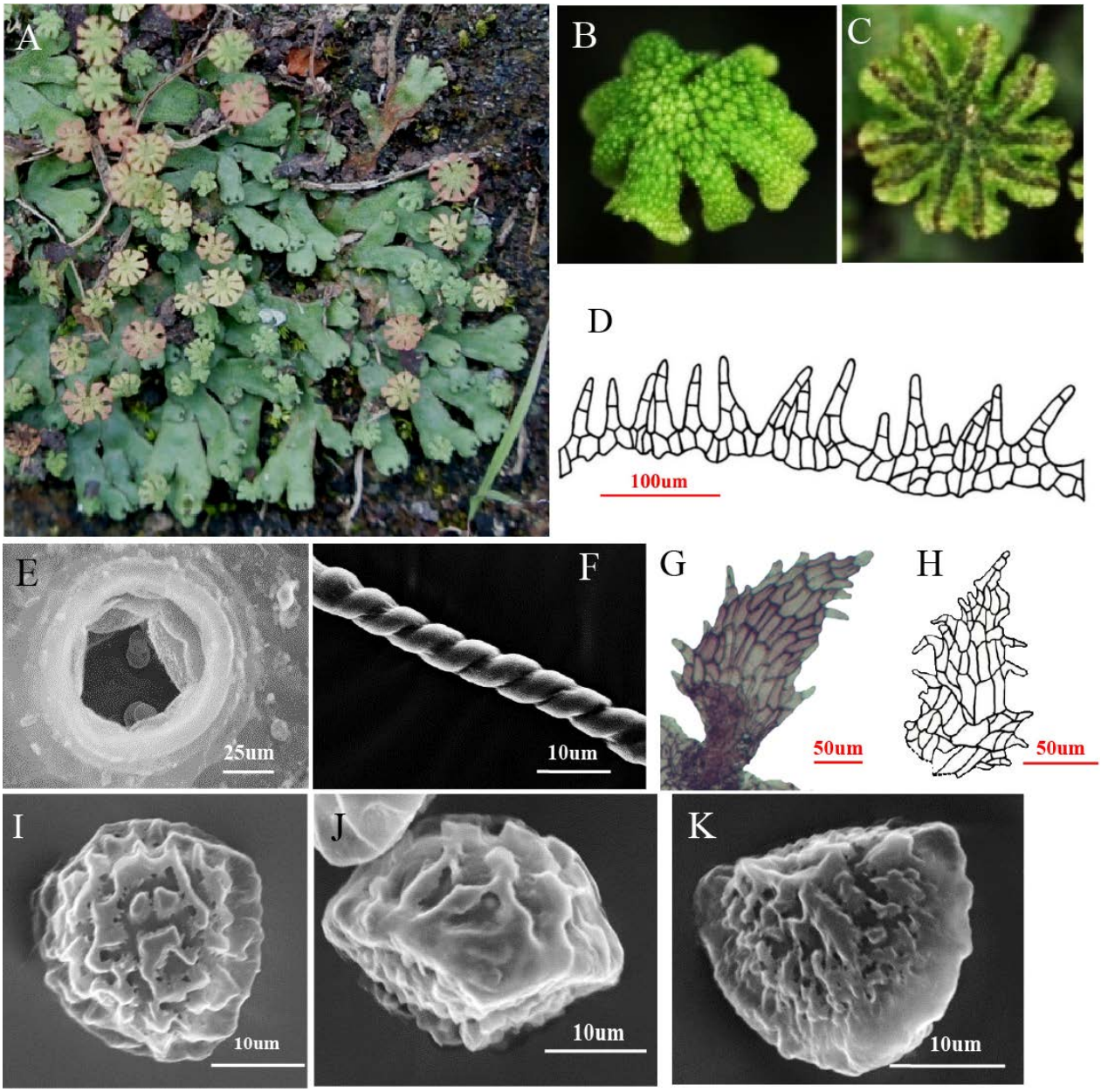


Fig. 2: ***Marchantia emarginata*** Reinw., Blume et Nees subsp. ***tosana*** (Steph.) Bischl. **A**: Habit, **B**: disk of archegoniophore, **C**: disk of antheridiophore, **D**: dissected cupule, **E**: pores on dorsal surface, **F**: elater, **G-H**: appendage of ventral scale, **I**: distal view of spore, **J**: equatorial view of spore, **K**: proximal view of spore.

