Ten New Records of Liverwort and Hornwort Species from Guangxi (Postprint)

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Date: 2023-10-22T00:00:00+00:00

Abstract

Based on the study of liverwort and hornwort specimens collected from Baise, Guilin, Hechi, Nanning and other locations in Guangxi during 2019-2022, a total of 10 new species records for Guangxi were discovered, namely broad-lobed Riccia (Riccia cavernosa Hoffm.), Japanese Riccia (R. nipponica S. Hatt.), sparse-leaved Metacalypogeia alternifolia (Nees) Grolle, ovate-leaved Bazzania (Bazzania angustistipula N. Kitag.), different-bracted Cheilolejeunea (Cheilolejeunea kitagawae W. Ye & R.L. Zhu), striped-lobed Cololejeunea magnistyla (Horik.) Mizut., tube-leaved Colura calyptrifolia (Hook.) Dumort., concave-lobed Lejeunea (Lejeunea convexiloba M.L. So & R.L. Zhu), Taiwan hornwort (Anthoceros angustus Steph.), and minute hornwort (A. subtilis Steph.), among which tube-leaved Colura calyptrifolia is reported for the first time from mainland China, and the genus Metacalypogeia is a newly recorded genus for Guangxi. The paper lists the main diagnostic characters, specimen information, geographic distribution and other information for the newly recorded species, and provides plates. These research results further enrich the baseline data for bryophyte diversity studies in Guangxi and China.

Full Text

Ten New Records of Liverworts and Hornworts in Guangxi, China

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DOI: 10.11931/guihaia.gxzw202304060

Abstract

Based on the examination of specimens collected from Baise, Guilin, Hechi and Nanning regions from 2019 to 2022, ten species of liverworts and hornworts, including *Riccia cavernosa* Hoffm., *R. nipponica* S. Hatt., *Metacalypogeia alternifolia* (Nees) Grolle, *Bazzania angustistipula* N. Kitag., *Cheilolejeunea kitagawae* W. Ye & R.L. Zhu, *Cololejeunea magnistyla* (Horik.) Mizut., *Colura calyptrifolia* (Hook.) Dumort., *Lejeunea convexiloba* M.L. So & R.L. Zhu, *Anthoceros angustus* Steph., and *A. subtilis* Steph., are reported new to the Guangxi Zhuang Autonomous Region. Among them, *Colura calyptrifolia* represents the first record for mainland China, and *Metacalypogeia* is a new genus record for Guangxi province. The diagnostic characters, voucher specimens, distribution, microscopic illustrations and taxonomic notes are also documented for each species. This study shall provide useful knowledge to better understand the bryophytes biodiversity in Guangxi, as well as in China.

Keywords: range extension, Ricciaceae, Calypogeiaceae, Lepidoziaceae, Lejeuneaceae, Anthocerotaceae, species diversity

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Funding

National Natural Science Foundation of China (31960045); Guangxi Natural Science Foundation (2020GXNSFAA297085, 2020GXNSFBA297044)

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Introduction

Bryophytes are small, non-vascular land plants comprising mosses, liverworts, and hornworts. Globally, there are approximately 20,000 species, including about 7,270 liverworts and 215 hornworts (Wang et al., 2022), predominantly distributed in tropical regions (Wang et al., 2017). To date, China has recorded 1,175 liverwort species (including infraspecific taxa) and 27 hornwort species (Liu and Qin, 2022). Guangxi, located in southern China and spanning both tropical and subtropical climate zones, possesses unique natural geographical features and complex climatic conditions that have fostered rich bryophyte resources, particularly distinctive liverwort and hornwort flora.

The earliest reports of liverworts and hornworts from Guangxi date back to German scholar Hermann Reimers (1931), who published "Beiträge zur Mossflora Chinas, I" in *Hedwigia*, documenting 25 liverwort species from Guangxi, including an unidentified *Cephaloziella* sp. However, by 1990, Piippo's annotated catalogue of Chinese Hepaticae and Anthocerotae listed only 49 species from the region (Piippo, 1990). Zhu and So (2003) significantly increased this number to 225 species (including two hornworts) in their study of Shangsi County. Subsequently, Wei et al. (2018) updated the bryophyte checklist for Guangxi, recording 1,230 species (including infraspecific taxa), comprising 411 liverworts and six hornworts, and clarified their distribution patterns. In recent years, intensive field surveys have continuously uncovered new records (Tang et al., 2018, 2019; Wei et al., 2018) and new species (Shu & Zhu, 2019; Zhang et al., 2021; Wei et al., 2023) from Guangxi. Additionally, several novel liverwort genera described by Chinese botanists have been reported from the region, including *Gaolejeunea* R.L. Zhu & W. Ye, *Soella* R.L. Zhu, L. Shu, Qiong He & Y.M. Wei (distributed in Guangxi, Japan's Ryukyu Islands, and Thailand), and *Gradsteinianthus* R.L. Zhu & Jian Wang bis (found in Guangxi and northern Vietnam) (Wang et al., 2016; Ye & Zhu, 2018; Zhu et al., 2018; Senayai et al., 2021). These discoveries not only enrich the bryoflora of Guangxi but also underscore the value of continued investigation into the region's liverwort and hornwort resources.

