



The Moss family Erpodiaceae in Yunnan Province, China

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Abstract

Erpodiaceae, a poorly collected or recorded moss family in Yunnan, is increasingly found to be common in previously overlooked habitat such as tree trunks in disturbed areas. Four species are known in Yunnan with *Erpodium perrottetii* representing a genus new for China according to current generic placement, and *Solmsiella biseriata* new for Yunnan. The habitat preference of Erpodiaceae is re-evaluated and *Aulacopilum abbreviatum* is suggested to be excluded from the Red-List-Species in China. Keys and images are provided to aid recognition of all four genera of Erpodiaceae in China.

Key words: *Aulacopilum abbreviatum*, *Erpodium perrottetii*, *Solmsiella biseriata*, new record, red-list, *Venturiella sinensis*

Introduction

An overview of the history of bryophyte collection in Yunnan

China has a long history of using bryophytes ethno-botanically which dates back several centuries. In the 15th century, mosses were listed in the ancient Chinese traditional medical book: *Ben-Cao-Gang-Mu*, which is probably the earliest recorded evidence known on bryophyte collecting activities in China. Common and showy species, now known as *Polytrichum commune* Hedwig (1801: 88) and *Marchantia polymorpha* Linnaeus (1753: 1137). were used in traditional medicine and listed in the ancient Chinese medical literature (Harris 2008). These medical uses of bryophytes, however, had little impact promoting the floristic and biodiversity study of bryophytes in China.

It was not until the early 19th century when European naturalists began exploring the forests in China. Attracted by its primary vegetation and the culture in Yunnan, amateur botanists such as Augustine Henry, Père Jean Marie Delavay, George Forrest and Heinrich von Handel-Mazzetti started the first comprehensive bryological collections in Yunnan (Zang & Li, 2008). These specimens were studied by world experts at that time and many species and genera were published as new to science.

Professor P. C. Chen, known as the “Father of Chinese Bryology”, began a new era in the 1950s with training a generation of bryologists. Many interesting specimens were collected in Yunnan by his students in subsequent years. It is generally believed for such a relatively “well-studied” area in China that new discoveries are becoming more and more difficult to make. However, even with the publication of several volumes of regional bryofloras (Gao & Cao 2000; Li 2002, 2005), species new to this region continue to be discovered (for example, Shevock *et al.* 2006; 2011).

Study of Erpodiaceae in China

Erpodiaceae are primarily a trunk dwelling pleurocarpous moss family distributed in tropical and subtropical areas with approximately 25 species worldwide (Crum 1972; Crosby *et al.* 2000; Frey *et al.* 2009). Plants are tiny and slender and many species resemble liverworts with their imbricate leaves under dry condition. The number of genera in Erpodiaceae has undergone different circumscriptions. Five genera were proposed by Crum (1972) and had been widely accepted. Subsequently, *Microtheciella* Dixon (1931: 6) was later segregated into its own family Microtheciellaceae (Miller & Harrington 1977). Although Stone (1997) took an alternate approach by accepting only the genus *Erpodium*

(Bridel) Bridel (1827: 788) in the family, the most updated view as presented in the moss classification system by Goffinet *et al.* (2009), recognize five genera, namely: *Aulacopilum* Wilson (1848: 90), *Erpodium*, *Solmsiella* Müll. Hal. (1884: 149), *Venturiella* Müll. Hal. (1875: 421), and *Wildia* Müll. Hal. & Brotherus (1891: 103), and Frey (2009) also took the similar classification.

The first report of Erpodiaceae in China was probably published in the *Genera Muscorum Sinicorum* (Chen 1978), in which *Aulacopilum abbreviatum* Mitten (1873: 308) was vaguely referenced as being distributed in all southwestern provinces in China. However, Erpodiaceae was not presented in the moss treatment of *Flora Yunnanica* (Li 2005). In *Flora Bryophytorum Sinicorum Vol. 5* (Wang 2011a), *A. abbreviatum* was listed as the only known member of Erpodiaceae from Yunnan. Nonetheless, in the Moss Flora of China (Wang 2011b), two species in different genera of Erpodiaceae are documented in Yunnan—*A. abbreviatum* was reported from Bao-shan Co., Lu-shui Co., Chu-xiong Co. and Meng-la Co., and *Venturiella sinensis* (Venturi 1873: 1211) Müll. Hal. (1897: 262) was confirmed from one specimen collected in Lu-xi Co. in southwest Yunnan.