Specimens examined: **TAIWAN**: **Taipei City:** Hsienchiyen, *S.-F. Huang* (黃星凡) *200812181, 200902182, 200902195*; Mucha, *Y.-W. Lu* (呂彥玟) *095, 102, 103, 104, 105*; Yangmingshan, *Y.-W. Lu 075, 124*. New Taipei City: Shenkeng, *S.-F. Huang 2010021012, 2010021019*; Shihting, *S.-F. Huang 2010020106, K.-Y. Yao* (姚奎宇) *5926* (TAIE); Wulai, *Chou* (周思妤) *1000210001, 10002100029*; Manyueyuan, Sanhsia, *Chang* (張智勳) *14, 15, 74*; Pingling, *C.-K. Lin* (林仲剛) *B11733* (TNM), *Y.-W. Lu 110*. Taoyuan City: Shihmenshan, *C. J. Chen* (陳昭榮) *11, 357*; Aipingtzu, Yangmei, *Wu* (吳玉志) *22, 37, 90, 26, 252, 257*; Lalashan, *Y.-W. Lu 064, 116*; Chiaopanshan, *Y.-W. Lu 082*. Hsinchu County: Jinshan, *Y.-W. Lu 049, 050*; Shangping, *Y.-W. Lu 127*; Neiwan, *Y.-W. Lu 128, 129, 130, 135, 136, 142, 143, 144*. Miaoli County: Shihtoushan, *S.-F. Huang 200902101*, *Y.-W. Lu 001, 056, 057, 099, 101, 148, 149, 151, 159, 160*; Erkongchishan, *S.-F. Huang 2009122208, 2009122212*, *Y.-W. Lu 120*; Erpengsung, *Y.-W. Lu 086*; Hsuechien, *Y.-W. Lu 091, 092, 093*. Taichung City: Lineng, *C.-K. Lin B08253* (TNM). Nantou County: Lushan-Tunyuan, *S.-F. Huang 2011040602, 2011040603*. Chiayi County: Sanchiaonanshan, *T.-Y. Chiang* (蔣鎮宇) *3119* (TAIE). Pingtung County: Shuanliu, *K.-Y. Yao 5840* (TAIE); Wutai, *Y.-W. Lu 141*. Taitung County: Lakalakarshan, *C.-C. Chuang* (莊清章) *5060* (TAIE); Chihpeng, *Y.-W. Lu 051*; Nanhui highway, *Y.-W. Lu 052*. Hualien County: **Hsioulin,** *C.-K. Lin B11589, B11533, B11561* (TNM); Hoping, *C.-K. Lin B06306* (TNM), Tienzanku Hot Spring, *Y.-W. Lu 084*. Ilan County: North Cross highway, *Y.-W. Lu 079, 081*.

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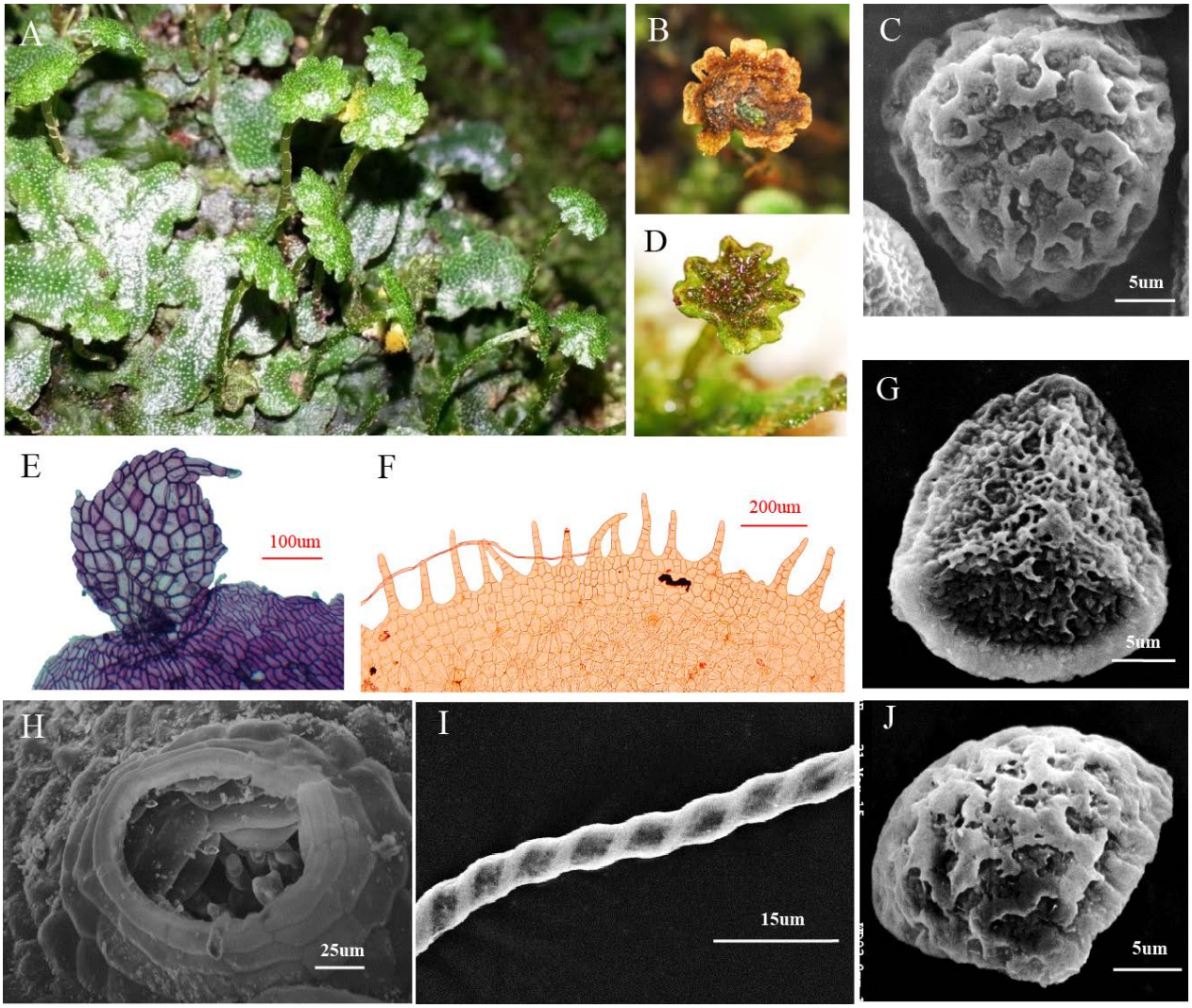


