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Bryophyte species richness on Heritage Trees in Fort Canning Park, Singapore

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Abstract. In Singapore, Heritage Trees (HTs) are often large, old trees that provide stable substrates and may support diverse native epiphytic communities. However, bryophyte richness on mature trees in urban settings remains poorly studied. This study aims to document the epiphytic bryophyte species on selected HTs in Fort Canning Park, focusing on these culturally significant trees because their age, and substantial size provide microhabitats for epiphytes. Sampling of eight HTs yielded 16 unique bryophyte species, including eight from the liverwort family Lejeuneaceae and four from the moss family Calymperaceae, both being the most species-rich families in this study. Of the recorded bryophytes, two liverworts were classified as 'Endangered' and one moss as 'Vulnerable' in Singapore. The results of this study showed the importance of HTs as reservoirs of native bryophyte diversity in urban landscapes, contributing to knowledge about the ecological value of HTs and biodiversity conservation efforts in Singapore.

Key words. Bryophytes, Calymperaceae, Lejeuneaceae, liverworts, mature trees, mosses

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INTRODUCTION

Bryophytes are a diverse group of non-vascular land plants that, despite their small size, play important ecological roles by storing water, nutrients, and carbon in their biomass (Bahuguna et al., 2013). Comprising three phylogenetically distinct lineages, mosses, liverworts, and hornworts, bryophytes are among the earliest land plants, with origins dating back to at least the Late Silurian, about 419 million years ago (Gensel, 2008). They form the second most diverse group of land plants after angiosperms, with about 13,000 species of mosses, 7,500 species of liverworts, and 200 to 250 species of hornworts known (Von Konrat et al., 2010; Zhang et al., 2020; Glime, 2021). Studying bryophytes is thus essential for understanding embryophyte phylogeny, the clade encompassing all land plants, and understanding the adaptations that enabled their aquatic algal ancestors to colonise land.

Although bryophytes are commonly found in damp, shaded environments, they also inhibit extreme habitats, including Arctic, Antarctic, and alpine regions (Bahuguna et al., 2013). Many species are epiphytic, meaning they are nonparasitic plants that rely on other plants for structural support without drawing nutrients or water from their hosts (Nadkarni et al., 2013). As epiphytes, they depend strongly on the physical and chemical properties of their substrates, such as tree bark texture (Becker et al., 2019; Shao et al., 2023). Though these interactions with their substrates, bryophytes influence ecological processes such as in water retention, nutrient cycling, soil improvement, and serve as bioindicators of environmental conditions (Oishi & Hiura, 2017; Moore et al., 2018; Van Zuijlen et al., 2020; Glime, 2021).

Despite their ecological significance, bryophytes remain understudied compared to angiosperms, particularly in Singapore. Existing research has largely focused on fundamental studies such as species inventories (e.g., Piippo et al., 2002; Zhu et al., 2018; Ho & Sukkharak, 2021; Ho et al., 2022), while little is known about their distribution on urban vegetation. Large trees in city parks represent important yet often overlooked habitats for epiphytic bryophytes, providing vertical gradients that can shape species richness. A study by Oishi & Tabata (2015) found that the diversity of epiphytic bryophytes increased with tree size because the nature of tree bark changes with size and generally longer lives of larger trees. There are also likely more available microhabitats on larger trees that can support higher epiphyte diversity.

In this context, Heritage Trees (HTs) provide an ideal natural test bed for examining urban bryophyte communities in Singapore. HTs are usually mature trees with girths greater than five meters, recognised for their cultural, historical, and/or botanical significance (NParks, 2025a). Established in 2001 by the National Parks Board, the Heritage Tree Scheme protects these trees through community nominations, signages, and the installation of lighting protection systems. Fort Canning Park (FCP), an urban park in Singapore, hosts 17 HTs across nine species, making it the third most species-rich locality for such trees in the country (NParks, 2025b, 2025c). These large, mature trees often support diverse epiphytic communities (Izuddin & Webb, 2015), providing an opportunity to investigate urban bryophyte diversity in the tropics.

