New record of *Bonnosukea serrulata* (Cardot & P. de la Varde) H. Akiyama (Pylaisiadelphaceae) from Taiwan, with quantitative morphological documentation

SUN, CHENG-HAN[1], TSENG, YEN-HSUEH[2] & YANG, JIA-DONG[3]

[1]*Department of Forestry, National Chung Hsing University, 145 Xingda Rd., South Dist., Taichung City, 402202, Taiwan (R.O.C.)* alen8753@gmail.com

[2]*Taiwan Forestry Research Institute, No. 53, Nanhai Rd., Zhongzheng Dist., Taipei City, 100051, Taiwan (R. O. C.)* tseng2005@nchu.edu.tw *(Corresponding author)*

[3]*Taiwan Biodiversity Research Institute, 1, Ming-Shen East Road, JiJi Township,552005, Taiwan (R.O.C.)* jdyang@tbri.gov.tw

Abstract: Sun, Cheng-Han, Tseng, Yen-Hsueh & Yang, Jia-Dong (2026): New record of *Bonnosukea serrulata* (Cardot & P. de la Varde) H. Akiyama (Pylaisiadelphaceae) from Taiwan, with quantitative morphological documentation. *Frahmia* 48: 1- 7.*

A pylaisiadelphaceous moss collected during a bryological survey in central Taiwan was identified as *Bonnosukea serrulata* (Cardot & P. de la Varde) H. Akiyama based on detailed morphological comparison and quantitative measurements of leaf and laminal cell characters with published descriptions. This represents the first confirmed record of the genus *Bonnosukea* H. Akiyama and its sole species in Taiwan, extending the known distribution of this recently established lineage.

1. Introduction

The monotypic moss genus *Bonnosukea* H. Akiyama was established by Akiyama (2019) based on combined morphological and molecular evidence (*rps*4, *trn*L-F, and *rbc*L genes), representing a distinct lineage formerly included within *Clastobryum* Dozy & Molk. The sole species, *B. serrulata* (Cardot & P. de la Varde) H. Akiyama, is known from South Asia, Southeast Asia, and Japan, where it occurs epiphytically on tree trunks in temperate forests (Akiyama 2019). Despite its recent generic recognition and broad Asian distribution, the presence of *Bonnosukea* and its species *B. serrulata* in Taiwan has not been documented in the regional moss flora.

During a recent field survey in Sun-Link Sea (Nantou County, central Taiwan), specimens were collected that superficially resembled species of *Aptychella* (Broth.) Herzog in overall habit, owing to their slender, creeping, and terete-foliate secondary shoots. However, detailed microscopic examination revealed a suite of characters—such as distinctly serrulate leaf margins extending to the base, oblong-lanceolate leaves often contorted at the apex, and well-developed alar cells arranged in a scalariform pattern—that closely correspond to the diagnostic features of *B. serrulata*.

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Akiyama (2019) noted that plants of *Bonnosukea* are morphologically similar to those of *Clastobryellina* (M. Fleisch.) H. Akiyama, particularly *C. merrillii* (Broth.) H. Akiyama, sharing features such as terete-foliate secondary shoots and distinctly serrulate leaf margins extending to the base. This documented resemblance highlights the need for careful morphological assessment when evaluating specimens referable to these genera.

To further assess the taxonomic identity of the Taiwanese material, a series of quantitative morphological measurements was conducted, including leaf dimensions, leaf shape indices, and laminal cell measurements from different regions of the leaf. These data were evaluated in comparison with published descriptions to determine whether the observed variation falls within the circumscription of *B. serrulata*. The overall combination of qualitative characters and quantitative traits was found to be most consistent with *B. serrulata* as defined by Akiyama (2019).

In the present study, we provide the first confirmed record of the genus *Bonnosukea* and its sole species, *B. serrulata*, in Taiwan, thereby extending the known distribution of this recently recognized lineage and contributing new morphological documentation to the regional bryoflora of Pylaisiadelphaceae.

