Postprint: Morphological and Anatomical Observations on Stems and Leaves of Eight Calymperaceae Species from Hainan

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Abstract

Eight species of Calymperaceae mosses belonging to five genera native to Hainan Province were selected (Syrrhopodon armatus, Syrrhopodon involutus, Calymperes graeffeanum, Calymperes tenerum, Calymperes cucullatum, Calymperes serratum, Octoblepharum albidum, and Leucophanes candidum). Paraffin sectioning and scanning electron microscopy were employed to examine the morphological and anatomical structures of stems and leaves, as well as their surface micromorphology, from a morpho-anatomical perspective. Differences in morphological characteristics, internal anatomical structures, costae, and surface ornamentation were compared among these moss species to differentiate the eight Calymperaceae taxa. The results demonstrated that the stem and leaf anatomical structures of the eight species—including stem cross-sectional shape, presence or absence of central axis cell differentiation, number of cell layers, the number and position of central cells in leaf costa cross-sections, the degree of smoothness or roughness of dorsal and ventral cell surfaces, and the shape of chlorophyllose cells—all exhibited distinct differences. Stem cross-sections of the eight Calymperaceae species ranged from elliptical to circular; except for Octoblepharum albidum and Leucophanes candidum, which lack central cells in the costa, the remaining species possessed varying numbers of central cells, which were generally positioned in the center of the costa; Calymperes serratum exhibited numerous short longitudinal striations on the dorsal cell walls; only Octoblepharum albidum showed differentiation of central axis cells in its stem cross-sectional structure. These results have important taxonomic significance for distinguishing among moss genera and species, and can provide a foundation for the identification and classification of additional Calymperaceae species.

Full Text

Morphological and Anatomical Observation of Stems and Leaves of Eight Calymperaceae Species from Hainan

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Abstract: This study investigated the morphological characteristics and micromorphological structures of eight Calymperaceae species belonging to five genera native to Hainan Province: *Syrrhopodon armatua*, *Syrrhopodon involutus*, *Mitthyridium fasciculatum*, *Mitthyridium flavum*, *Calymperes moluccense*, *Calymperes afzelii*, *Octoblepharum albidum*, and *Leucophanes albescens*. Using paraffin sectioning and scanning electron microscopy, we examined internal anatomical structures of stems and leaves, comparing differences in costal morphology, cell surface ornamentation, and other features to distinguish among these species. The results revealed clear interspecific differences in stem and leaf anatomy, including stem cross-sectional shape, presence of axial cell differentiation, cell layer number, number and position of central main cells in the costa, surface roughness of dorsal and ventral cells, and shape of chlorophyllose cells. Stem cross sections ranged from elliptical to circular across all eight species. Except for *Octoblepharum albidum* and *Leucophanes albescens*, which lack central main cells in the costa, other species showed varying numbers of central main cells typically positioned at the costa' s center. *Calymperes afzelii* exhibited numerous short longitudinal striations on dorsal cell walls. Only *Octoblepharum albidum* showed differentiated axial cells in stem cross sections. These findings provide important taxonomic criteria for distinguishing genera and species within Calymperaceae and establish a foundation for identification and classification of additional species in this family.

Keywords: Calymperaceae; stem; leaf; morphological anatomy; taxonomy

Hainan Province lies at the southernmost tip of China. Diaoluo Mountain National Forest Park, located in southeastern Hainan Island at 18°43 -18°58 N, 109°43 -110°03 E, features a tropical maritime monsoon climate with abundant rainfall and humid conditions that support rich vegetation and diverse bryophyte communities. Bryophytes are relatively primitive higher plants with minute individuals and lack vascular tissue (Hu, 1987). In plant evolutionary history, they represent a transitional type from aquatic to terrestrial environments and serve as pioneers in extreme habitats (Jiang, 2009), playing important roles in maintaining ecological balance and exploring plant origin and evolution (Chen et al., 2013).

Bryophyte anatomical research began with specimen collection, identification, and classification. Because bryophytes are morphologically small, systematic classification based solely on external morphology is difficult. Consequently, researchers typically combine external morphological features with internal struc-

tural characteristics for comparison and differentiation, making morphological anatomy a scientific basis for bryophyte classification.