Thus, HTs were selected as focal study to establish a baseline for understanding bryophyte richness and distribution on mature urban trees.

This study therefore aims to document the bryophyte species richness of selected HTs in Fort Canning Park, providing a baseline for understanding bryophyte distribution across mature trees within Singapore's urban landscape.

MATERIAL & METHODS

Study site. Fort Canning Park (FCP) is a historic hilltop site in the heart of Singapore's city centre. Once the residence of Malay kings, the area later served civil and military functions under British colonial rule. It was also the site of Singapore's first botanical and experimental garden before the establishment of the present-day Singapore Botanic Gardens (Foong, 1989). Thus, FCP provides a suitable site for studying epiphytic bryophyte diversity because of its historical significance and the presence of large, mature trees.

Sampling methods and species identification. The study was conducted at FCP from 24 January 2025 to 7 February 2025. A total of eight HTs, each representing a different species, were sampled (Fig. 1 & Table 1). Bryophyte collection took place once a week, targeting three to four HTs per session. Additional visits were made as needed to complete the sampling of all selected trees.

Bryophytes were sampled from within two metres from the ground, including above exposed roots, aerial roots and buttress roots. The part of the tree bole below one metre was classified as tree base (TB) and that from one to two metres was classified as tree trunk (TT). Roots exposed above the soil were classified as tree roots (TR). Each collection was recorded with the corresponding HT name, designated Heritage Tree ID, and microhabitat details.

A hand lens was used in the field to preliminarily differentiate bryophytes from algae and lichens. A paper knife was then used to scrape a small sample of each discernible bryophyte from the substrate for voucher specimens. Specimens were stored in pre-folded envelopes (approximately 100 by 150 mm), each labelled with a unique voucher number and corresponding field notes (Glime, 2021).

Collected bryophyte voucher specimens were brought to the Herbarium of the Singapore Botanic Gardens (SING), where they were sorted under a stereomicroscope and their detailed morphology was examined under a compound microscope. Identification of bryophytes to the species level was conducted using published taxonomic accounts relevant to Southeast Asia and adjacent regions (e.g., Bartram, 1939; Manuel, 1981; Iwatsuki & Suzuki, 1982; Mizutani, 1982; Iwatsuki, 1987; Ellis & Tan, 1999; Piippo et al., 2002; Tan & Choy, 2002; Iwatsuki & Ramsay, 2009; Lee, 2013; Promma & Chantanaorrapint, 2013; Wang et al., 2016; Cairns et al., 2020, 2021; Seppelt et al., 2021, 2022; Meagher et al., 2023). Vouchers were deposited in SING for documentation and future taxonomic verification.

Bryophyte conservation status. Bryophyte data recorded from the eight sampled HTs were used to calculate overall species richness, defined as the number of bryophyte species present on each HT. The bryophytes' conservation status followed the plant section of the Singapore Red Data Book, third edition (Middleton et al., 2024).

Fig. 1. Map of Fort Canning Park showing the locations of the sampled HTs (Adapted from Google Earth V 7.3 (2025)).

Table 1. Information of sampled Heritage Trees at FCP. [N] denotes tree species native to Singapore. Tree girths were measured at 1.3 m height above the ground, unless otherwise stated.

Heritage Tree ID	Species name	Girth (m)	Location	Bark roughness
2001-04	*Pithecellobium dulce* (Roxb.) Benth.	8.5	Along footpath besides service reservoir (Fig. 2a)	Gnarled trunk (Rough) (Fig. 2b)
2001-08	*Samanea saman* (Jacq.) Merr.	8.33	Behind Registry of Marriage (Fig. 3a)	Flaky and fissured (Rough) (Fig. 3b)
2001-11	*Enterolobium cyclocarpum* (Jacq.) Griseb.	5.94	Along footpath (Fig. 4a)	Lenticellate (Rough) (Fig. 4b)
2001-12[N]	*Artocarpus elasticus* Reinw. ex Blume	5.68 m at 1 m height	Along footpath (Fig. 5a)	Smooth to slightly scaly (Fig. 5b)
2001-31[N]	*Maranthes corymbosa* Blume	3.78	On slope near pedestrian underpass (Fig. 6a)	Smooth (Fig. 6b)
2010-181	*Ficus elastica* Roxb. ex Hornem.	19.75	In-front of National Museum of Singapore (Fig. 7a)	Smooth (Fig. 7b)
2014-224	*Dalbergia oliveri* Gamble ex Prain	5.48	Open field in Fort Green (Fig. 8a)	Rough (Fig. 8ba)
2014-227[N]	*Mangifera foetida* Lour.	2.55	On slope behind Singapore Management University (Fig. 9a)	Lenticellate (Rough) (Fig. 9b)