2. Material and Methods

Specimen collection and microscopic examination

Specimens examined in this study were collected from tree trunks at Sun-Link-Sea Forest Recreation Area, Nantou County, central Taiwan (approximately 1,660 m a.s.l.; N 23°38′01.4″, E 120°47′25″). Voucher specimens are deposited under the collection number *C.-H. Sun 2923* (TAIE). Most morphological observations were conducted using rehydrated material. Leaves were carefully detached from shoots under a dissecting microscope (LEICA MZ125) and mounted on glass slides using Hoyer's solution following Anderson (1954). Micromorphological observations and image documentation were carried out using a compound light microscope (ZEISS Axio Imager.A2) equipped with an Axiocam 712 color camera. Images were captured using 2.5×, 5× and 40× objective lenses with appropriate adjustments to focus and illumination. Leaf arrangement on intact shoots was additionally documented using a digital microscope (Keyence VHX-7020).

Leaf-level measurements

To document leaf size and shape variation in the examined Taiwanese specimen, leaf-level measurements were conducted on gametophytic leaves following the parameters summarized in Table 1. For each shoot, 10 mature, intact, and undamaged leaves were randomly selected. The following leaf-level traits were measured: leaf length (LL), defined as the linear distance from the midpoint of the leaf base to the distal end of the apex; leaf width (LW), measured as the maximum transverse width of a fully flattened leaf; the length-to-width ratio (L/W), used as an index of leaf slenderness; the position of maximum leaf width (Wp), measured as the distance from the leaf base to the point of maximum width along the longitudinal axis; and the relative width position (reWp), calculated as Wp divided by LL.

Laminal cell measurements

To characterize laminal cell variation along the leaf axis, three leaves were randomly selected from the measured leaf set for cellular-level analysis. Each leaf was subdivided into five regions corresponding to those summarized in Table 1: apical (A), subapical (SA), middle (M), basal (B), and alar (Al). From each region, ten cells were randomly selected and measured for cell length (CL) and cell width (CW), and the corresponding length-to-width ratio (CL/CW) was calculated. Alar cells were treated as a distinct category due to their clear structural differentiation from adjacent laminal cells.

Comparative morphological analysis and character selection

Comparative morphological analyses were conducted to evaluate the taxonomic identity and name application of the examined Taiwanese specimen. Quantitative leaf- and laminal cell measurements were obtained from the present material using the measurement protocol described above and were used as original data for comparison. Character selection and comparative assessment were based primarily on the published descriptions and diagnostic

characters of *Bonnosukea serrulata* and *Clastobryellina merrillii* provided by Akiyama (2019). Because sporophytes were not observed in the field-collected Taiwanese material, the comparison focused exclusively on gametophytic characters. These include overall plant habit, secondary stem length, leaf dimensions (length × width), leaf shape, degree and extent of leaf margin serrulation, costa development, laminal cell length and wall ornamentation, alar cell differentiation and arrangement, and the morphology of filamentous gemmae.

Measurement calibration and data presentation

All leaf- and cell-related measurements were performed on calibrated digital images using ImageJ version 8 after scale conversion. Measurements of the Taiwanese specimen are presented as observed ranges, means, and standard deviations. Quantitative data derived from leaf- and cell-level measurements form the basis for the comparative morphological characters summarized in Table 2.

3. Results & Discussion

Leaf measurements

Leaves of *B. serrulata* (*C.-H. Sun 2923*, TAIE) are lanceolate to narrowly lanceolate and moderately slender in outline (Table 1). Quantitative measurements indicate relatively limited variation in overall leaf proportions, with leaf length consistently exceeding width by approximately three to four times. The position of maximum leaf width is variable but generally located in the proximal to median part of the lamina, as reflected by both absolute and relative width position indices. This pattern suggests a stable leaf outline characterized by a slightly broadened lower to middle lamina rather than a strictly basal or median expansion.

Table 1. Leaf and laminal cell measurements of *Bonnosukea serrulata* (Cardot & P. de la Varde) H. Akiyama from Taiwan (*C.-H. Sun 2923*, TAIE).