Over the years, scholars have conducted in-depth research on bryophyte morphology, classification, and flora, though studies on stem and leaf anatomical structure remain relatively limited. Several Chinese researchers have investigated bryophyte stem and leaf anatomy. From the 1960s to 1990s, Chen et al. (1963) summarized moss stem morphology and types, laying a foundation for subsequent research. Han (1999) studied seven Chinese Mniaceae species, concluding that leaf anatomical structure could serve as a taxonomic basis at the genus and species levels. Wang (2002) used paraffin sectioning and SEM to examine five Grimmiaceae species, finding that despite belonging to the same family, different species showed variations in stem and leaf internal structure, leaf cuticle ornamentation, and cell folds. Wang (2008) compared the structures of four moss species from the perennially cold Glacier No. 1 region, noting significant differences in stem and leaf internal structure among species and suggesting that anatomy provides scientific evidence for moss taxonomy. Sha et al. (2008) compared morphological anatomy of Chinese *Lyellia* species, finding that obvious stomata in Polytrichaceae represent an evolutionary trait while spore wall ornamentation is primitive, providing taxonomic evidence. Jiang (2010) observed different stem segments of seven moss species, discovering that shape variation from stem base to apex is gradual and related to rhizoid presence and leaf insertion position. Wang et al. (2014) studied Pottiaceae anatomy, finding that stem and leaf cell walls differed significantly among species, providing important taxonomic criteria for genus and species identification. Abuduaini and Wang (2016) analyzed stems of ten *Bryum* species from the Urumqi River source area, finding that stem cell surface cuticle ornamentation was mostly scaly or granular—likely survival strategies in harsh environments that reveal typical characteristics of strong cold and drought resistance. However, research on Calymperaceae stem and leaf structure remains scarce in China.

Calymperaceae represents an important component of haplolepideous mosses. The family comprises approximately 357 species across eight genera worldwide, with China recording only 35 species and two varieties in six genera (Jia and He, 2012). Due to numerous established taxa within this large and variable family, its systematic position, generic boundaries, and defining criteria have remained controversial, with frequent repositioning between Pottiales and Dicranales.

The term Calymperaceae first appeared in Müller' s *Synopsis* as a subtribe including *Encalypta*, *Calymperes*, and *Syrrhopodon* (Fisher et al., 2007). Kindberg (1897) established Calymperaceae at the family level but included only *Calymperes*, placing *Syrrhopodon* in Pottiaceae. Brotherus (1924) reintegrated Calymperaceae and Syrrhopodontaceae, retaining Calymperaceae with five genera: *Syrrhopodon*, *Calymperes*, *Calymperopsis*, *Thyridium* (now *Mitthyridium*), and *Hypodontium*, while removing *Leucophanes*. In Brotherus' s system, Calymperaceae belonged to Pottiales, preceding Dicranales. Vitt (1984) also placed Calymperaceae in Pottiales but before Dicranales. As research progressed, many

scholars suggested merging Leucobryaceae with Calymperaceae and proposed the concept of *Leucophanes*, considering *Leucophanes*, *Octoblepharum*, and *Exodictyon* as Calymperaceae components (Andrews, 1947). La Farge et al. (2000) used three chloroplast gene fragments (rbcL, rps4, trnL-F) to study Calymperaceae phylogeny, finding that *Octoblepharum* was closely related but should constitute a separate family, Octoblepharaceae, while *Leucophanes* and *Exostratum* nested within *Syrrhopodon* and should be included in Calymperaceae. Moreover, Calymperaceae and Octoblepharaceae were found in the same clade as Dicranaceae and Leucobryaceae, distinct from Pottiaceae in Pottiales, suggesting placement in Dicranales after Pottiales. Frey and Stech (2009) also placed Calymperaceae in Dicranales but considered *Octoblepharum* within Calymperaceae. Jia and He (2012) published *Species Catalogue of China Volume One: Bryophytes*, placing Chinese Calymperaceae in Dicranales before Pottiales, including six genera: *Syrrhopodon*, *Mitthyridium*, *Calymperes*, *Leucophanes*, *Octoblepharum*, and *Exostratum*. According to literature, *Octoblepharum* and *Leucophanes* are placed in Calymperaceae due to morphological similarities such as acute leaf apices, prominent costae, hyaline basal cells, gemmae at leaf tips, and peristome features (Santos and Stech, 2016). Current Calymperaceae descriptions and research follow Jia and He' s (2012) classification.