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1. Materials and Methods

We examined over 800 liverwort and hornwort specimens collected from Baise, Guilin, Hechi, and Nanning between 2019 and 2022. Some species lacked detailed documentation or were only briefly mentioned in existing Chinese bryophyte floras. These taxa were identified through consultation of relevant domestic and international literature (see references below). Field habitat photographs were taken with a Canon G16 camera. Microscopic structures were photographed and observed using a stereomicroscope (Olympus SZX7), optical microscope (Olympus BX43), and image acquisition system (Mshot MH125). Spore morphology of *Riccia cavernosa*, *R. nipponica*, and *Anthoceros*

angustus was examined with a Zeiss EVO18 scanning electron microscope. All voucher specimens are deposited at the Guangxi Herbarium (IBK).

2. Results

This study documented ten new records for Guangxi, comprising eight liverwort species [two Ricciaceae, one Calypogeiaceae, one Lepidoziaceae, and four Lejeuneaceae] and two hornwort species. Among these, *Metacalypogeia* represents a new genus record for Guangxi, while *Colura calyptrifolia* is recorded for the first time from mainland China. The ten new records are listed below following the classification system of *Species Catalogue of China, Volume 1: Bryophytes* (Jia and He, 2013). An asterisk (*) indicates species reported in this study.

2.1 *Riccia cavernosa* Hoffm. (Fig. 1: A-F)

Riccia cavernosa belongs to Ricciaceae. Its main diagnostic features include: (1) plants are flat and thalloid, typically forming rings of 2-4 individuals; (2) the thallus dorsal surface is dark green with conspicuous spongy reticulations and lacks grooves; (3) spores exhibit band-like or vermiculate ornamentation on the proximal surface with a distinct trilete mark, while the distal surface shows irregular reticulate patterns with winged margins.

References: Özenoğlu Kiremit et al. (2016), Borovichev and Bakalin (2016).

Specimen examined: Lafu Reservoir, Yizhou District, Hechi City, Guangxi, 108°22 56.49 E, 24°42 36.80 N, alt. 197 m, on soil, Ping Huang 20190928-1.

Distribution: China (Beijing, Inner Mongolia, Xinjiang, Guangxi*), widely distributed in warmer regions of all continents except the Arctic highlands and Antarctica (Zhang and Wu, 2006; Jia and He, 2013; Borovichev & Bakalin, 2016).

Notes: Species of *Riccia* are typically ephemeral, persisting for only 2-3 months with distinct seasonal growth cycles. Thallus morphological characters become difficult to observe after desiccation. China currently records 19 *Riccia* species, making it one of the more species-rich genera in Marchantiopsida. However, domestic research materials on this genus remain limited and fragmented, complicating species identification. Only two species were previously reported from Guangxi: *R. fluitans* L. and *R. huebeneriana* Lindenb., both of which have extremely narrow thalli (<1 mm wide) and typically exhibit large polygonal air chambers in cross-section, clearly distinguishing them from *R. cavernosa*.

Morphologically, *R. cavernosa* resembles *R. crystallina* L., but the latter has a relatively firm and compact thallus with inconspicuous spongy reticulations on the dorsal surface and regular reticulate ornamentation on the spore distal surface (Rivola, 1967; Özenoğlu & Kirmaci, 2018).

2.2 *Riccia nipponica* S. Hatt. (Fig. 1: G-L)

Riccia nipponica is characterized by: (1) flat, thalloid plants typically forming rings of 2-4 individuals or sometimes growing scattered; (2) light green thallus dorsal surface with transparent, crystal-like cells and V-shaped apical grooves; (3) spores with regular reticulate ornamentation on the proximal surface and distinct trilete mark, while the distal surface features regular reticulate patterns with 4-6 areoles spanning the entire surface, each with central spine-like projections and winged margins.

References: Shimizu and Hattori (1953), Borovichev and Bakalin (2015).