Fig. 3: ***Marchantia formosana*** Horik. **A**: Habit, **B**: disk of archegoniophore, **C**: distal surface of spore, **D**: disk of antheridiophore, **E**: appendage of ventral scale, **F**: dissected cupule, **G**: proximal surface of spore, **H**: dorsal pore, **I**: elater, **J**: equatorial view of spore.

Marchantia formosana Horikawa in J. Sci. Hiroshima Univ. ser. B, div. 2, 2: 121, fig. 5, 1934; Bischler in Bry. Bibl. 38: 149, figs. 42, 43, 1989; Lin, The Liverwort Flora of Taiwan. 237, 2000. **Figs. 1B & 3. 臺灣地錢**

Thalli deep green to dark green, divaricate, relatively slender; on dorsal surface: median line absent; compound air pores distinctive; cupules cup-shaped; lobes narrowly triangular to linear, 3-7 cells long, without serration at margin; on ventral surface: rhizoides pale yellowish; scales purple or dark purple, new-moon-shaped; appendages of scales ovate to broadly ovate, toothed at margin. Dioicous. Disk of archegoniophore disk-like, shallowly divided; rays finger-like, rounded or emarginated at apex. Disk of antheridiophore disk-like, undivided. Spores globular, 18.8-23.8 um in diameter; reticulate, ridges broader at distal surface, narrower at proximal surface; trilets distinctive; elaters 2-spirally thickened.

Distribution: Endemic in Taiwan (Bischler-Causse, 1989).

Habitat: On damp soils between 1000 to 2500 m in elevation in Taiwan.

Specimens examined: **TAIWAN**: Taoyuan City: Lalashan, *S.-F. Huang 2010120405*, *C.-C. Liu* (劉祝娟) *6*, *110*, *Y.-W. Lu 065*, *066*, *067*, *114*, *115*, *119*. Hsinchu County: Chenghsipao, *S.-F. Huang 2010041002*; Neiwan, *Y.-W. Lu 131*, *132*, *133*, *145*, *146*, *154*, *155*. Nantou County: Hsinyi, *K.-Y. Yao 6133* (TAIE); Hohuanshan-Meifeng, *C.-K. Lin B8185* (TNM); Chitou, *Y.-W. Lu 096*. Chiayi County: Alishan, *Y.-W. Lu 037*; Tatungshan, *Y.-W. Lu 040*, *055*.

Marchantia paleacea Bertol. in Opusc. Sci. (Bologna) 1：242, 1817.

subsp. ***paleacea*** Bischler in Crypt. Bryol. Lichénol. 10: 77, 1989; Bischler in Bry. Bibl. 38: 93, 1989;

Figs. 1C & 4. 粗裂地錢

Marchantia paleacea Bertol.var. *paleacea*: Lai & Wang-Yang in Taiwania 21(2): 171, 1976; Lin, The Liverwort Flora of Taiwan. 235, 2000.