Material & Methods

Specimens for this study were mainly obtained from our field trips in Yunnan Province during 2007, 2013, 2014 and 2015, and historical Erpodiaceous collections in both herbaria of the California Academy of Sciences (CAS) and Kunming Institute of Botany (KUN) were also examined. Species identification were done either by referring to published bryological literature (Wang 2011a; 2011b), or comparing with vouchers in CAS that previously had been named by R. A. Pursell. Plant images were produced from the GigaMacro Magnify 2 imaging system. All specimens were deposited in CAS and KUN, with several vouchers sent to other herbaria as indicated in the parentheses after each specimen cited below.

Results

Four species representing four genera of Erpodiaceae are now confirmed from Yunnan Province, the distribution of each species based on voucher specimens is shown in Figure 1.

Key to known genera in Erpodiaceae in China

- | | | |
|----|--|--------------------|
| 1. | Leaves dimorphic, the apices of dorsal leaf rounded, branches complanate foliate | <i>Solmsiella</i> |
| 1. | Dorsal and ventral leaves similar in shape, apices of dorsal leaf acuminate, branches imbricate folate | 2 |
| 2. | Leaf cells multipapillose..... | <i>Aulacopilum</i> |
| 2. | Leaf cells smooth..... | 3 |
| 3. | Cells in leaf apex elongated (length-width ratio up to 11:1) | <i>Venturiella</i> |
| 3. | Cells in leaf apex oval-hexagonal (length-width ratio about 5–6:1) | <i>Erpodium</i> |

1) *Aulacopilum abbreviatum* Mitten (1873: 308) (Figure 2)

Illustrations: Noguchi (1952: 13), Wang (2011a: 5), Wang (2011b: 3)

Notes: *Aulacopilum abbreviatum* is frequent encountered in Yunnan. It has a much wider distribution range in Yunnan than our previous understanding of this Himalayan species (Fig. 1). The vivid coloration of this plant, especially after a rain event, which appears bright yellow to light green, probably has attracted more attention than other members in this family. Nevertheless, when sterile, moss collectors may be confused by its appearance superficially resembling the liverwort family Lejeuneaceae, and therefore, less likely to collect it.

Aulacopilum japonica is another species reported from several provinces in Eastern China. Two species could be easily distinguished from each other by counting the number of papilla within the cell. For *A. japonica*, there are 16–32 papillae per cell, while this number is less than 9 in *A. abbreviatum*, and the shape of cell is hexagonal in *A. japonica*

but rounded in *A. abbreviatum* (Wang 2011a). As these two species look quite similar to each other morphologically, it is hard to rule out the possibility that both species could be collected in Yunnan in the future.