Specimens examined: Shuijiang, Huixian Town, Lingui District, Guilin City, Guangxi, 110°13 17.88 E, 25°4 10.15 N, alt. 148 m, on soil in paddy fields, Yunbiao Liao 20210122-1; Liujia Village, Yanshan Town, Yanshan District, Guilin City, Guangxi, 110°16 53.33 E, 25°4 56.63 N, alt. 157 m, on moist soil, Qiming Tang 20210124-3; Huangdong Village, Xiuren Town, Lipu County, Guangxi, 110°13 31.58 E, 24°21 59.23 N, alt. 226 m, on soil, Yunbiao Liao 20220420-1.

Distribution: China (Guizhou, Shanghai, Zhejiang, Guangxi*), Russia, Japan, Africa (Rwanda) (Jia and He, 2013; Borovichev & Bakalin, 2016, 2017).

Notes: *Riccia nipponica* most closely resembles *R. crystallina*, as both have transparent, crystal-like cells on the thallus dorsal surface and regular reticulate ornamentation on the spore distal surface. However, *R. crystallina* has 6-10 areoles spanning the distal surface with spine-like projections at the reticulum nodes (Borovichev & Bakalin, 2015).

2.3 *Metacalypogeia alternifolia* (Nees) Grolle (Fig. 2: A-F)

Metacalypogeia alternifolia belongs to Calypogeiaceae. Its main diagnostic features include: (1) small plants with few branches; (2) leaves ovate-triangular with rounded or acute apices; (3) underleaves reniform, half the size of lateral leaves and more than 2.5 times the stem width; (4) leaf cells thin-walled with small to large trigones and finely verrucose cuticle.

References: Schuster (1995); Gao (2003).

Specimen examined: Summit of Mao'er Mountain National Nature Reserve, Xing'an County, Guangxi, 110°24 43.31 E, 25°51 53.48 N, alt. 2,106 m, on rocks, Yumei Wei et al. 20190330-98.

Distribution: China (Guizhou, Sichuan, Taiwan, Tibet, Yunnan, Guangxi*), Bhutan, India, Nepal, Japan, Vietnam, USA (Hawaii) (Staples & Imada, 2006[2007]; Jia and He, 2013; Bakalin, 2018[2017]).

Notes: *Metacalypogeia* is a new genus record for Guangxi. The genus comprises only two species worldwide: *M. cordifolia* (Steph.) Inoue and *M. alternifolia*, both occurring in China. The former has larger plants with underleaves less than one-quarter the size of lateral leaves and only twice the stem width.

2.4 *Bazzania angustistipula* N. Kitag. (Fig. 2: G-L)

Bazzania angustistipula belongs to Lepidoziaceae. Its main diagnostic features are: (1) plants with dichotomous branching and numerous ventral flagelliform branches; (2) lateral leaves ovate-triangular, sparsely arranged on stems, easily detached, with 1-2 teeth at the apex; (3) underleaves oblong-ovate, often shallowly bilobed at the apex, with cells similar to leaf cells.

References: Zhou et al. (2012).

Specimens examined: Shiwang Ancient Field, Chemiao Miao Township, Ziyuan County, Guangxi, 110°22 14.48 E, 26°4 45.96 N, alt. 1,759 m, on tree base, Qiming Tang 20210619-75; same locality, 110°22 26.79 E, 26°4 28.04 N, alt. 1,713 m, on tree trunk, Qiming Tang 20210620-191.

Distribution: China (Guizhou, Sichuan, Yunnan, Guangxi*), Bhutan, Malaysia, Nepal, Thailand, India, Vietnam (Zhou et al., 2012; Cheah & Yong, 2016).

2.5 *Cheilolejeunea kitagawae* W. Ye & R.L. Zhu (Fig. 3: A-H)

Cheilolejeunea kitagawae belongs to Lejeuneaceae. Its main diagnostic features include: (1) paroicous inflorescences; (2) lateral leaves imbricate, dorsal lobes ovate with rounded apices, ventral lobes rectangular and exceeding half the length of dorsal lobes; (3) middle tooth reduced, angular teeth 1-3 cells long; (4) hyaline papilla located on the abaxial side at the base of angular teeth; (5) underleaves entire, not lobed.

References: Zhu and So (1999), Yang (2009).

Specimen examined: Pengzuping Reserve, Longsheng County, Guangxi, 110°12 9.39 E, 25°55 59.45 N, alt. 786 m, on dead branches, Ping Huang et al. 210331-13.

Distribution: China (Fujian, Hunan, Taiwan, Guangxi*), Japan, Thailand, India (Jia and He, 2013).