RESULTS

Of the eight HTs sampled, three were native to Singapore (HT2001-12, HT2014-227, HT2001-31), while five were non-native. A total of 16 species of epiphytic bryophytes from 14 genera across seven families were recorded (voucher information in Appendix 1). Among these, all eight species of liverworts from six genera belonged to the family Lejeuneaceae, while the eight species of mosses from eight genera spanned six families, with the family Calymperaceae being the most predominant (Table 2). No hornworts were recorded.

In terms of conservation status, three liverwort species were classified as 'Endangered' (EN) in Singapore, while one moss species was listed as 'Vulnerable' (VU), and the remaining were categorised as 'Least Concern' (LC) (Middleton et al., 2024).

Table 2. Species richness of bryophytes recorded on selected HTs at FCP, including their corresponding conservation status in Singapore according to Middleton et al. (2024). Photographs of the respective bryophyte species are in Appendix 2 (Figs. A1–16).

Liverwort taxa	**Conservation status**	**Figure in Appendix 2**
Lejeuneaceae		
Acrolejeunea fertilis (Reinw., Blume & Nees) Schiffn.	LC	Fig. A1
Cheilolejeunea intertexta (Lindenb.) Steph.	LC	Fig. A2
Cololejeunea planissima (Mitt.) Abeyw.	EN	Fig. A3
Cololejeunea raduliloba Steph.	EN	Fig. A4
Cololejeunea wightii Steph.	LC	Fig. A5
Lejeunea adpressa Nees	LC	Fig. A6
Lopholejeunea nigricans (Lindenb.) Steph. ex Schiffn.	LC	Fig. A7
Microlejeunea ulicina (Taylor) Steph.	LC	Fig. A8
Moss taxa		
Calymperaceae		
Calymperes tenerum Müll.Hal.	LC	Fig. A9
Leucophanes glaucum (Schwägr.) Mitt.	LC	Fig. A10
Octoblepharum albidum Hedw.	LC	Fig. A11
Syrrhopodon armatus Mitt.	VU	Fig. A12
Fissidentaceae		
Fissidens crenulatus var. *elmeri* (Broth.) Z.Iwats. & Tad.Suzuki	LC	Fig. A13
Hypnaceae		
Vesicularia reticulata (Dozy & Molk.) Broth.	LC	Fig. A14
Pylaisiadelphaceae		
Isopterygium albescens (Hook.) A.Jaeger	LC	Fig. A15
Taxithelium nepalense (Schwägr.) Broth.	LC	Fig. A16

Bryophyte richness. Bryophytes were recorded on all eight sampled HTs, with most found on tree trunks (TT) indicating that tree trunks consistently supported the highest species richness (Table 3). The mean species richness per tree was 5.5. *Cheilolejeunea intertexta* and *Microlejeunea ulicina* were the most widespread, occurring on six out of eight trees, followed by *Leucophanes glaucum* (five trees) and *Isopterygium albescens* and *Octoblepharum albidum* (four trees each). *Cololejeunea raduliloba, Cololejeunea wightii, Lopholejeunea nigricans*, and *Vesicularia reticulata* were all recorded on a single tree (HT2001-11 *Enterolobium cyclocarpum*).