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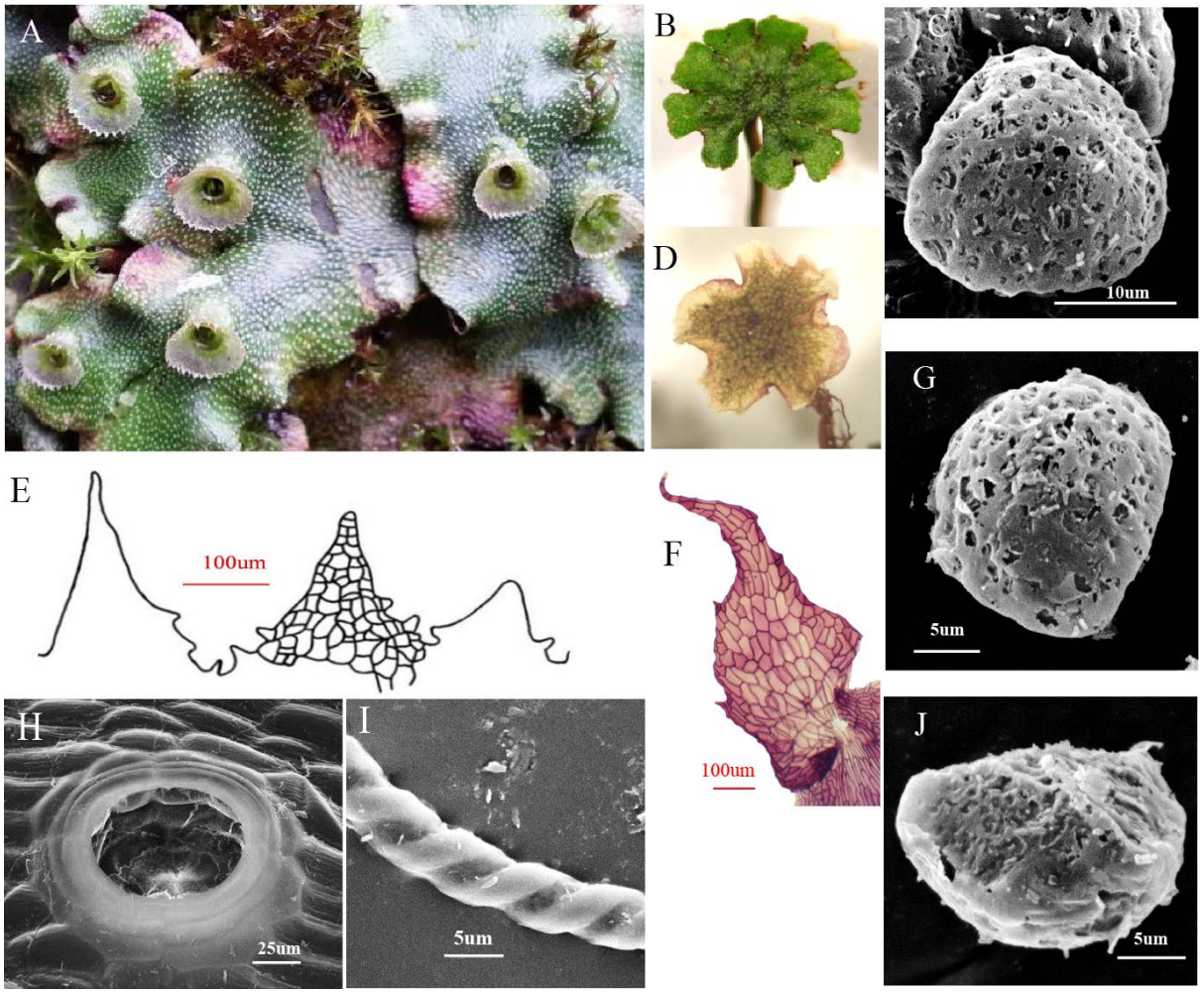


Fig. 4: ***Marchanatia paleacea*** Bertol. subsp. ***paleacea*** Bischl. **A**: Habit, **B**: disk of archegoniophore, **C**: distal surface of spore, **D**: disk of antheridiophore, **E**: part of dissected cupule, **F**: appendage of ventral scale, **G**: equatorial view of spore, **H**: pore on dorsal thallus, **I**: elater, **J**: proximal surface of spore.