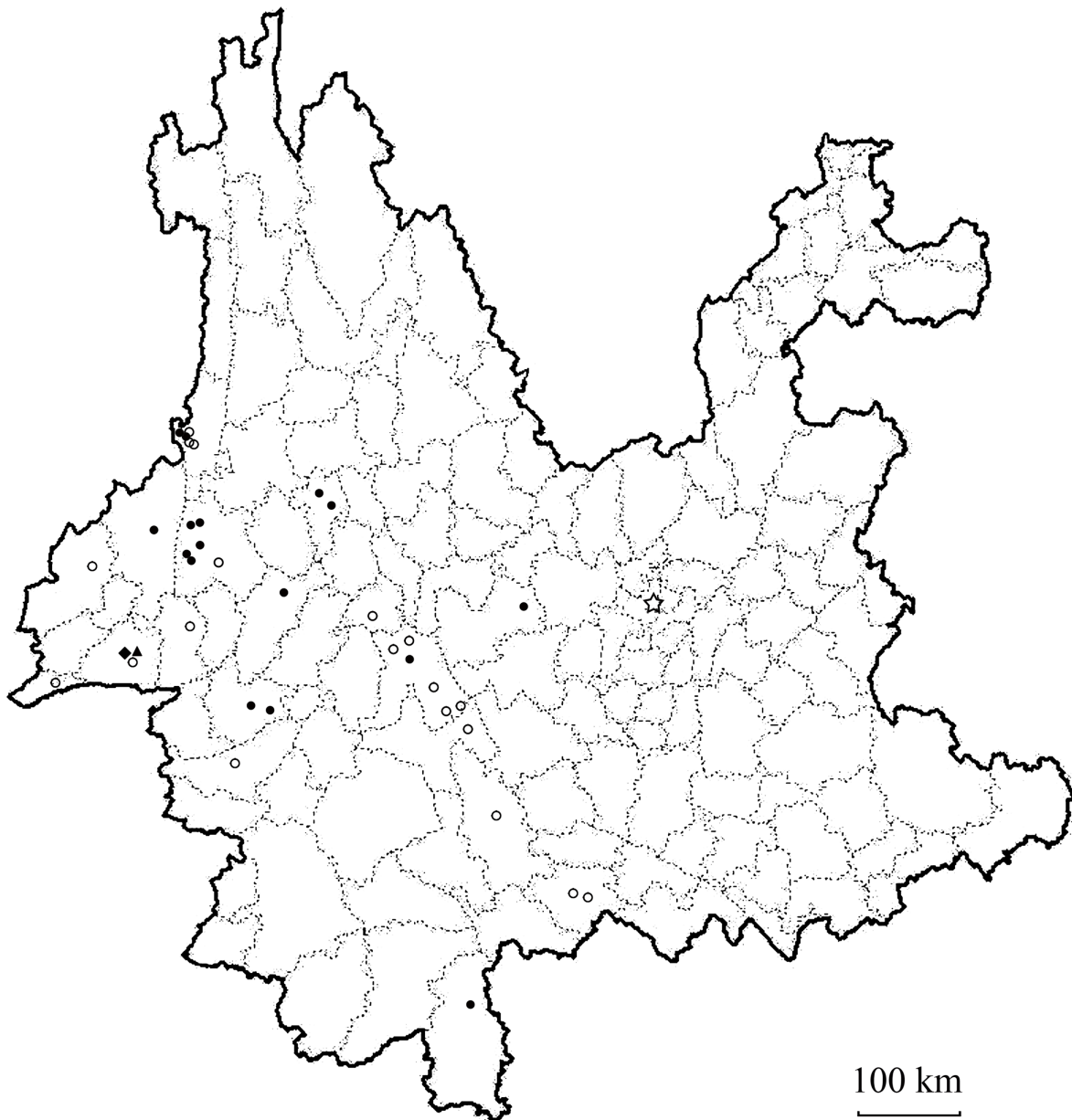


FIGURE 1. Distributions of four species of Erpodiaceae in Yunnan ●: *Aulacopilum abbreviatum*, ○: *Erpodium perrottetii*, u: *Solmsiella biseriata*, ▲: *Venturiella sinensis*.

Specimens examined: **BAOSHAN**, LONG-YANG DIST., Long & Shevock 37427 (CAS, E, KUN); Long & Shevock 37458 (CAS, E, KUN); Long & Shevock 37518 (CAS, E, KUN); Ma & Shevock 14-5673 (CAS, KUN); Ma & Shevock 14-5716 (CAS, KUN); Shevock & Long 31142 (CAS, E, KUN, MO); Shevock & Long 31173 (CAS, E, KUN, MO); Shevock & Long 31204 (CAS, E, KUN, MO); Shevock & Long 31272 (CAS, E, KUN, MO). **TENG-CHONG CO.**, Ma, Shevock & Yao, 15-6259 (CAS, KUN). **CHUXIONG**, CHU-XIONG Co., Redfearn & He 1761a (CAS, KUN, MO). **DALI**, YANG-BI Co., Ma 10-1652 (CAS, KUN); Su 75 (KUN, MO). **PUER**, JING-DONG Co., Ma & Shevock 14-5790 (CAS, KUN). **NUJIANG**, LU-SHUI Co., Shevock & Long 30693 (CAS, E, KUN, MO), Shevock, Ma & Yao 42946 (CAS, KUN). **LINCANG**, YONG-DE Co., Shevock 45328 (CAS, KUN, MO, SZG); Shevock, Ma & Yao 43376 (CAS, KUN); Shevock, Ma & Yao 43516 (CAS, KUN). **XISHUANGBANNA**, MENG-LA Co., Redfearn et al. 33963 (KUN, MO).