This study uses eight Calymperaceae species from five genera collected in Diaoluo Mountain, Hainan, for morphological anatomical and SEM observation to provide scientific evidence for Calymperaceae classification.

1.1 Experimental Materials

Eight Calymperaceae species from five genera collected in Diaoluo Mountain, Hainan, served as experimental materials (Table 1).

Paraffin sectioning was used to observe stem and leaf anatomical structures. Materials were cleaned and fixed in FAA solution (formalin:acetic acid:ethanol, 18:1:1) for 24 hours, then dehydrated through an ethanol gradient (50%, 70%, 85%, 95%, 100%) for two hours each. Samples were stained with 1% safranin and 0.5% fast green mixture for 24 hours at 42°C, cleared in xylene, embedded in paraffin, and sectioned at 10 m thickness (Shanghai Medical Equipment Factory). Sections were dewaxed in xylene twice (5 minutes each) and mounted with neutral balsam. Slides were observed and photographed under an Olympus BX43 microscope (Tokyo, Japan) with a DP74 CCD using CellSens Entry software for image acquisition.

Scanning electron microscopy was used to observe stem and leaf surface structures. After rehydration, materials were cleaned with a KQ3200DE ultrasonic cleaner. Stems and leaves were separated and fixed in FAA solution, dehydrated through the same ethanol gradient (two hours each), mounted on stubs, sputter-coated after drying, and observed under an S-4300 SEM (Hitachi, Japan) with images retained.

2.1 *Syrrhopodon armatua*

Plants are small, dark brownish-green. Leaves are long-lanceolate with involute margins; the sheath margin bears 4–8 long, curved cilia (Plate I:1–4). The costa extends to the leaf apex, with spines on both dorsal and ventral surfaces and single papillae. Upper leaf green cells are rounded-square, with convex-rounded junctions between green and hyaline cells. The costa contains four central main cells that are large and thin-walled, with similar dorsal and ventral epidermal cells; dorsal small thick-walled cell layers slightly outnumber ventral layers, with water-conducting main cells basically central (Plate II:1). Ventral leaf cell surfaces are rough with irregular longitudinal striations and mammillose papillae; the costa bears spines. Dorsal leaf surfaces have longer costal spines, with smooth basal cells (Plate IV:1–2). The stem cross-section is nearly circular with irregular polygonal cells. The epidermis comprises one layer of small, rectangular or irregular hexagonal cells. The cortex shows no differentiation between inner and outer layers, with 2–3 layers of large thin-walled irregular polygonal cells interspersed with small cells; cell walls are notably thickened, without axial differentiation (Plate III:1). Dry stems have rough, twisted surfaces with rhizoid hairs (Plate IV:3).

2.2 *Syrrhopodon involutus*

A small moss with soft, grayish-white to light green plants. Stems are highly branched and erect. Leaves are dense, loose when dry, not curled, ovate-lanceolate with short acute apices and entire margins. Hyaline cells extend nearly to the leaf apex. The costa is slender, reaching or exceeding the leaf apex (Plate I:5–8) with fine papillae on the dorsal side. Costa cross-sections have 1–2 central main cells with slightly thickened dorsal and ventral cell walls. Leaf cells are large and transparent, gradually decreasing near margins (Plate II:2). Ventral surfaces are relatively smooth with strongly depressed costal cells in regular rectangular arrangement; dorsal surfaces are smooth with protruding costae and elongated cells (Plate IV:4–5). Stem cross-sections are nearly pentagonal with one layer of small epidermal cells. The cortex shows no inner-outer differentiation, possessing two layers of large thin-walled irregular polygonal cells without axial differentiation (Plate III:2). Dry stems are twisted with smooth surfaces and variously depressed cell walls (Plate IV:6).