	Range	**Mean ± SD**
LL × LW; L/W	1.38–1.87 × 0.43–0.54; 2.7–4.1	1.62 ± 0.18 × 0.48 ± 0.04; 3.39 ± 0.45
Wp	0.2–0.8	0.39 ± 0.2
reWp	0.08–0.53	0.25 ± 0.15
A CL × CW; CL/CW	32.3–55.0 × 3.79–6.38; 5–14	42.51 ± 8.49 ×5.29 ± 0.75; 8.66 ± 1.97
SA CL × CW; CL/CW	34.8–60.6 × 3.43–5.39; 6–23	49.62 ± 7.90 ×4.67 ± 0.62; 13.00 ± 3.13
M CL × CW; CL/CW	59.0–88.1 × 3.43–6.12; 12–24	73.08 ± 9.13 ×4.74 ± 0.99; 17.41 ± 3.56
B CL × CW; CL/CW	53.3–97.3 × 3.48–5.69; 12–30	82.66 ± 11.96 ×4.31 ± 0.73; 18.91 ± 4.07
Al CL × CW; CL/CW	7.13–17.67 × 10.54–18.10; 0.5–2.3	11.33 ± 3.66 ×15.35 ± 2.33; 1.02 ± 0.41

Leaf-level measurements include leaf length (LL, mm), leaf width (LW, mm), length-to-width ratio (L/W), position of maximum leaf width measured from the leaf base (Wp, mm), and relative position of maximum leaf width (reWp = Wp / L). Laminal cell measurements are given for different leaf regions: apical (A), subapical (SA), middle (M), basal (B), and alar (Al) cells. For each region, cell length (CL, µm), cell width (CW, µm), and cell length-to-width ratio (CL/CW) are presented. Values are shown as observed ranges followed by mean ± standard deviation.

Laminal cell measurements

Laminal cells exhibit a clear and continuous longitudinal differentiation along the leaf axis (Table 1). Cell elongation increases progressively from the apical to the basal regions of the lamina, resulting in a marked gradient

in length-to-width (L/W) ratios. Apical and subapical cells are relatively short and weakly elongate, whereas middle and basal laminal cells are distinctly elongate, with substantially higher L/W ratios. This gradual transition in cell shape contributes to the overall slender appearance of the lamina. Alar cells are sharply differentiated from laminal cells by their short length, greater width, and low L/W ratios. Their scalariform arrangement and contrasting proportions form a conspicuous alar region, which is consistent with the diagnostic features of *B. serrulata* and supports the taxonomic identification of the Taiwanese material.

Intra-leaf variation

Although moderate variation in cell dimensions is observed among different leaves, the overall pattern of laminal cell differentiation remains consistent. In all examined leaves, cell length increases gradually from the apical to the basal regions, whereas cell width shows comparatively less variation. Alar cells consistently differ from laminal cells by their shorter length, greater width, and lower L/W ratio.

Table 2. Comparison of diagnostic morphological characters among the Taiwanese specimen of *Bonnosukea serrulata* (Cardot & P. de la Varde) H. Akiyama (*C.-H. Sun 2923*, TAIE), *Clastobryellina merrillii* (M. Fleisch.) H. Akiyama, and *B. serrulata* based on published descriptions (Akiyama 2019).

Character	*C. -H. Sun 2923*	*C. merrillii*	*B. serrulata*
1. Plant appearance	light green to yellowish green, with glossy	Yellowish green, not shiny	Green, older specimen shiny-brown
2. Secondary stems	5–25 mm, often curved when dry	3–6 mm, creeping to patent, often weakly curved	up to 5 mm, often curved when dry
3. Leaf length × width (mm)	1.38–1.87 × 0.43–0.54	0.6–0.9 × 0.15–0.25	1.0–1.6 ×0.2–0.3
4. Leaf shape	oblong-lanceolate, long-cuspidate, apex often contorted	ovate-oblong to shortly lanceolate, acute to acuminate	linear-lanceolate, long-cuspidate, apex often contorted
5. Leaf margins	distinctly serrulate to the base	distinctly serrate to the base	distinctly serrulate to the base
6. Costa	usually absent, or faint double	absent	usually absent, or faint double
7. Upper laminal cell length (µm)	30–50	20–30	30–40
8. Median laminal cell length (µm)	60–85	50–60	60–85
9. Laminal cell	walls obscure, median sometimes minutely prorate	smooth, plane (not prorate)	walls obscure, median sometimes minutely prorate
10. Alar cells	well-developed, quadrate-short-rectangular, scalariform, thick-walled	well-developed, quadrate-rectangular, scalariform, thick-walled	well-developed, quadrate-short-rectangular, scalariform, thick-walled
11. Filamentous gemmae	0.6-0.9 mm, cells distinctly mammillose throughout	0.5–0.8 mm; cells smooth–moderately mammillose	to 1 mm; cells distinctly mammillose throughout