FIGURE 2. Plants of *Aulacopilum abbreviatum* (Shevock & Long 31251 CAS) (Photo by: Codie Otte).

2) *Erpodium perrottetii* (Montagne 1856: 26) A. Jaeger (1876: 90) (Figures 3–4)

Description: Plants slender, yellowish green to pale green, old parts sometimes appear grey. Stems 5–15 mm long, growing appressed to substratum, forming loose or dense mats. Branch irregularly, semi-erect, 2–5 mm long, horizontally creeping but less attached to substrate. Leaves complanate, oblong-ovate, entire, ecostate, 0.8–1.1 × 0.4–0.6 mm. Cells thin-walled, hexagonal; apical cells 35–42 × 12–14 μm; median cells 35–47 × 15–20 μm; middle basal cells 40–70 × 15–23 μm; alar cells rectangular, 17–22 × 22–28 μm. Leaf margin is bordered by a column of smaller sized cells 12–25 × 12–14 μm, and transversely elongated downward. Rhizoids scattered on ventral side of stem. Sporophytes terminal on branches. Setae very short, no longer than 0.3 mm. Perichaetial leaves broadly lanceolate, 0.6–0.7 × 0.3 mm, oblong-ovate, entire, acute. Capsules *ca* 1.0–1.2 × 0.5–0.6 mm, urn-shaped, between whitish and yellowish green, fragile after spore release, exthothecium cells thin-walled, irregularly sized, 15–25 × 30–75 μm, stomata not seen. Spores 35–43 × 33–36 μm, green, globose to ovoid, finely papillose.

Notes: A species new to China, confirmed by R. A. Pursell and B. Allen. Unlike other members of Erpodiaceae, the growth form of *E. perrottetii* shares little resemblance with liverworts. The vegetative part of this species resembles the genus *Fabronia* Raddi (1808: 231) to a certain degree, and they frequently occur in mixed populations with each other. Fortunately, *E. perrottetii* produces capsules frequently and in large quantities which greatly aids in recognition of this species in the field.

Erpodium perrottetii resembles *E. mangiferae* Müll.Hal. (1872: 178) to a great extent. According to the description by Daniels *et al.* (2012), *E. mangiferae* has a “roughly spindle-shaped primordial utricle” within the cell, which we failed to find from all our recent collections, but the historical specimens in KUN collected during the 1970s (*Li* 2401; *Zang & Xi* 888; *Zang* 898; *Zang* 955) showed this structure. So this phenomenon may result from plasmolysis. The cell-walls in the upper part of cell are projected in the apex region of *E. perrottetii* (Figure 4: C), this could be another character to distinguish it from *E. mangiferae* based on descriptions from Gangulee (1976) and Daniels *et al.* (2012).

Specimens examined: BAOSHAN, LONG-YANG DIST., Shevock & Ma 45334 (CAS, KUN); Shevock & Ma 45337 (CAS, KUN). LONG-LING CO., Ma, Shevock & Yao 15-6345 (CAS, KUN). DALI, Nan-Jian Co., Ma 15-6625 (CAS,