Among the sampled HTs, HT2001-11 (*Enterolobium cyclocarpum*) exhibited the highest bryophyte richness, supporting 13 species, with eight species recorded on its roots. While HT2001-31 (*Maranthes corymbosa*) and HT2010-181 (*Ficus elastica*) exhibited the lowest species richness, each supporting only two species. Notably, HT2001-31 had *Cheilolejeunea intertexta* across multiple microhabitats, including its trunk, base, and buttress. The huge buttress of HT2001-12 (*Artocarpus elasticus*) supported a greater diversity of bryophytes.

Table 3. Sampled Heritage Trees and their respective microhabitat bryophyte richness, where "✓" indicates presence, "A" indicates on aerial root and "B" on buttress root (may or may not occur also on exposed ground root), ^{N} denotes HT species native to Singapore. For information of the respective HTs, refer to Table 1.

Habitat	**Tree Trunk (TT)**							
HT Tree ID	2001-04	2001-08	2001-11	2001-12 ^{N}	2001-31 ^{N}	2010-181	2014-224	2014-227 ^{N}
Liverworts								
Acrolejeunea fertilis							✓	
Cheilolejeunea intertexta	✓		✓		✓			✓
Cololejeunea planissima							✓	
Cololejeunea raduliloba								
Cololejeunea wightii								

Lejeunea adpressa		✓	✓	✓				
Lopholejeunea nigricans								
Microlejeunea ulicina	✓			✓	✓			✓
Mosses								
Calymperes tenerum							✓	✓
Fissidens crenulatus var. *elmeri*								
Isopterygium albescens		✓	✓				✓	
Leucophanes glaucum	✓	✓	✓	✓				
Octoblepharum albidum	✓	✓	✓	✓				
Syrrhopodon armatus	✓			✓				
Taxithelium nepalense								
Vesicularia reticulata								
Habitat				**Tree Base (TB)**				
HT Tree ID	2001-04	2001-08	2001-11	2001-12 [N]	2001-31 [N]	2010-181	2014-224	2014-227 [N]
Liverworts								
Acrolejeunea fertilis							✓	
Cheilolejeunea intertexta			✓	✓	✓			
Cololejeunea planissima								
Cololejeunea raduliloba								
Cololejeunea wightii								
Lejeunea adpressa		✓		✓				
Lopholejeunea nigricans								
Microlejeunea ulicina			✓					
Mosses								
Calymperes tenerum							✓	
Fissidens crenulatus var. *elmeri*				✓				
Isopterygium albescens		✓		✓				
Leucophanes glaucum		✓		✓				
Octoblepharum albidum		✓						
Syrrhopodon armatus								
Taxithelium nepalense								
Vesicularia reticulata								
Habitat				**Tree Root (TR)**				
HT Tree ID	2001-04	2001-08	2001-11	2001-12 [N]	2001-31 [N]	2010-181	2014-224	2014-227 [N]
Liverworts								
Acrolejeunea fertilis							✓B	
Cheilolejeunea intertexta			✓	B	B		✓	
Cololejeunea planissima			✓	✓B			✓	
Cololejeunea raduliloba			✓					
Cololejeunea wightii			✓					
Lejeunea adpressa				✓B				
Lopholejeunea nigricans			✓					
Microlejeunea ulicina						A		
Mosses								
Calymperes tenerum							✓B	
Fissidens crenulatus var. *elmeri*			✓	✓				
Isopterygium albescens		✓					✓B	
Leucophanes glaucum						A		
Octoblepharum albidum								
Syrrhopodon armatus				✓				
Taxithelium nepalense			✓	✓				
Vesicularia reticulata			✓					
Total liverworts:	2	1	7	4	2	1	3	2
Total mosses:	3	3	6	6	0	1	2	1

