

Rediscovery of the monospecific moss genus *Cyptodontopsis* (Cryphaeaceae) in China: a species restricted to flood plain habitats

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Cyptodontopsis leveillei (Thér.) P. Rao & Enroth (Cryphaeaceae), the single species of its genus, is reported as new for Yunnan Province along banks of the Nu and Wulong Rivers in the Gaoligongshan region. The microhabitat requirement of periodic inundation forms an exceedingly narrow zone for establishment and maintenance of this species. The realization that *C. leveillei* is actually an obligate rheophyte may explain why previous searches to rediscover this species within forest habitats in China were not successful.

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Introduction

From 2002–2007 several expeditions to the Gaoligongshan region of western Yunnan Province were initiated between the Kunming Institute of Botany, Chinese Academy of Sciences (KUN), Department of Botany, California Academy of Sciences (CAS) and the Royal Botanic Garden, Edinburgh, Scotland (E). This mountainous region is part of the Three Parallel Rivers and identified as a World Heritage site adjacent to the

border with Myanmar (Burma). The Gaoligongshan forms the southern end of the Hengduan Mountains, the easternmost extension of the Himalayas. This region of China has long been recognized as an area of high species diversity and one of the major botanical hot spots in Asia. With an elevation gradient of nearly 5000 m, the Gaoligongshan represents habitats from low elevation sub-tropical evergreen forests to alpine tundra and ice fields. During these multiyear expeditions nearly 8000 bryophyte collections

were obtained from the Gaoligongshan. As specimens were examined and named to species, some proved to be new to Yunnan, others new to China, and a few were determined as new to science.

New to science

- Shevockia* Enroth & Ji (2006)
- Gottschelia grollei* Long & Váňa (2007)
- Lobatiriccardia yunnanensis* Furuki & Long (2007)
- Hamatostrepta concinna* Váňa & Long (2008)
- Pinnatella homaliodelphoides* Enroth *et al.* (2010)
- Philonotis lizangii* Koponen (2010)
- Bucklandiella shevockii* Ochyra & Bednarek-Ochyra (2010)
- Yunnanobryon* Shevock *et al.* (2011)
- Schistidium riparium* and *S. mucronatum* Blom *et al.* (2011)

New to Yunnan or China

- Bryoxiphium norvegicum* subsp. *japonicum* (Shevock 2005),
- Hydrocryphaea wardii* (Shevock *et al.* 2006)
- Mannia californica*, *Paraleptodontium recurvifolium* and *Pleurozia subinflata* (Long 2008)
- Dixonia orientalis* and *Trismegistia korthalsii* (He *et al.* 2009)
- Anastrophyllum aristatum* (Daniels *et al.* 2012)

Regional revisions

- Jungermanniaceae (Váňa & Long 2009)
- Gongylanthus* and *Southbya* (Váňa & Long 2012)
- Hedwigiaceae (Dalton *et al.* 2013)
- Cheilolejeunea* (Ye *et al.* 2013)

During these Gaoligongshan expeditions, the second author was particularly interested in sampling bryophytes occurring in fast flowing rivers and streams where plants are periodically inundated and submerged. While examining a set of Gaoligongshan specimens belonging to the Cryphaeaceae, it became readily apparent that a

species attached to branches and stems of hardwood shrubs at the high water zone of the Nu Jiang was new for Yunnan Province. We determined these plants to be *Cyrtodontopsis leveillei* (Thér.) P. Rao & Enroth (Figs. 1 and 2; Rao & Enroth 1999).

During September 2013 a return visit to the Gaoligongshan was initiated by the first two authors with the primary purpose to explore more riparian habitats along the Nu Jiang, revisit the initial *Cyrtodontopsis* collection sites, locate additional populations, and determine the habitat specificity and ecology of this species.

Rheophytes, seasonally submerged bryophytes

Among bryophytes, the ability to be seasonally submerged and then withstand an extended period of time exposed and desiccated usually in full sun appears to be a rare combination of physiological and structural attributes to a highly specialized habitat (Vitt & Glime 1984, Akiyama 1995, Enroth 1999). This ecological condition is described as being ‘rheophytic’ (van Steenis 1981, 1987). The number of rheophytic bryophytes is currently unknown, but probably between 300–400 species worldwide. As more riparian areas are surveyed, especially throughout Asia, this number is likely to increase (Akiyama 1992). The difficulty to determine the actual number of rheophytic bryophytes is mainly due to the lack of habitat specificity indicated on herbarium labels, or when a collection was made along a river does not indicate whether it was actually obtained at or below the high water zone.