KUN). **DEHONG**, LU-XI Co., *Ma, Shevock & Yao 15-6317; Shevock, Ma & Yao 46624* (CAS, E, KUN, MO). RUI-LI CITY, *Ma, Shevock & Yao 15-6310* (CAS, KUN), *Shevock, Ma & Yao 46619* (CAS); YING-JIANG Co., *Shevock, Ma & Yao 46600* (CAS, KUN); *Yao, Shevock & Ma 15-902* (KUN). **HONGHE**, LÜ-CHUN Co., *Zang & Xi 888* (CAS, KUN), *Zang 898* (KUN), *Zang 955* (KUN). **LINCANG**, GENG-MA Co., *Ma 09-679* (CAS, KUN). **NUJIANG**, LU-SHUI Co., *Shevock, Ma & Yao 42944* (CAS, KUN); *Shevock, Ma & Yao 42952* (CAS, KUN); *Shevock, Ma & Yao 43375* (CAS, KUN); *Ma, Shevock & Yao 13-4782* (CAS, KUN). **PUER**, MO-JIANG Co., *Li 2401* (CAS, KUN). JING-DONG Co., *Ma & Shevock 14-5818* (CAS, KUN); *Shevock & Ma 45617* (CAS, HSNU, KUN, MO, TAIE); *Shevock & Ma 45689* (CAS, HSNU, KUN, MO, TAIE); *Shevock & Ma 45690* (CAS, KRAM, KUN, MO, SZG). **ZHEN-YUAN** Co., *Shevock & Ma 45691* (CAS, KUN, MO).



FIGURE 3. Plants of *Erpodium perrottetii* (*Shevock & Ma 45689* CAS) (Photo by: Aaron Yang).

3) *Solmsiella biseriata* (Austin 1877: 142) Steere (1935: 100) (Figure 5)

Illustrations: Wang (2011a: 8), Wang (2011b: 6)

Notes: This species occurs in isolated, disjunct populations, but is geographically widespread, occurring on multiple continents (Crum 1972; Stone 1997; Pursell & Allen 2007). *Solmsiella biseriata* in China is documented only for Guizhou, Guangdong, and Taiwan Provinces based on a handful of collections. We now report *S. biseriata* as new for Yunnan. According to Touw (1992) this species is frequently encountered in “man-made” habitats, and this is true for the Guizhou locality of *S. biseriata* (as *Erpodium biseriatum*) where it was found nowhere else but at a scenic spot (Tan *et al.* 1994). Similarly, the Yunnan population of *S. biseriata* is found on planted *Ficus* tree trunks along the sidewalk in the city. Among all members of the Erpodiaceae, *S. biseriata* is the most liverwort-looking species. When in a sterile condition, it would generally not be recognized as a moss.

Specimen examined: **DEHONG**, LU-XI Co., *Shevock, Ma & Yao 46625* (CAS); *Yao, Shevock & Ma 15-929* (KUN, MO, PE).