Thalli green to grayish green, divaricate, relatively large, wavy at margin; on dorsal surface: median line absent; compound air pores distinctive; cupules cup-shaped; lobes triangular, 2-3 serrations at base; on ventral surface: rhizoides pale yellowish; scales half-moon-shaped, purple or pale-purple; appendages triangular to broadly ovate-triangular, acuminate at apex, with few serrations or without at margin. Dioicous. Disk of archegoniophore disk-like, with a protrusion at top, shallowly divided, with a deep cut, rays 7-9, slightly emarginated at apex; stalks 2.6-5.6 cm long. Disk of antheridiophore disk-like, irregularly emarginated. Spores globular, 18-21.3 um in diameter, reticulate, with broader ridges at distal face, with narrower ridges at proximal surface; trilets indistinctive; elaters 2-spirally thickened.

Distribution: worldwide distribution, especially in northern Hemisphere (Bischler-Causse, 1989).

Habitat: On damp soils between 300 to 2500 m in elevation in Taiwan.

Specimens examined: **TAIWAN**: Taipei City: Mucha, *Y.-W. Lu 094, 106*. Taoyuan City: Lalashan, *S.-F. Huang 2010120403, C.-C. Liu 673, Y.-W. Lu 062, 063, 113, 118*. Hsinchu County: Kuanwu, *Y.-W. Lu 108, 109, 164*; Shangping, *Y.-W. Lu 126*; Neiwan, *Y.-W. Lu 137, 138, 139*. Miaoli: Hsiangtienhu, *Y.-W. Lu 058*; Hsuechien, *Y.-W. Lu 087, 089, 090, 091*. Taichung City: Tahsueshan, *Y.-W. Lu 070, 071, 072, 073*. Nantou County: Sanlinchi. *G.-D. Syue 7* (TAIE), *Y.-W. Lu 021, 022, 024*; Hsinyi, *K.-Y. Yao 6135* (TAIE); Chitou, *K.-Y. Yao* 6163 (TAIE); Hohuanshan-Meifeng, *S.-Z. Chen B06343, Chung-Kang Lin B8153* (TNM), *Y.-W. Lu 003, 004, 010*; Tsuifeng, *Y.-W. Lu 012*. Chiayi County: Alishan, *K.-Y. Yao 6120, 6128* (TAIE), *Y.-W. Lu 035, 036, 053*; Tatungshan, *Y.-W. Lu 039*. Taitung County: Chihpenshan, *Y. Horikawa s.n.* Dec. 1932 (*fide* Horikawa, 1934); Chingshuiying, *Y. Horikawa s.n.* Jan. 1933 (*fide* Horikawa, 1934). Hualien County: Sakatan forest track, *C.-K. Lin B8005* (TNM); Yuli, *Y.-W. Lu 076, 077*. Ilan County: North Cross highway, *Y.-W. Lu 078, 080*.

subsp. ***diptera*** (Nees et Mont.) H. Inoue in J. Jap. Bot. 64(7), 194. 1989; Bischler in Bry. Bibl. 38: 104, 1987. **Fig. 5, 鳳兜地錢**

Only asexual organs have been seen. It looks like *M. polymorpha* at the first glance, but its molecular evidence (Huang and Lu, 2017; in reviewing) refers it

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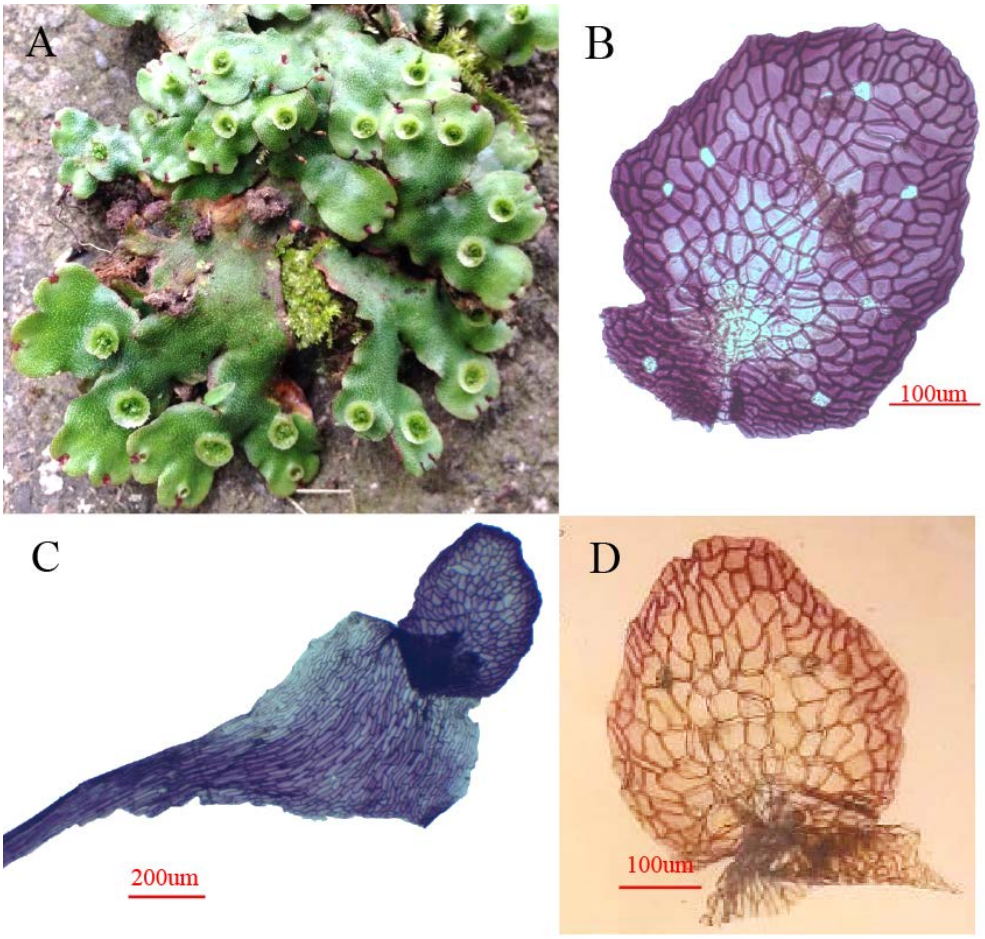