Rheophytes in China and along Nu Jiang in Yunnan

Rheophytic habitats in China remain poorly surveyed. Part of this is based on the fact that many rivers are usually highly disturbed and native forest cover has been lost, and therefore, species richness is generally low. Collectively, these

habitat attributes are not places where bryologists focus on conducting inventory work since much better primary forests occur higher up the mountain slopes. In addition, access by roads and trails along many rivers is limited due to steep and rugged terrain. The largest river in the Gaoligongshan region is the Nu Jiang (= Salween). A road along the Nu Jiang has provided relatively easy access for many former botanical expeditions into the Gaoligongshan region. Yet rheophytes such as *Hydrocryphaea* were not previously collected based on a review of specimens at KUN.

While the majority of rheophytes occur on rock walls and boulders, a few species seem to prefer being attached to small-diameter stems of hardwood shrubs and branches or occasionally on exposed roots. Shrubs and trees are rarely inundated or submerged for extensive periods whereas rheophytes attached to rock walls and boulders can be submerged for weeks or even months. Nu Jiang is rich in rheophytic mosses with extensive populations of the monospecific genera *Hydrocryphaea* (Neckeraceae; Shevock *et al.* 2006, Olsson *et al.* 2010) and *Yunnanobryon* (Regmatodontaceae; Shevock *et al.* 2011). These rheophytic mosses can cover square meters of rock walls and boulders forming a conspicuous cover within the river corridor generally devoid of forest vegetation.

However, the long-term conservation of rheophytic bryophytes in China is somewhat problematic. Many rivers in Yunnan Province are undergoing significant change through water diversion and damming associated with hydroelectric development. Plans are underway to dam portions of the Nu Jiang and several tributary rivers flowing into the Nu Jiang already have hydroelectric facilities built or are currently under construction. Species requiring periodic flooding or submersion are likely to be significantly impacted by such changes in river hydrology and ecology. Unfortunately, no populations of *Cyptodontopsis* are within any protected landscape along the Nu Jiang.

The family Cryphaeaceae

The Cryphaeaceae is a rather small moss family of c. 75 species with the largest genus being *Cryphaea* (Rao 2000, 2001). This family comprises four genera with fairly similar morphologies: *Cyptodon*, *Cyptodontopsis*, *Dendrocryphaea* and *Dendropogonella* (Dixon 1937). *Cyptodon*, *Cyptodontopsis* and *Dendrocryphaea* are rheophytic members of this family. *Cyptodon* contains four allopatric but apparently closely related species (Enroth 1995): *C. dilatatus* (Hook.f. & Wils.) Par. & Schimp. endemic to New Zealand, *C. muelleri* (Hampe) M. Fleisch. to Australia, *C. fasciculatus* (Duby) M. Fleisch. to New Caledonia, and *C. gracilis* (Mitt.) Broth. known from Fiji and Samoa. *Dendrocryphaea* has six species, five of which occur in the neotropics and one, *D. tasmanica* Broth., in Australia (states of New South Wales, Tasmania and Victoria) and New Zealand (cf. Griffin *et al.* 1982, Enroth 1995). *Cyptodontopsis* is monospecific (Rao & Enroth 1999).

Genus *Cyptodontopsis* Dixon

Ann. Bryol. 9: 64. 1937.

Cyptodontopsis leveillei (Thériot) P. Rao & Enroth

Bryobrothera 5: 185. 1999. – *Cryphaea leveillei* Thér., Le Monde des Plantes sér. 2, 9(45): 22. 1907.

Cryphaea henryi Thér. in Henry, Rev. Bryol. n. ser. 1: 44. 1928. – Synonymized by Rao & Enroth (1999).

Cryphaea obtusifolia Nog., J. Sci. Hiroshima Univ., Ser. B., Div. 2: 3, fig. 2. 1936. – *Cyptodontopsis obtusifolia* (Nog.) Nog., J. Jap. Bot. 17: 211. 1941. – Synonymized by Rao & Enroth (1999).

Cryphaea borneensis Bartr., Philippine J. Sci. 61: 244, fig. 4. 1936. – Synonymized by Rao & Enroth (1999).

Cyptodontopsis laosiensis Dix., Ann. Bryol. 9: 64. 1937. – *C. obtusifolia* var. *laosiensis* (Dix.) Nog., J. Jap. Bot. 17: 211. 1941. – Synonymized by Rao & Enroth (1999).