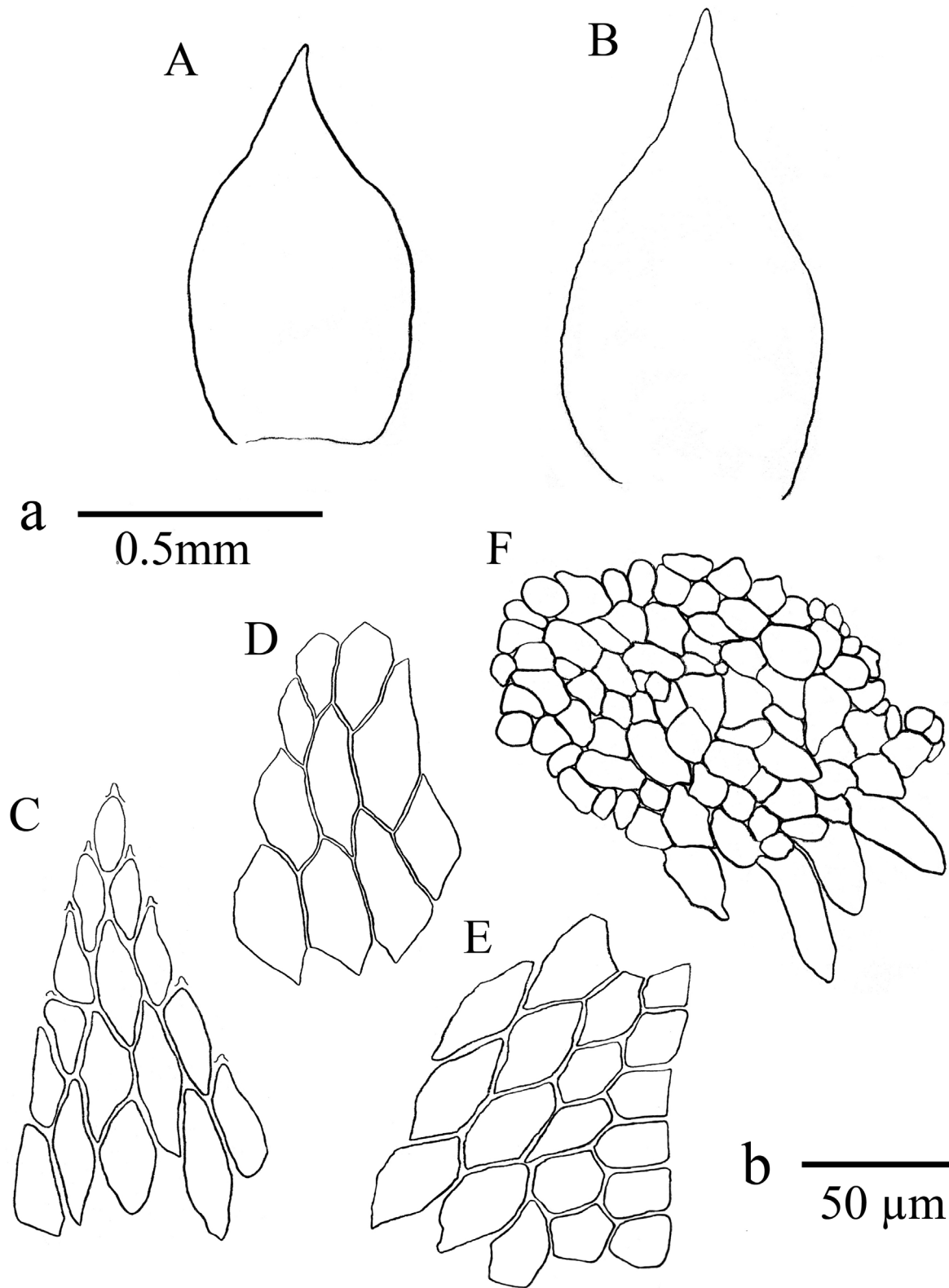


FIGURE 4. Illustration of *Erpodium perrottetii* (Drawn from Ma, Shevock & Yao 13-4782, KUN) A–B: leaves; C: apex cells; D: middle cells; E: marginal cells at lower part of leaf; F: cross section of stem; scale bar: a for A & B, b for C–F.