Fig. 5: ***Marchantia paleacea*** L. subsp. ***diptera*** (Nees. & Mont) Inoue. **A**: Habit, **B**: appendage of ventral scale, **C**: ventral scale, **D**: appendage of ventral scale (**D** is based on specimen of *H. Deguchi 38584* on loan from HIRO collected from Shikiku, Ehime-ken, Kamiukena-gun, Yanadani-mura, Narayabu, Japan)

to *M. paleacea* subsp. *diptera*. It differs from subsp. *paleacea* in appendages of ventral median scales that are orbicular to elliptic-orbicular with rounded apex against ovate with acute or acuminate apex.

Distribution: China, Japan and Taiwan (Bischler-Causse, 1989).

Habitat: On damp brick wall in about 450m in elevation in Taiwan.

Specimens examined: **TAIWAN**: Miaoli County: Shihtoushan, Yuankwang Temple, *S.-F. Huang 2015102801*, *Y.-W. Lu 043*.

Marchantia pinnata Steph., in Bonner, Candollea 14: 109. 1953；Bischler in Bry. Bibl. 38: 174, 1989.

Figs. 1D & 6　羽裂地錢

Marchantia cuneiloba auct. non Steph.: Horikawa in J. Sci. Hir. Univ., ser. B. div. 2. 2(2): 123, 1934.

Thalli grayish green, divaricate, 0.4-0.7 cm wide, entire at margin, usually adherent to the medium; on dorsal surface: median line distinctive, compound air pores scattered and distinctive, cupules cup-shaped, lobes evenly 1-2 cells long; on ventral surface: rhizoids abundant, pale yellowish; scales purple or deep purple, half-moon-shaped, appendages of scales ovate to oblong, pinnatified. Dioicous. Disk of archegoniophore absent in one side, fist-like at first, spreading and divided when mature; rays 4-5, unequal in length; stalks 0.3-0.5 cm long. Disk of antheridiophore palmately divided; rays finger-like, 5-7, unequal in length; stalks 0.2-0.4 cm long. Spores globular, 20.5-26 um in diameter, irregularly reticulate at distal surface, irregularly ridged at proximal surface; trilets distinctive; elaters 2-spirally thickened.

Distribution: Japan, the Ryukyus and Taiwan (Bischler-Causse, 1989).

Habitat: On damp soils below 1500m in elevation in the northern Taiwan.

Specimens examined: **TAIWAN**: Taipei City: Mucha, *Y.-W. Lu 107*; Yangmingshan, *Y.-W. Lu 125*. New Taipei City: Pingling, *Y.-W. Lu 111*, *112*. Taoyuan City: Aipingtzu, Yangmei, *Wu 91*, *127*, *146*, *253*; Amuping, *Y.-W. Lu 083*. Hsinchu County: Chinshan, *Y.-W. Lu 048*. Miaoli County: Shihtoushan, *S.-F. Huang 200902107*, *200907301*, *200911123*, *Y.-W. Lu 002*, *041*, *042*, *122*, *123*, *100*, *150*, *152*, *153*, *161*, *162*; Hsiangtienhu, *Y.-W. Lu 059*, *060*; Erpensung, *Y.-W. Lu 085*; Erkongchishan, *Y.-W. Lu 121*. Hualien County: Hsiulin, *C.-K. Lin B11587*, *11588* (TNM)