Notes: *Cheilolejeunea kitagawae* was formerly placed in *Leucolejeunea*, distinguished from *Cheilolejeunea* by its entire, unlobed underleaves. Molecular phylogenetic studies later merged *Leucolejeunea* into *Cheilolejeunea* (Ye & Zhu, 2010; Ye et al., 2015). China previously recorded three *Leucolejeunea* species: *C. kitagawae*, *C. xanthocarpa* (Lehm. & Lindenb.) Malombe, and *C. turgida* (Mitt.) W. Ye & R.L. Zhu, all now distributed in Guangxi. Distinguishing characters among them are detailed in Zhu and So (1999).

2.6 *Cololejeunea magnistyla* (Horik.) Mizut. (Fig. 3: I-M)

Cololejeunea magnistyla belongs to Lejeuneaceae. Its main diagnostic features are: (1) small plants, green or yellow-green; (2) lateral leaves imbricate, dorsal lobes ovate-round with entire margins, often obliquely triangular; (3) ventral

lobes highly variable, ranging from obliquely triangular, quadrate to ligulate; (4) stylus mostly clavate, 3-6 cells long and 1-3 cells wide; (5) underleaves absent.

References: Zhu & So (2001).

Specimen examined: Tongmu Village, Jiangdi Township, Longsheng County, Guangxi, alt. 765 m, on rocks, Ping Huang et al. 210609-13.

Distribution: China (Guizhou, Hunan, Taiwan, Guangxi*), Japan (Jia and He, 2013).

Discussion: *Cololejeunea magnistyla* is considered most similar to *C. tianmuensis* Jian Wang bis, X. Tang & Z. Dai, but the latter has mostly linear stylus typically one cell wide at the base and smaller gemmae (Dai et al., 2019).

2.7 *Colura calyptrifolia* (Hook.) Dumort. (Fig. 4: A-F)

Colura calyptrifolia belongs to Lejeuneaceae. Its main diagnostic features include: (1) leaves remote to contiguous, dorsal lobes lanceolate, ventral lobes large (about twice the length of dorsal lobes), cylindrical at base and strongly inflated upward to form a fusiform sac with a long tubular apex; (2) valve located at the sac mouth, composed of a ring of 16 transparent marginal cells and about 12 central cells; (3) underleaves remote, one per leaf, deeply bilobed; (4) perianth obovoid with five angular keels; (5) gemmae discoid, composed of 26-27 cells, usually borne on leaf apices.

References: Yang et al. (2013), Mufeed et al. (2018).

Specimen examined: Caowang Mountain, Quanda Village, Luosha Township, Leye County, Guangxi, 106°21 14.69 E, 24°43 57.25 N, alt. 1,854 m, on tree branches, Ping Huang et al. 210719-1.

Distribution: China (Taiwan, Guangxi*), reported from South America, West Indies, tropical Africa, western and northern Europe, and Asia including India, Nepal, Sri Lanka, and China (Yang et al., 2013; Gradstein et al., 2018; Mufeed et al., 2018).

Discussion: *Colura calyptrifolia* is the type species of the genus, first reported from Taiwan, China in 2013 (Yang et al., 2013). The present discovery in Guangxi represents the first record for mainland China. Morphologically, it closely resembles *C. tenuicornis* (A. Evans) Steph. (Zhu & So, 2001), but can be distinguished by the shape of the ventral lobe sac (fusiform vs. lanceolate), the length of the tubular leaf apex (1/3-1/4 vs. about 1/2 of leaf length), and the relative length of perianth keels (1/4-1/5 vs. 1/3-1/2 of perianth length).

2.8 *Lejeunea convexiloba* M.L. So & R.L. Zhu (Fig. 4: G-M)

Lejeunea convexiloba belongs to Lejeuneaceae. Its main diagnostic features are: (1) small plants, monoicous; (2) lateral leaves imbricate, dorsal lobes often falcate with rounded apices, ventral lobes large (more than half the length of dorsal

lobes) and strongly inflated; (3) middle tooth unicellular, angular teeth reduced; (4) underleaves small, bilobed, 1.5-2 times the stem width; (5) cells small with finely verrucose cuticle; (6) androecial underleaves present only at the base of male spikes.

References: So & Zhu (1998).

Specimen examined: Pengzuping Reserve, Longsheng County, Guangxi, 110°9 58.73 E, 25°58 54.67 N, alt. 1,194 m, on tree trunk, Ping Huang et al. 210331-14.

Distribution: China (Fujian, Guizhou, Shaanxi, Zhejiang, Guangxi*), Malaysia (Jia and He, 2013; Sarimi et al., 2021).