2.3 *Mitthyridium fasciculatum*

Yellowish-green with brownish base. Main stems are prostrate, densely covered with reddish-brown rhizoids at the base, slightly curved when dry. Leaves are broadly lanceolate with slight waves; sheaths are broad, tapering upward. Leaves with gemmae have rounded-obtuse or mucronate apices; green and hyaline cells are interlocked in a flat-wave pattern (Plate I:9–12). Costa cross-sections are dorsally convex with 3–4 central main cells; dorsal cells are small while ventral cells are larger, with 3–7 layers of dorsal thick-walled cells outnum-

bering ventral layers; water-conducting main cells are basically central (Plate II:3). Ventral leaf cell surfaces are rough with depressed walls, densely covered with irregular papillae and few costal protrusions and longitudinal striations; dorsal surfaces are rough with forked papillae and long longitudinal striations on the dorsally convex costa (Plate IV:7–8). Stem cross-sections are nearly elliptical with one epidermal layer internally composed of large thin-walled cells interspersed with small cells, without obvious inner-outer cortex differentiation or axial cell differentiation (Plate III:3). Stem surfaces are relatively smooth with shallow cell wall depressions (Plate IV:9).

2.4 *Mitthyridium flavum*

Densely tufted, relatively small moss. Stem apices have inconspicuous flagelliform short branches. Leaves are twisted when dry, extending from a short, broad, clasping base as ovate-broadly lanceolate with short apices; margins are erect and wavy, with cellular tooth projections above the middle. The costa disappears at the leaf apex; hyaline cells are irregularly trapezoidally inserted into green cells (Plate I:13–16). Costa cross-sections are dorsally convex with four central main cells; ventral epidermal cells are larger, with more dorsal small thick-walled cell layers than ventral layers; water-conducting main cells are positioned near the ventral side (Plate II:4). Ventral leaf cell surfaces are relatively rough with high mammillose projections on adjacent cell walls, few fine granules and papillae on the costa; dorsal surfaces are rough with dense mammillose papillae and long longitudinal striations on the costa (Plate IV:10–11). Stem cross-sections are nearly circular with 2–3 layers of thick-walled cells in epidermis and outer cortex, internally composed of large thin-walled irregular polygonal cells showing obvious inner-outer cortex differentiation but no axial cell differentiation (Plate III:4). Dry stems are twisted with mesh-like depressions on surface cell walls; adjacent cell walls are thick, some pressed into deep grooves (Plate IV:12).

2.5 *Calymperes moluccense*

Robust, densely tufted plants forming cushions, yellowish-green turning dark green with age. Stems are erect; leaves curve uniformly when dry, spreading erect when wet, gradually extending from extremely broad, ovate or obovate sheaths to broadly spatulate shapes. Leaf cells are round or irregularly polygonal with sharp single papillae dorsally and mammillose projections ventrally. The costa is strong, nearly reaching the leaf apex. Hyaline and green cells meet in a truncated or convex-rounded pattern, with 4–7 rows of guide cells on sheaths (Plate I:17–20). Costa cross-sections have 6–8 central main cells and dorsal-ventral thick-walled layers; dorsal-ventral cells are large but dorsal epidermal cells are slightly smaller than ventral ones, with main cells basically central (Plate II:5). Ventral leaf cell surfaces are relatively smooth but costae are rough with short longitudinal striations and small protrusions; dorsal surfaces are rough with dense regular small papillae, high mammillose projections

on adjacent cell walls mixed with papillae, and long spines on costae (Plate IV:13–14). Stem cross-sections are elliptical with 1–2 layers of thick-walled cells in epidermis and outer cortex, internally composed of large thin-walled irregular hexagonal cells without axial cell differentiation (Plate III:5). Dry stems are slightly twisted with relatively smooth surfaces; cells are variously depressed with thick adjacent cell walls (Plate IV:15).