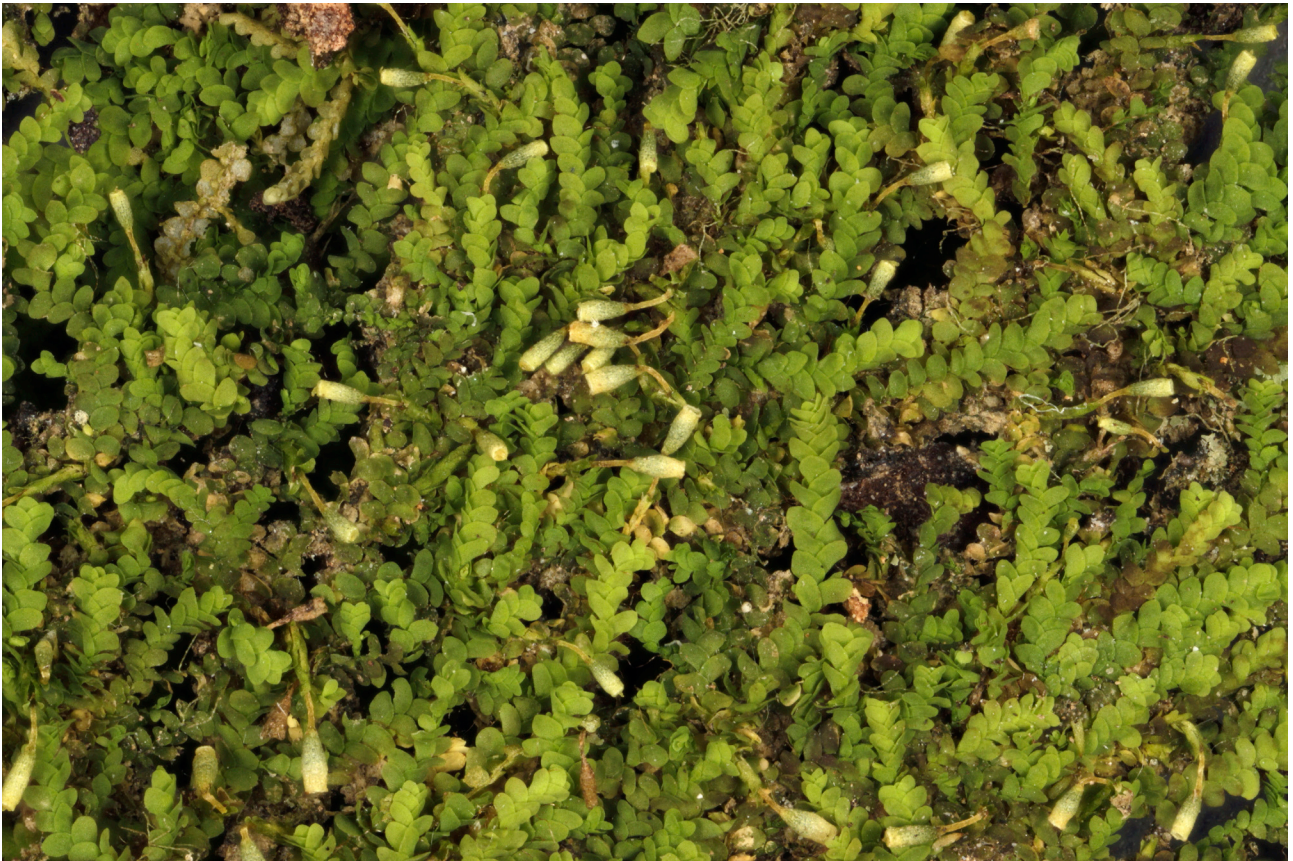


FIGURE 5. Plants of *Solmsiella biseriata* (Shevock & Yao 39052, CAS) (Photo by: Aaron Yang).

4) *Venturiella sinensis* (Venturi 1873: 1211) Müll. Hal. (1897: 262) (Figure 6)

Illustrations: Noguchi (1952: 10; 1988: 387), Wang (2011a: 6), Wang (2011b: 8)

Notes: This species has a wide distribution in the northern hemisphere, mainly in East Asia and North America (as var. *angusti-annulata* D.G. Griffin & Sharp ex D.G. Griffin 1985: 58). Herbarium records show it to be fairly common in the eastern part of China, but in Yunnan, it currently is represented by only a single collection in southwestern Lu-xi County; not far from the border with Burma. Of all the Yunnan members in Erpodiaceae, *V. sinensis* is the only species with peristome teeth, and the plant is distinguished vegetatively by its long hyaline cells at leaf apex. From the known data, this collection lies in the western boundary of its distribution range in China, and, very likely, it will be discovered to occur in Burma as well.

Specimen examined: DEHONG, LU-XI Co., Jia 910164 (MO, specimen confirmed by R. A. Pursell and S. He).

On other species

Erpodium guizhouensis Y.-X. Xiong & X.-L. Yan in Yan *et al.* (2000: 210), *nom. nud.*

Erpodium guizhouensis was mentioned as a new species found in neighboring Guizhou Province (Yan *et al.* 2010); unfortunately, this species was not validly published. Although we failed to examine the type specimen (subsequently lost), according to the original description (Yan 2005), *E. guizhouensis* is most likely the same as *E. perrottetii*. It thus becomes very likely that *E. perrottetii* may also occur in Guizhou Province.