Comparison with related taxa (Table 2)

The Taiwanese specimen (*C.-H. Sun 2923*, TAIE) shares several diagnostic characters with *B. serrulata* as described by Akiyama (2019), including oblong- to linear-lanceolate leaves with a long-cuspidate apex, distinctly serrulate leaf margins to the base, and mostly absent or faint double costae. Laminal cells have obscure walls, with median cells sometimes minutely prorate, and well-developed alar cells that are quadrate to short-rectangular, scalariform, and thick-walled. In contrast, *C. merrillii* differs by its smaller leaves (0.6–0.9 × 0.15–0.25 mm), ovate-oblong to shortly lanceolate leaf shape, smooth laminal cell surfaces, and distinctly serrate margins. Filamentous gemmae of the Taiwanese specimen are 0.6–0.9 mm long with cells distinctly mammillose throughout, differing from the shorter and less strongly mammillose gemmae of *C. merrillii*. Overall, the combination of leaf size, leaf shape, laminal cell dimensions, alar cell structure, and gemma morphology in the Taiwanese material corresponds well with published descriptions of *B. serrulata* and clearly distinguishes it from morphologically similar taxa.

4. Taxonomic treatment

Bonnosukea serrulata (Cardot & P.de la Varde) H. Akiyama. Figure 1.

Basionym: *Clastobryum serrulatum* Cardot & P. de la Varde, Rev. Bryol. 50: 75. 1923. ≡ *Aptychella serrulata* (Cardot & P.de la Varde) Broth., Nat. Pflanzenfam. (ed. 2) 11: 535. 1925. Type: INDIA, Maduri, kodaikanal, Mai 1909, J. Gilbert André 103 (holotype, PC; isotype, PC), erroneously cited as a synonym of *Aptychella speciosa* (Mitten 1859: 95) Tixier (1977: 423) by Tixier (1977) *fide* Akiyama (2019).

Description: See comprehensive description in Akiyama (2019)

Distribution & habitat: *Bonnosukea serrulata* is distributed in South India, northern Thailand, Vietnam, Laos, Indonesia (Java), and Japan (Akiyama 2019), and is here recorded from Taiwan. In Taiwan, the species grows epiphytically on tree trunks in temperate to montane forests. The Taiwanese specimen was collected from a mesic trunk of *Fraxinus griffithii* along a forest trail under relatively open light conditions.

Previous illustration: Akiyama (2019, Fig. 8)

Etymology & Chinese name: The generic name is derived from a personal nickname (Akiyama 2019). The specific epithet *serrulata* refers to the distinctly serrulate leaf margins. Based on the diagnostic morphological characters of this species, a Chinese name, 齒葉格角苔 (chi ye ge jiao tai), is provided here. The proposed Chinese generic name is based on the characteristic scalariform alar cells, whereas the Chinese specific name is a direct translation of the Latin epithet.

Specimens examined: TAIWAN – Nantou County, Lugu Township, Sun-Link-Sea Resort, Chun-Lin trail (N 23°38′01″ E 120°47′25″, alt. 1660 m); *C.-H. Sun 2923*; TAIE.

Note: The Taiwanese specimen generally agrees well with the description of *Bonnosukea serrulata* provided by Akiyama (2019). However, slight deviations were observed in several quantitative characters. Leaves of the Taiwanese material are somewhat larger, measuring 1.38–1.87 × 0.43–0.54 mm, compared with 1.0–1.6 × 0.2–0.3 mm reported by Akiyama (2019). In addition, the upper laminal cell length in the Taiwanese specimen ranges from 30–50 μm, slightly extending the upper range previously reported (30–40 μm). At present, the species is represented in Taiwan by a single collection, and sporophytes have not been observed in the field. Further collections from additional localities or different seasons, particularly those bearing sporophytes, would be valuable for a more comprehensive understanding of the Taiwanese population.