2.6 *Calymperes afzelii*

Small yellowish-green moss turning brownish with age. Stems are erect and simple; leaves twist when dry, ovate-lanceolate with cellular tooth projections on margins. The costa reaches or exceeds the leaf apex; green cells are nearly square with fine papillae, meeting hyaline cells in an irregular trapezoidal pattern with 3–4 cells-wide guide rows (Plate I:21–24). Costa cross-sections have 6–8 central main cells with small dorsal-ventral cells; dorsal epidermal cells are slightly smaller than ventral ones, with numerous short longitudinal striations on dorsal cell walls and central main cells basically positioned medially (Plate II:6). Ventral leaf cell surfaces are relatively smooth with short, slightly protruding costal cells, sparsely mammillose cells with obvious intercellular spaces; dorsal costae are relatively smooth with striations in depressions; dorsal leaf surfaces are rough with small papillae (Plate IV:16–17). Stem cross-sections are nearly circular with 3–4 layers of small thick-walled cells in epidermis and outer cortex, internally composed of large thin-walled irregular polygonal cells without obvious axial cell differentiation (Plate III:6). Dry stems are slightly twisted with rectangularly arranged surface cells and thick adjacent cell walls (Plate IV:18).

2.7 *Octoblepharum albidum*

Grayish-green with slight gloss. Leaf bases are long-ovate, upper portions long-ligulate with short apices; margins are nearly entire, rarely minutely toothed. The costa is broad and thick, occupying nearly the entire leaf (Plate I:25–28). Costa cross-sections are dorsally convex with multilayered hyaline cells (1–4 layers dorsally, 2–5 ventrally) and a single layer of green cells positioned centrally or dorsally; basal cross-sections are quadrangular, upper ones triangular (Plate II:7). Ventral surfaces are relatively smooth with rectangularly arranged cells and long longitudinal striations; dorsal surfaces are slightly protruding and rough with strongly depressed cell walls, high adjacent cell walls in a pressed configuration (Plate IV:19–20). Stem cross-sections are circular with similar-sized epidermal and inner-outer cortex cells that are irregularly polygonal with slightly thickened walls. The axis has several differentiated cells, though differentiation is insufficiently obvious and similar in morphology to cortical cells but smaller (Plate III:7). Stem surfaces bear rhizoid hairs with thin cell walls variously depressed, sometimes pressed into deep grooves (Plate IV:21).

2.8 *Leucophanes albescens*

Plants are yellowish-green or grayish-white, densely tufted with erect, simple stems. Leaves are slightly wrinkled when dry, ovate-lanceolate with sharp acute apices; margins have many small teeth; the costa is broad and thin with a central thickened cell strand (Plate I:29–32). Costa cross-sections have a central yellowish thickened cell strand, with more hyaline cell layers dorsally (5–6 thick-walled layers) than ventrally (2–3 layers). Green cells in leaf cross-sections are quadrangular, single-layered throughout the leaf, positioned centrally within hyaline cells that are two-layered (Plate II:8). Ventral surfaces are relatively smooth with long folds in depressions; dorsal surfaces are slightly rough with strongly depressed cell walls, costal spines, and longitudinal striations (Plate IV:22–23). Stem cross-sections are nearly elliptical with 2–3 layers of small thick-walled cells in epidermis and outer cortex, internally composed of large thin-walled irregular polygonal cells interspersed with small cells, without obvious axial cell differentiation (Plate III:8). Dry stems are slightly twisted with thin cell walls showing mesh-like depressions; adjacent cell walls are relatively high and pressed, forming deep groove-like structures (Plate IV:24).