Other illustrations: Noguchi 1941 (fig. 16 as *Cyptodontopsis obtusifolia* var. *laosiensis*, fig. 17 as *C. laosiensis*), 1989: 627 (fig. 278A as *Cyptodontopsis obtusifolia*); Enroth 1990: 182 (fig. 2 a–f as *Cyptodontopsis obtusifolia*); Rao & Enroth 1999: 187 (fig. 6).

The world distribution of *Cyptodontopsis leveillei* is based on very few herbarium collections. Specimens have been obtained from several Asian countries and nearby areas including China, Indonesia, Japan, Laos, Malaysia, New Guinea and Vietnam (Bartram 1936, Dixon 1937, Noguchi 1941, Noguchi & Iwatsuki 1989, Enroth 1990, Akiyama 1992, Rao & Enroth 1999, Zhang & He 2011). The first collections obtained from several of these areas were initially described as new species of *Cryphaea*. Dixon (1937) created the genus *Cyptodontopsis* to accommodate a specimen collected by A.F.G. Kerr in 1932 from Laos he viewed as distinct from *Cryphaea*. Rao & Enroth (1999) concluded that four taxa, three of which were known only from type specimens, actually represent a single species and placed these names in synonymy (see above). However, a moss requiring seasonal or periodic submersion as a rheophyte is an unlikely candidate to have such a wide-ranging distribution pattern coupled with being so rarely encountered. Rheophytes often have restricted ranges but within their specific geographic range they are generally common. Currently there are thousands of kilometers between the occurrences of *Cyptodontopsis*.

In China, *Cyptodontopsis leveillei* was initially described as *Cryphaea leveillei* based on a single collection by J. Cavalerie obtained in 1903 from neighboring Guizhou Province. This species was known only from the type specimen (Zhang & He 2011). The Nu Jiang *Cyptodontopsis* collections are the first ones obtained in China in over 100 years. Since the majority of rheophytes in the Nu Jiang occur on rock walls and boulders, we were especially interested in a moss that was attached to small diameter stems of hardwood shrubs and branches along the high water level of the river bank.

Along the disturbed banks of the Nu Jiang

several shrubs are periodically flooded and partially submerged by flood waters primarily during the monsoon season. The most common shrubs along the high water zone of the Nu Jiang supporting populations of *Cyptodontopsis leveillei* are *Photinia arguta* (see Figs. 1, 2), *Ficus ischnopoda*, and to a lesser extent, *Cotoneaster turbinatus*. *Cyptodontopsis leveillei* is commonly attached to stems and branches of these shrubs that are periodically submerged primarily during the monsoon season. Older *Cyptodontopsis* plants can form pendulous branches by which they can move readily with the current when submerged. *C. leveillei* displays a pendant growth form on small diameter stems and branches of shrubs rarely exceeding 2–3 m in height. These same shrubs just above the high water level were devoid of *Cyptodontopsis*. Seasonal submersion of *Cyptodontopsis* forms one of the narrowest potential habitats along the Nu Jiang for any rheophytic species. We did not locate any *Cyptodontopsis* on rocks adjacent to these shrubs within the flood plain. Much of the Nu Jiang has been impacted. Large areas have been farmed and adjacent forests have been converted to agriculture or are in various stages of secondary forest recovery. Many non-native trees of economic importance, especially tung oil trees (*Aleurites*) have been planted along the river banks. In addition, the Nu Jiang supports many towns and villages. Only this narrow strip of land directly influenced by the Nu Jiang remains intact, even though highly disturbed by seasonal flooding and deposit of fine silt.

Cyptodontopsis leveillei is a rather unusual species in being both epiphytic and rheophytic. Along the banks of the Nu Jiang epiphytic bryophytes are rather uncommon. It is due to hot summer months coupled with past conversion of forests to agricultural fields. Bryophytes occurring on hardwood trees along the river bank are primarily appressed to the bark substratum, whereas *C. leveillei* displays a pendant growth form. We speculate that the periodic inundation and submersion during the summer monsoon season probably contributes markedly to its survival. Compared to many rheophytic monospecific genera where sporophytes remain un-

known, *Cyptodontopsis*, being autoicous, produces sporophytes frequently. This suggests that new populations of *C. leveillei* rely primarily on wind-dispersed spores, and a dry period may be necessary for its population expansion and maintenance. In addition, vegetative colonization likely occurs when pendulous branches are cast adrift during peak river flows and become entangled on shrub branches downstream.