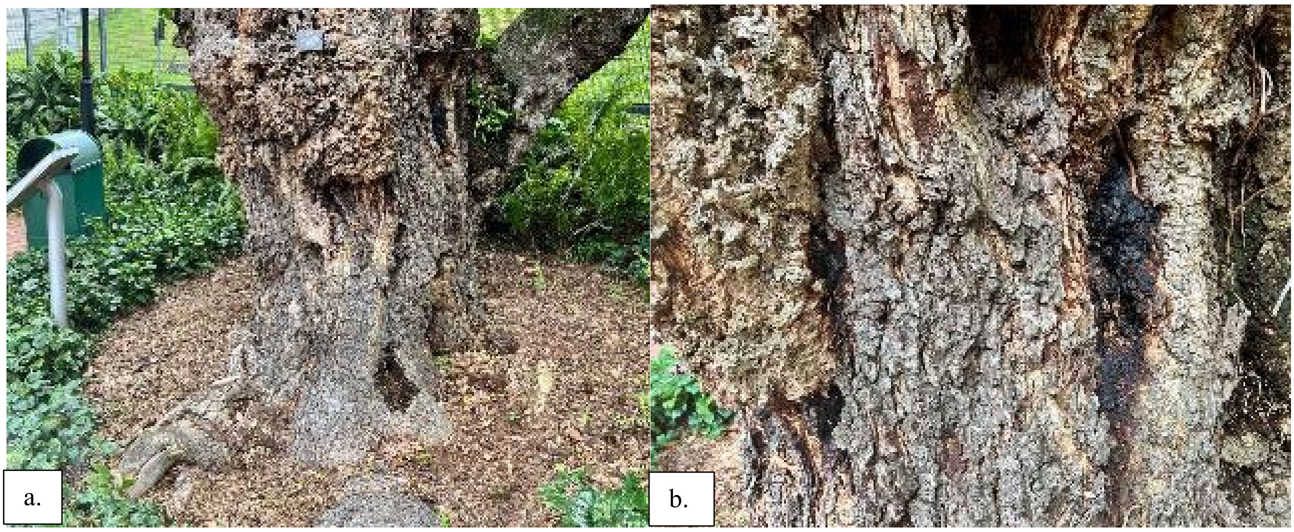

Fig. 2. HT2001-04 (*Pithecellobium dulce*). a, Sampled area; b, Bark texture.

Fig. 3. HT2001-08 (*Samanea saman*). a, Sampled area; b, Bark texture.

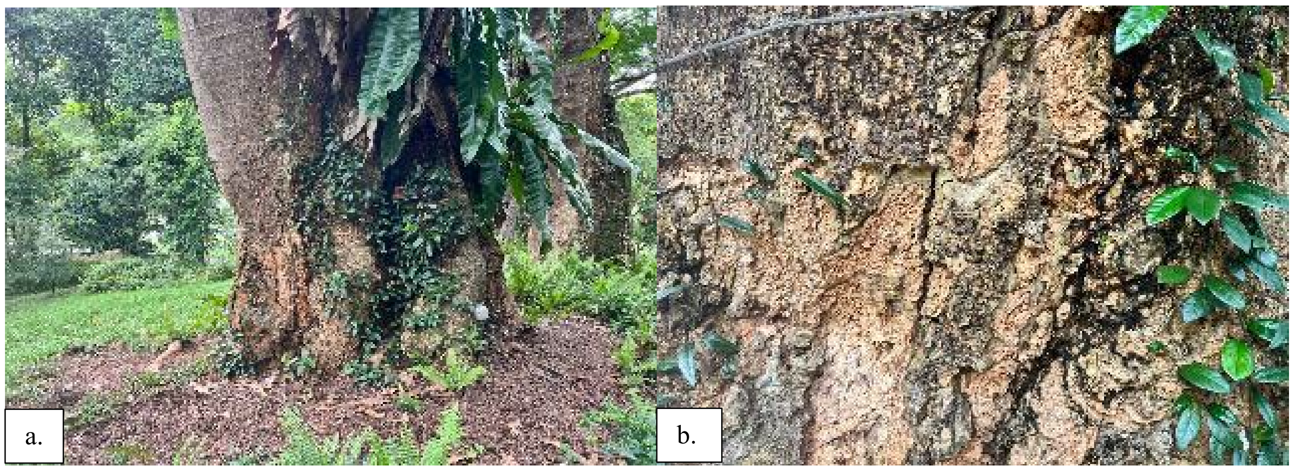

Fig. 4. HT2001-11 (*Enterolobium cyclocarpum*). a, Sampled area; b, Bark texture.