3 Discussion and Conclusion

Leaf tissue structure is significant in plant taxonomic research. Bryophytes lack true vascular tissue, absorbing water primarily through leaf-environment contact, while the costa supports the leaf. Its thickness and presence of water-conducting cells represent important indicators of water conduction capacity (Sha et al., 2008). The eight Calymperaceae species studied here share some similar leaf morphological features, such as acute leaf apices in most species, thick cell walls, single cell layers, and prominent costae—stable hereditary traits representing relatively primitive characteristics. However, distinct interspecific differences exist in leaf cells and costae, including presence/absence of central main cells in costal cross-sections, differentiation of dorsal-ventral epidermal cells, and chlorophyllose cell shapes in leaf cross-sections, all bearing important taxonomic significance at generic and specific levels. For example, *C. moluccense* and *C. afzelii* are congeneric species difficult to distinguish externally, but can be identified through anatomical structure and leaf surface spines or papillae: *C. moluccense* has larger dorsal-ventral cells, while *C. afzelii* has smaller dorsal-ventral cells with numerous short longitudinal striations on dorsal cell walls. Moreover, *C. moluccense* has four central main cells, whereas *C. afzelii* has 6–8 (Plate II:5–6; Plate IV:13–18). Similarly, *S. armatua* and *S. involutus* belong to the same genus but show obvious structural differences: *S. armatua* has four central main cells in costal cross-section, while *S. involutus* has 1–2; *S. armatua* has rough dorsal-ventral surfaces with costal spines, while *S. involutus* surfaces are smooth (Plate II:1–2; Plate IV:1–6). Although all have central water-conducting cells, each species differs in main cell size and distribution, enabling clear distinction. In leaf anatomical structure, all studied species except *O. albidum* have central main cells in costal cross-sections, indicating that

Calymperaceae can adequately absorb and retain water (Wang, 2002). Additionally, Calymperaceae species have numerous costal thick-walled cell layers, possibly related to their habitat, providing protection against strong winds (An et al., 2018; Wang, 2017). Longitudinal striations on leaf surfaces not only form protective layers and reduce water transpiration but also decrease bacterial invasion from the environment (Plate II:7; Plate IV:19–21) (Cai et al., 2007).

Stem anatomical structure is a commonly used taxonomic criterion in bryophytes. Our study of eight Calymperaceae species reveals obvious interspecific differences even within the same family or genus, including stem cross-sectional shape, cell size, axial differentiation, and degree of cell wall depression. For instance, *O. albidum* stems have differentiated axial cells (Plate III:7). *M. fasciculatum* and *M. flavum* belong to the same genus and are closely related, yet differ markedly: *M. fasciculatum* has nearly elliptical stem cross-sections with one epidermal layer, no obvious inner-outer cortex differentiation, relatively smooth surfaces, and shallow cell wall depressions (Plate III:3; Plate IV:7–9); *M. flavum* has nearly circular cross-sections with 2–3 layers of thick-walled cells in epidermis and outer cortex, obvious inner-outer cortex differentiation, mesh-like depressions on dry stem surfaces, thick adjacent cell walls, and some pressed into deep grooves (Plate III:4; Plate IV:10–12). Among the eight species, circular or elliptical stem cross-sections relate to water absorption (Yang et al., 2007). Epidermal cell walls show various degrees of thickening, which reduces water transpiration and maintains cellular water content (Zhang and Sun, 2014). Presence/absence of inner-outer cortex differentiation relates to cell metabolism (Cao, 2010), while such differentiation protects plants from strong winds and humid-heat environments, enhances conduction and support, and relates to water storage function (Zhan et al., 2006), representing environmental adaptations. Most moss stems are slightly twisted when dry, with variously depressed epidermal cell walls, high and thick adjacent walls, rough surfaces, and rhizoids that can fully absorb atmospheric moisture (Wang, 2014).

In summary, Calymperaceae species can be distinguished based on differences in stem and leaf morphological anatomy and surface micromorphology, including presence/absence of acute leaf apices; entire, toothed, or ciliate leaf margins; presence of costal spines; and characteristics of hyaline-green cell junctions. For example, *S. armatua* has ciliate leaf margins and obvious costal spines, while *S. involutus* lacks cilia and has smooth costae (Plate IV:1–6). Hyaline-green cell junctions differ: *C. moluccense* shows a truncated pattern, while *C. afzelii* shows a trapezoidal pattern. Additionally, presence/absence, distribution, size, and number of thick-walled cell layers of central main cells in costal cross-sections, plus dorsal-ventral spines or papillae, provide distinguishing features. Stem differences are also pronounced, enabling identification and classification through presence/absence of axial cell differentiation in stem cross-sections (e.g., *L. albescens* has elliptical stems while *O. albidum* has circular ones), cell layer number and size, degree of stem surface cell wall depression, and rhizoid hair presence. This study provides reference for further taxonomic

research at generic and specific levels within Calymperaceae and establishes a theoretical foundation for subsequent related scientific research.