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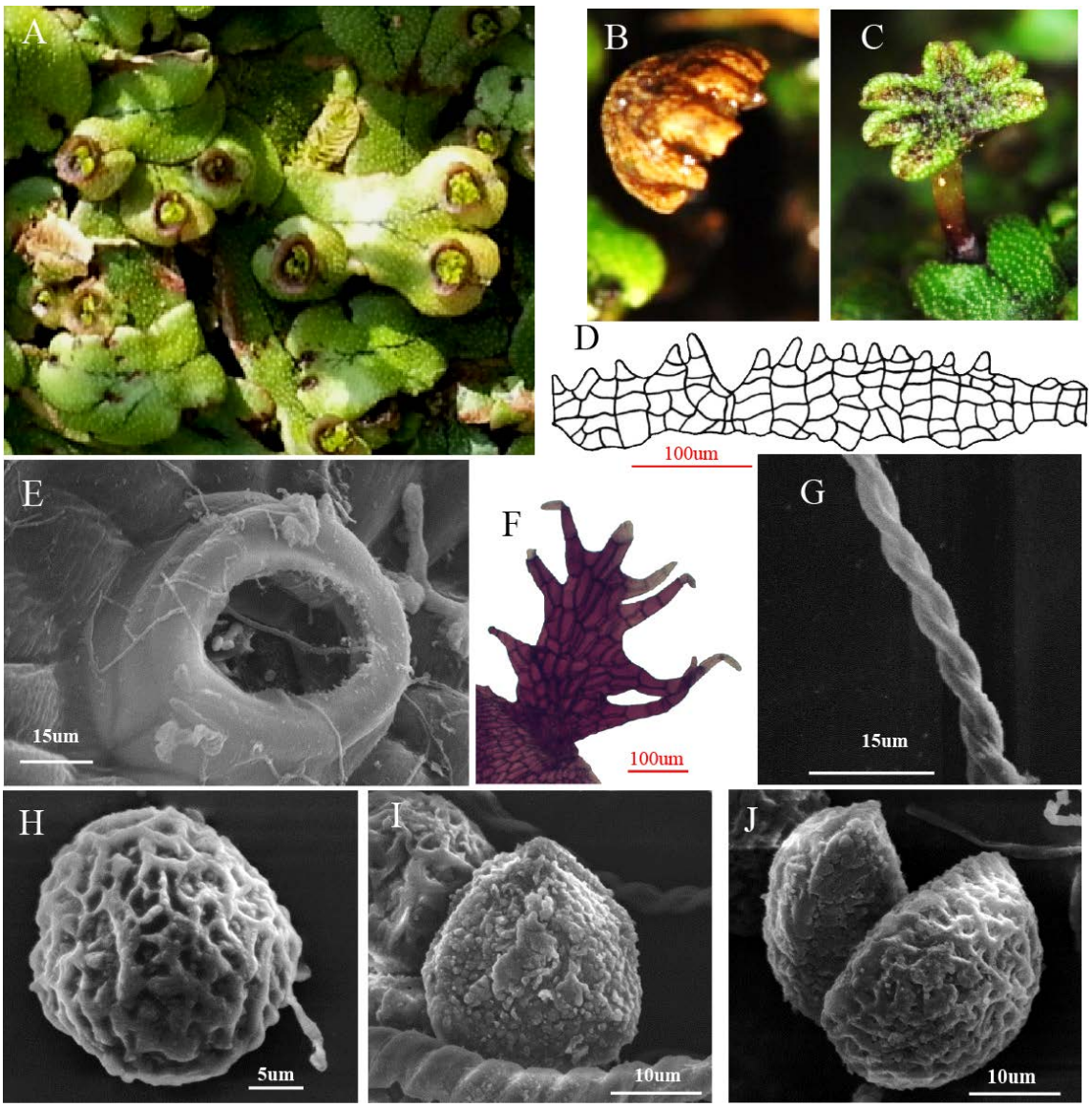


Fig. 6: ***Marchanatia pinnata*** Steph. **A**: Habit, **B**: disk of archegoniophore, **C**: disk of antheridiophore, **D**: dissected cupule, **E**: pore on dorsal thallus, **F**: appendage of ventral scale, **G**: elater, **H**: distal surface of spore, **I**: equatorial view of spore, **J**: proximal surface of spore.

Marchantia polymorpha L., Sp. Pl., 1137, 1753; Horikawa in J. Sci. Hiroshima Univ. ser. B. div. 2. 2(2): 120, 1934. Bischler in Bry. Bibl. 38: 74, figs. 19 & 20, 1989; Lin, The Liverwort Flora of Taiwan. 235, 2000.