As stated above, *Cyptodontopsis* produces sporophytes frequently. So why is *Cyptodontopsis* so rarely encountered or collected? Obviously bryologists have not been looking for it extensively in the narrow habitat conditions it requires. In herbaria, the majority of *Cyptodontopsis* collections were collected from Japan and labeled as *C. obtusifolia* (Nog.) Nog. and distributed widely as part of various exsiccati sets (see below). In Japan the habitat is given as *Rhododendron* branches along water courses (Noguchi 1989) while other collections are from *Salix* trunks or branches. The Japan occurrences represent the northeastern extension of the range. However, no collections of *Cyptodontopsis* have yet been obtained from either the Philippines or Taiwan (province), a likely pathway from either New Guinea or Borneo to Japan. We anticipate that at least in southwest China additional occurrences of *Cyptodontopsis* are likely to be encountered through focused surveys along river flood plain habitat containing shrub cover.

Exsiccata

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Chinese specimens

Guizhou Province (see Rao & Enroth 1999, Zhang & He 2011). **Yunnan Province.** Nu Jiang, Fugong County: Gaoligong Shan Range, southern end of the Hengdian Shan. Nu Jiang (Salween River) watershed. Footbridge across river from Aludi Village, 4.5 km south of Yaping Bridge, 27°05'57.8"N, 98°52'20.12"E, 1200 m, on *Photinia* branches, 23.IV.2004 *Shevock 24984* (CAS, E, H, KUN, MO, NY, PE, TNS); footbridge at km marker 290.8 c. 35 km north of Yaping Bridge near Majimi Village, 27°23'46.7"N, 98°49'40.1"E, 1360 m, scattered secondary hardwood forest at high water mark of river with shrubs and ferns, pendulous on *Photinia* branches, 28.IV.2004 *Shevock 25181* (CAS, E, FH, H, KUN, MO, NY, PE); Maji Xiang, west river bank of Nu Jiang about 40 km south of Gongshan at Budaga Bridge, 27°28'05"N, 98°50'01"E, 1370 m, on branch of *Cotoneaster turbinatus*, seasonally submerged, 20.IX.2013 *Ma, Shevock & Yao 13-5136* (CAS, HIRO, KUN, TNS) and on *Photinia* and *Ficus* branches, *Shevock, Ma & Yao 43329* (CAS, CONN, GNUB, H, HYO, KRAM, KUN, MO, NY, PE, SZG, TAIE); Liming Village, near Mukeji hydroelectric power station, east bank of Nu Jiang, 27°20'18"N, 98°51'01"E, 1320 m, on branch of *Photinia arguta* in a seasonally flooded zone of river, 20.IX.2013 *Ma, Shevock & Yao 13-5142* (CAS, GUNB, KUN); Shiyueliang (Stone Moon) Xiang, Jiangqiao Village, near Fandi Bridge, 27°14'11"N, 98°53'40"E, 1294 m, on stem of *Photinia arguta* in a seasonally flooded zone of river, 20.IX.2013 *Ma, Shevock & Yao 13-5143* (CAS, KUN, SZG); off highway S-228 between km marker 265–266, bridge at Jiang Qiao Village, 1 km from Mieluosheng, 27°14'13.3"N, 98°53'30.6"E, 1275 m, 20.IX.2013 *Shevock, Ma & Yao 43336* (CAS, H, KUN, MO); Zilijia Xiang, west river bank of Nu Jiang near Zilijia Bridge, 26°43'06"N, 98°53'36"E, 1130 m, on fine twigs of *Ficus ischnopoda* in seasonally flooded zone of river, 22.IX.2013 *Ma, Shevock & Yao 13-5190* (CAS, HSNU, KUN) and *Shevock, Ma & Yao 43373* (CAS, KUN); Lushui County: Wulong He (river), tributary of the Irrawaddy



Fig. 1. *Cyptodontopsis leveillei* on stems and branches of *Photinia arguta*. Photo by J.R. Shevock.



Fig. 2. Young *Cyptodontopsis leveillei* plants on primary stem of hardwood shrub in early stages of pendant growth. Photo by J.R. Shevock.

River, floodplain of river at border with Myanmar, 6.9 km south of Gongfan crossing and 25.5 km from Pianma, 26°05'42"N, 98°35'07"E, on branches of rosaceous shrub, 1550 m, 12.V.2005 *Shevock 26567* (CAS, E, H, KUN, MO, PE, TAIE, TNS).

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