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Plate I Morphological characteristics of plant and leaves of eight Calymperaceae species. 1. *Syrrhopodon armatua* (dry); 2. *S. armatua* (wet); 3. Full leaf of *S. armatua* (×40); 4. Leaf base of *S. armatua* (×100); 5. *Syrrhopodon involutus* (dry); 6. *S. involutus* (wet); 7. Full leaf of *S. involutus* (×40); 8. Leaf upper of *S. involutus* (×100); 9. *Mitthyridium fasciculatum* (dry); 10. *M. fasciculatum* (wet); 11. Full leaf of *M. fasciculatum* (×40); 12. Leaf central of *M. fasciculatum* (×100); 13. *Mitthyridium flavum* (dry); 14. *M. flavum* (wet); 15. Full leaf of *M. flavum* (×40); 16. Leaf base of *M. flavum* (×100); 17. *Calymperes moluccense* (dry); 18. *C. moluccense* (wet); 19. Full leaf of *C. moluccense* (×40); 20. Leaf base of *C. moluccense* (×100); 21. *Calymperes afzelii* (dry); 22. *C. afzelii* (wet); 23. Leaf upper of *C. afzelii* (×40); 24. Leaf base of *C. afzelii* (×100); 25. *Octoblepharum albidum* (dry); 26. *O. albidum* (wet); 27. Leaf upper of *O. albidum* (×40); 28. Leaf base of *O. albidum* (×40); 29. *Leucophanes albescens* (dry); 30. *L. albescens* (wet); 31. Leaf upper of *L. albescens* (×40); 32. Leaf base of *L. albescens* (×40)

Plate II Cross sections of leaves of eight Calymperaceae species by paraffin section. 1. *Syrrhopodon armatua* (×200); 2. *S. involutus* (×200); 3. *Mitthyridium fasciculatum* (×200); 4. *M. flavum* (×200); 5. *Calymperes moluccense* (×200); 6. *C. afzelii* (×200); 7. *Octoblepharum albidum* (×200); 8. *Leucophanes albescens* (×200)

Plate III Cross sections of stems of eight Calymperaceae species by paraffin section. 1. *Syrrhopodon armatua* (×200); 2. *S. involutus* (×200); 3. *Mitthyridium fasciculatum* (×200); 4. *M. flavum* (×200); 5. *Calymperes moluccense* (×200); 6. *C. afzelii* (×200); 7. *Octoblepharum albidum* (×200); 8. *Leucophanes albescens* (×200)

Plate IV SEM photographs of the stem and leaf surfaces of eight Calymperaceae species. 1. Ventral side of *Syrrhopodon armatua* (×1000); 2. Dorsal side of *S. armatua* (×600); 3. Stem surface of *S. armatua* (×300); 4. Ventral side of *Syrrhopodon involutus* (×1000); 5. Dorsal side of *S. involutus* (×1000); 6. Stem surface of *S. involutus* (×600); 7. Ventral side of *Mitthyridium fasciculatum* (×1000); 8. Dorsal side of *M. fasciculatum* (×1000); 9. Stem surface of *M. fasciculatum* (×300); 10. Ventral side of *Mitthyridium flavum* (×1000); 11. Dorsal side of *M. flavum* (×1000); 12. Stem surface of *M. flavum* (×300); 13. Ventral side of *Calymperes moluccense* (×1000); 14. Dorsal side of *C. moluccense* (×1000); 15. Stem surface of *C. moluccense* (×300); 16. Ventral side of *C. afzelii* (×1000); 17. Dorsal side of *C. afzelii* (×1000); 18. Stem surface of *C. afzelii* (×300); 19. Ventral side of *Octoblepharum albidum* (×1000); 20. Dorsal

side of *O. albidum* (×500); 21. Stem surface of *O. albidum* (×300); 22. Ventral side of *Leucophanes albescens* (×1000); 23. Dorsal side of *L. albescens* (×1000); 24. Stem surface of *L. albescens* (×300)

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