Discussion: *Lejeunea convexiloba* was previously considered endemic to China, but was recently discovered in Malaysia (Sarimi et al., 2021). Due to its extremely small size, this species is easily overlooked during field collection. We anticipate that its actual distribution is more extensive than currently known with further field surveys. Morphologically, it resembles *L. curviloba* Steph., but the latter has ventral lobes usually less than half the length of dorsal lobes, and androecial underleaves distributed along the entire male spike.

2.9 *Anthoceros angustus* Steph. (Fig. 5: A-E)

Anthoceros angustus belongs to Anthocerotaceae. Its main diagnostic features include: (1) flat, thalloid plants without midrib, possessing mucilage cavities; (2) thallus surface cells each containing a large chloroplast; (3) thallus margins often bearing numerous circular or pillow-shaped gemmae.

References: Peng and Zhu (2013).

Specimen examined: Near Guisan Expressway, Longsheng County, Guangxi, 25°44 49.25 N, 110°2 41.63 E, alt. 469 m, on soil by ditch, Ping Huang et al. 210828-9.

Distribution: China (Fujian, Guizhou, Hunan, Sichuan, Taiwan, Tibet, Yunnan, Guangxi*), Bhutan, Nepal, Japan, India (Jia and He, 2013; Peng & Zhu, 2013).

2.10 *Anthoceros subtilis* Steph. (Fig. 5: F-J)

Anthoceros subtilis belongs to Anthocerotaceae. Its main diagnostic features are: (1) flat, thalloid plants without midrib, possessing mucilage cavities; (2) thallus surface cells each containing a large chloroplast; (3) thallus margins with irregular small lobes but lacking gemmae; (4) spores with small spine-like or lamellar projections on the proximal surface and distinct trilete mark, distal surface with relatively dense spine-like projections that sometimes branch at the tips; (5) pseudoelaters 2-3 cells long, sometimes with irregular band-like thickenings.

References: Peng and Zhu (2013).

Specimen examined: Daling Village, Wuling Town, Binyang County, Guangxi, 108°52 11.02 E, 23°10 20.86 N, alt. 79 m, on soil by ditch, Ping Huang 220209-2.

Distribution: China (Guizhou, Heilongjiang, Jilin, Liaoning, Yunnan, Guangxi*), Nepal, Japan, Thailand, India, Vietnam (Peng & Zhu, 2013).

Discussion

The ten liverwort and hornwort species reported here, except for *Metacalypogeia alternifolia*, belong to groups covered in the unpublished final volumes of *Flora Bryophytorum Sinicorum* or were not documented in previously published volumes. With limited references available in regional bryophyte floras, we have emphasized the main diagnostic characters of these species, provided detailed illustrations, and included verifiable references to contribute foundational data for the ongoing compilation of China's bryophyte flora and to facilitate identification for researchers, especially students.

Bryophytes, being highly sensitive to environmental changes, face greater threats than other plant groups from deforestation, rapid urbanization, pollution, and global climate change. Most bryophytes have disappeared from heavily disturbed habitats, with remote mountainous areas becoming their primary refugia. The six leafy liverworts reported here (*Metacalypogeia alternifolia*, *Bazzania angustistipula*, *Cheilolejeunea kitagawae*, *Cololejeunea magnistyla*, *Colura calyptrifolia*, and *Lejeunea convexiloba*) were discovered in remote natural mountains or nature reserves with minimal human disturbance. In contrast, the four thalloid species (*Riccia cavernosa*, *R. nipponica*, *Anthoceros angustus*, and *A. subtilis*) were found in highly disturbed environments such as reservoirs, farmlands, and roadside slopes. While surveys should focus on natural mountains and protected areas rich in bryophyte resources, habitats with strong human disturbance also warrant appropriate attention.

Riccia nipponica is listed as a threatened bryophyte species (Vulnerable, VC) in China's 2020 Red List of Biodiversity (https://www.mee.gov.cn/xxgk2018/xxgk/xxgk01/202305/t20230522_{1 Its discovery in Lingui and Yanshan districts of Guilin City and Lipu County provides new data for future reassessments. For provinces like Guangxi, which harbor extremely rich bryophyte resources but have significant gaps in baseline surveys, our understanding of species diversity remains insufficient. This deficiency greatly affects the assessment of China's bryophyte resources. For example, among the 20 *Riccia* species recorded in the Red List, half cannot be evaluated due to insufficient distribution data. Therefore, continued and prioritized bryophyte resource surveys and research in Guangxi remain essential.

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Note: Figure translations are in progress. See original paper for figures.