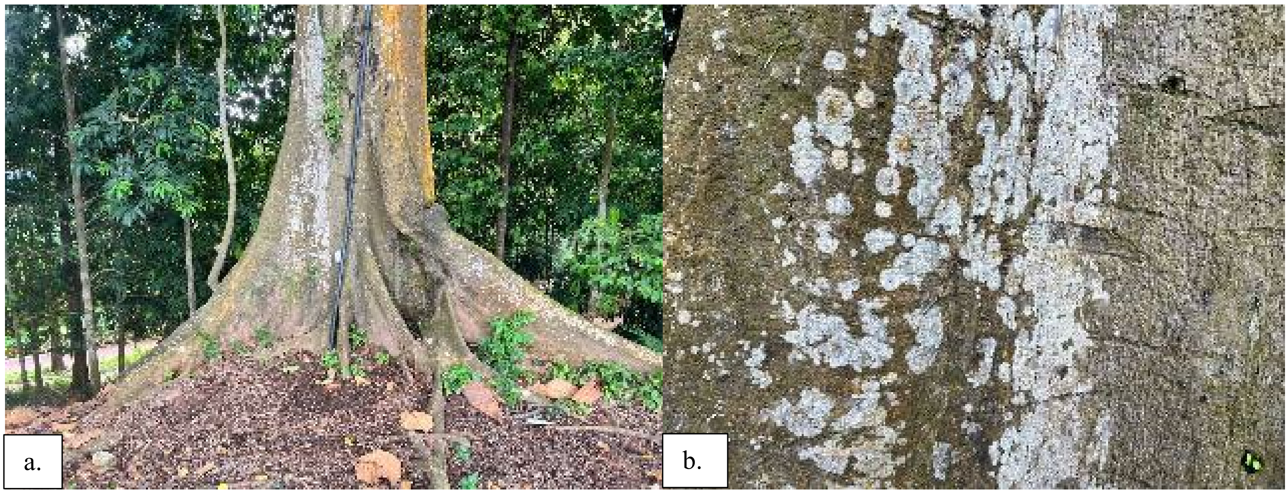

Fig. 5. HT2001-12 (*Artocarpus elasticus*). a, Sampled area; b, Bark texture.

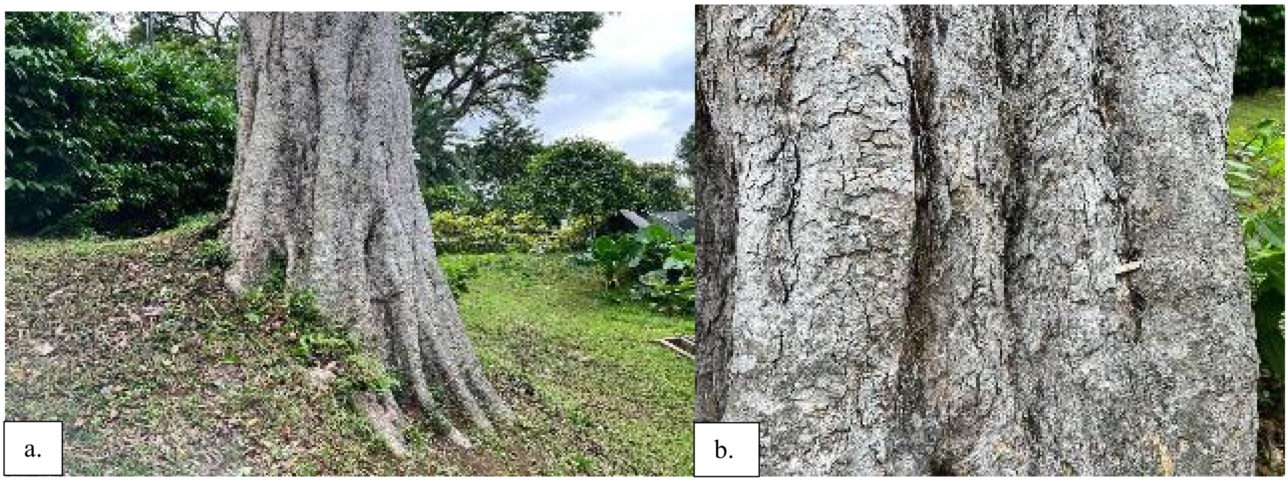

Fig. 6. HT2001-31 (*Maranthes corymbosa*). a, Sampled area; b, Bark texture.