FIGURE 6. Plants of *Venturiella sinensis* (He & Yi 44950, CAS) (Photo by: Codie Otte).

Discussion

Erpodiaceae has a wide distribution across tropical and subtropical regions worldwide, however, it was so poorly collected that no Chinese literature provided sufficient information on either species distribution or habitat preferences. We suggest the following reasons why Erpodiaceae were under-collected in Yunnan.

First of all, the habitat specificity of members of Erpodiaceae is poorly understood. Trees planted for horticultural or economical purposes, are generally regarded as poor substrates for bryophytes, especially when villages are surrounded by agricultural fields. However, this is not true for the moss family Erpodiaceae. Among all our collections made in Yunnan, almost all species were found on trees, both native and non-native, along roads, streets, or by villages where human disturbances exist. A similar situation was reported by Daniels *et al.* (2012) that most members of Erpodiaceae in India were found either in “degraded” forests or on “lofty” trees.

The Chinese name of the family, which literally means “tree-dwelling moss”, is misleading to bryologists who have never encountered them in the field before. With very limited habitat information recorded on labels from early collected specimens, collectors probably have associated the character “tree-dwelling” with “well protected forests”, so they were easily attracted to forests where they believe to have high species diversity, while open and dry habitats that Erpodiaceae actually prefer are more likely to be ignored. Although few occurrences of *Aulacopilum abbreviatum* were made near the boundary of Gao-li-gong-shan National Nature Reserve in west Yunnan, primary forests are not the best habitats to seek species of Erpodiaceae based on all our collection records. Nonetheless, because of forest edge effect, the altered light regime on tree trunks may provide suitable condition for members of Erpodiaceae to colonize, as a result, fallen branches may be another potential micro-habitat to explore.

Beside the less understood habitat requirements of Erpodiaceae, the resemblance of some members in the family to certain taxonomically difficult liverwort groups reduced the chance for them to be sampled. This is particularly true for *Aulacopilum abbreviatum* and *Solmsiella biseriata*; both grow on tree trunks and look like Lejeuneaceae or Frullaniaceae, when they are sterile and in a dry condition. Although *Erpodium perrottetii* may not share this situation, the resemblance to *Fabronia*, a fairly weedy moss genus in China, made it less attractive to most bryophyte collectors,

especially when the plants bear no capsules. According our field observations, *E. perrottetii* is the most frequently encountered species of Erpodiaceae in Yunnan.

Finally, we suspect a few collections are either misidentified in herbaria or waiting determination. A systematic and comprehensive survey in the unidentified material stored in Fabroniaceae, Frullaniaceae, Lejeuneaceae, and Radulaceae in Chinese herbaria may yield additional records.

Conclusion

From our current understanding of Erpodiaceae, members of the family are far more common and widespread than previously known based on herbarium collections and their preferred habitats, and we suggest *Aulacopilum abbreviatum* be excluded from the “Red List Species” in China, which evaluated as DD (Data Deficient) (Ministry of Environmental Protection of the People’s Republic of China 2013).

We anticipate that the occurrences of species in the Erpodiaceae will increase both in Yunnan and some other southern regions in China, where urbanization of rural areas is taking place. As forests or farmlands are converted to “man-made” habitats, more Erpodiaceous collections would be expected in habitats with the following traits:

1) *Isolated tree trunks with limited shading.* Although trees that have bark textures favoring water retention would provide quality micro-environments for epiphytes, it is the moderate amount of direct sunlight that contributes to the ability of Erpodiaceous species to compete against other bryophytes with less drought tolerance. This may also explain why most specimens were collected on deciduous trees.

2) *Sites where human activity prevail.* Based on our collecting experience, members of Erpodiaceae favor some level of human disturbance. Human activities seem to influence the rates of colonization. Planted trees in roadsides, parks, temple yards, or even on sidewalks along urban streets are likely to become new potential habitats as they mature.

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