Figs 1E & 7. 地錢

Thalli yellowish green or pale green, divaricate, 0.7-1 cm wide, wavy at margins; on dorsal surface: median line indistinct or absent, compound air pores scattered and distinctive, cupules cup-shaped, lobes triangular, with 1-2 serrations at margin; on ventral surface: rhizoids abundant, pale yellowish; scales half-moon-shaped, yellowish brown to pale purple, transparent; appendages of scales ovate-orbicular, obtuse or rounded at apex, few toothed at margin. Dioicous. Disk of archegoniophores umbrella-like, deeply divided; rays 7-11, terete; stalks 0.6-6.1 cm long. Disk of antheridiophore disk-like, 8-9; rays flat; stalks 0.5-1.6 cm long. Spores globular, 17.5-22.5 um, irregularly reticulate; ridges shallow and broad at distal face, narrower at proximal face; trilets indistinctive; elaters 2-spirally thickened.

Distribution: Worldwide distribution, especially in northern Hemisphere (Bischler-Causse, 1989).

Habitat: On damp soils between 300m and 2500m in elevation in Taiwan.

Specimens examined: **TAIWAN**: Taoyuan City: Lalashan, *S.-F. Huang 2012020105*, *Y.-W. Lu 068*, *069*, *117*; Aipingtzu, Yangmei, *Wu 79*, *92*. Nantou County: Hohuanshan-Meifeng, *Y.-W. Lu 005*, *007*; Tsuifeng, *Y.-W. Lu 011*; Sanlinchi, *Y.-W. Lu 019*; Shuili, *Y.-W. Lu 046*. Chiayi County: Alishan, *K.-Y. Yao 6138* (TAIE), *Y.-W. Lu 038*; Tsuchung police station, *K. -Y. Yao 6166* (TAIE). Hualien County: Paiyang trail, *C.-K. Lin B08097* (TNM).

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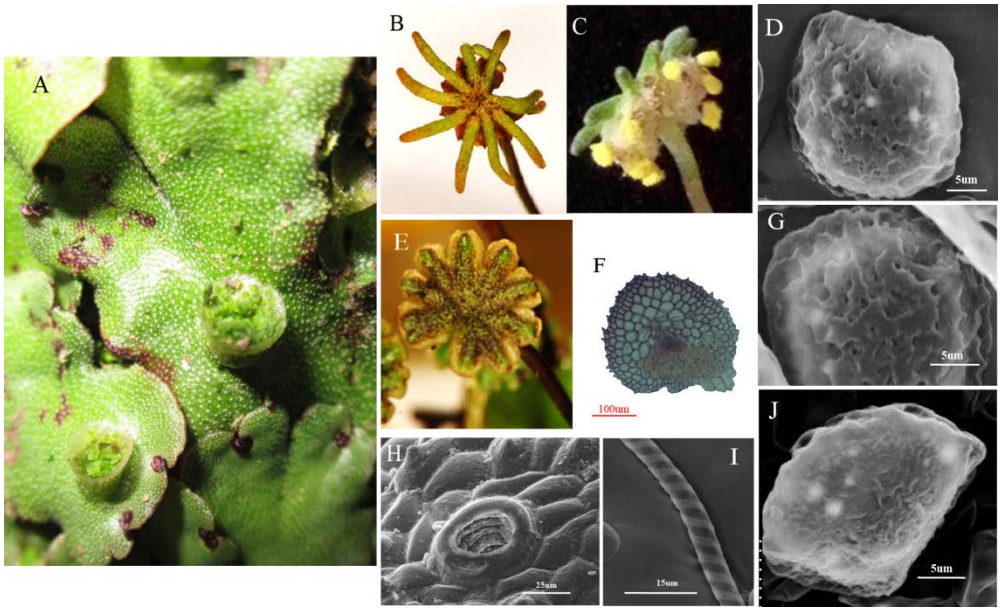


Fig. 7: ***Marchantia polymorpha*** L. **A**: Habit, **B**: & **C**: disk of archegoniophore, **D**: distal surface of spore, **E**: disk of antheridiophore, **F**: appendage of ventral scale, **G**: proximal surface of spore, **H**: pore on dorsal thallus, **I**: elater, **J**: equatorial view of spore.

Note: Three subspecies are classified under this species and they are separable by allozyme (Boisselier-Dubayle *et al.*, 1995). Regarding dorsal surface of thalli, subspecies *polymorpha* bears distinct and continuous median line, subspecies *ruderal* bears indistinct and interrupted median line while subspecies *montivagen* does not bear any line. According to this distinction, most specimens from Taiwan should be assigned to subspecies *ruderal*, except those at Meifeng, Nantou, which should refer to subspecies *montivagen*.

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