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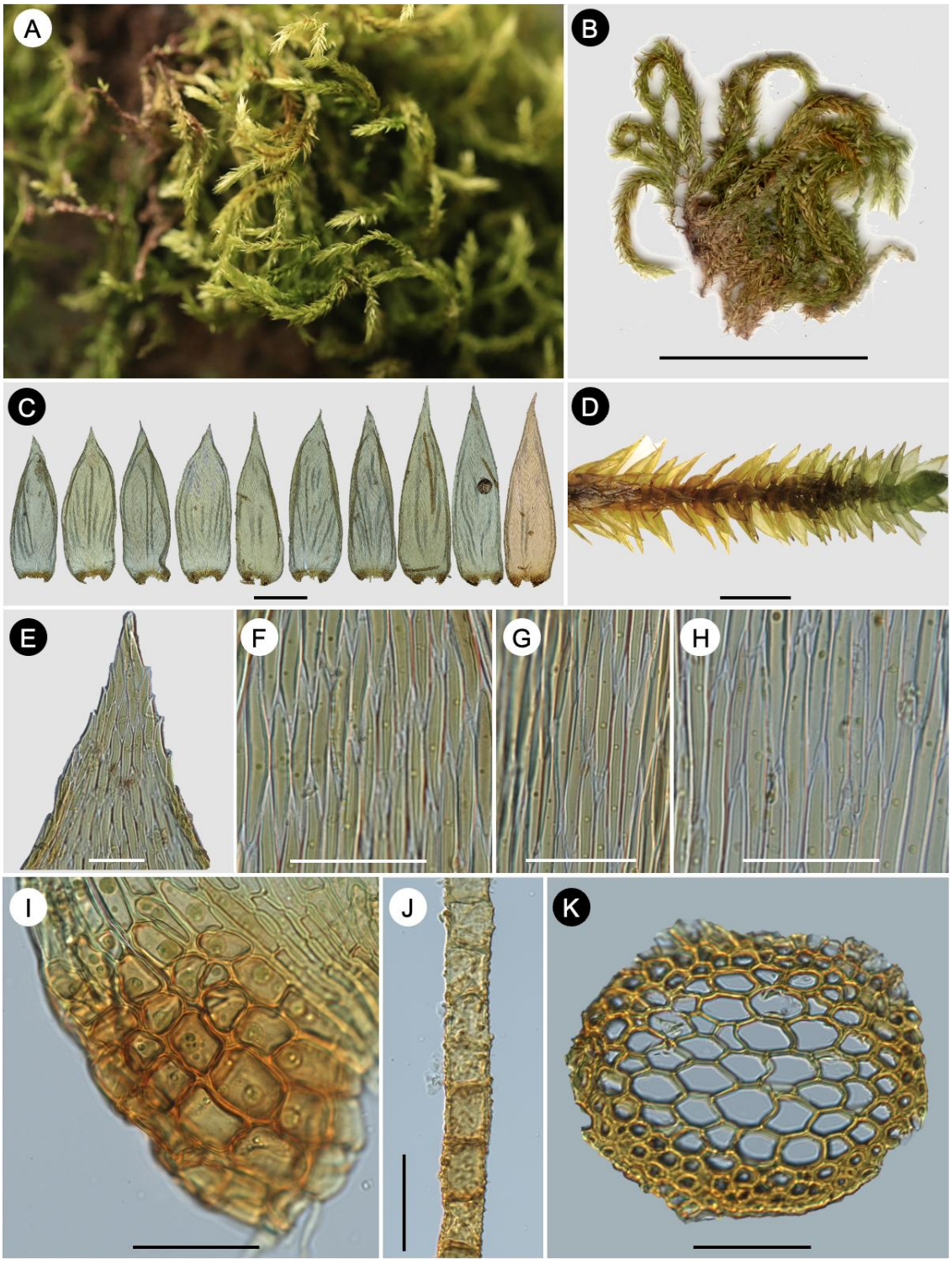

Figure 1. Illustrations of *Bonnosukea serrulata* (Cardot & P. de la Varde) H. Akiyama (based on *C.-H. Sun 2923* [TAIE]). A. habit; B. specimen; C. leaves; D. partial secondary shoot; E. leaf apex; F. subapical cells; G. median leaf cells; H. basal cells; I. alar region; J. asexual propagule. K. cross-section of secondary shoot. Scale bar: B = 1 cm; C = 0.5 mm; D = 2 mm; E-K = 50 µm.