Fig. 7. HT2010-181 (*Ficus elasticus*). a, Sampled area; b, Bark texture.

Fig. 8. HT2014-224 (*Dalbergia oliveri*). a, Sampled area; b, Bark texture.

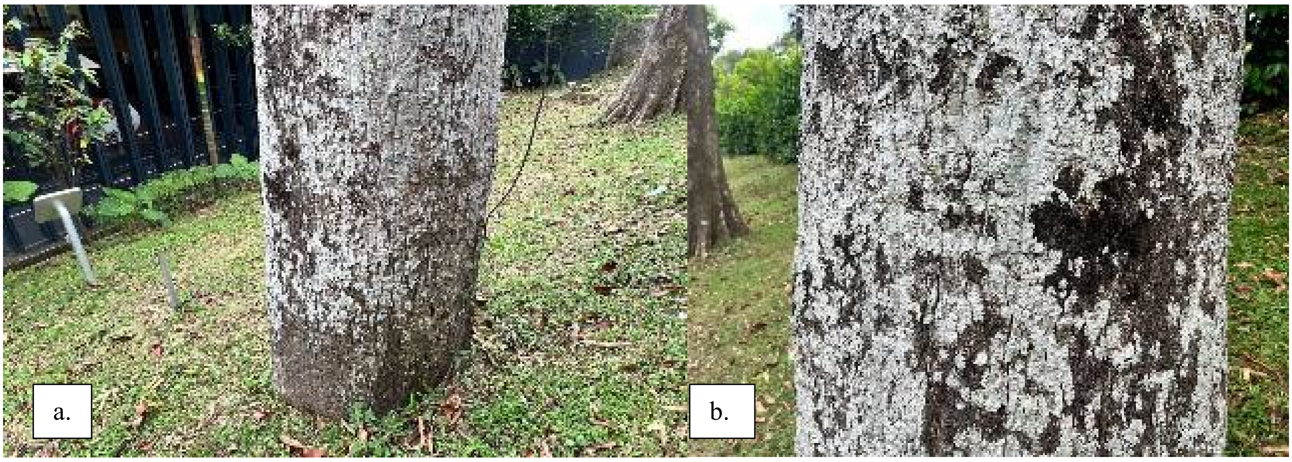

Fig. 9. HT2014-227 (*Mangifera foetida*). a, Sampled area; b, Bark texture.

DISCUSSION

Total richness of epiphytic bryophytes. The Lejeuneaceae is the largest family of liverworts, comprising a highly diverse group of predominantly epiphytic species (Gradstein et al., 2001; Wang et al., 2016). This ecological specialisation allows them to thrive on tree bark, such as those on HTs, contributing significantly to epiphytic bryophyte communities in tropical and subtropical forests (Becker et al., 2019; Shao et al., 2023). Their wide distribution and morphological diversity make them an important component of bryophyte assemblages, influencing microhabitat conditions and overall vegetation dynamics, particularly in urban ecosystems (Wierzcholska et al., 2018; Kutnar et al., 2023). Similarly, Calymperaceae is the largest moss family in Singapore (Lindsay et al., 2022), and its species were the most frequently recorded mosses in this study (Table 2), with many adapted to epiphytic habitats (Gradstein et al., 1989). Other moss families recorded in the study included Fissidentaceae and Hypnaceae, which are also some of the largest moss families in the tropics (Lee et al., 2011; Costa & Peralta, 2015; Cataytay et al., 2024). These bryophytes' ability to colonise a wide range of substrates, including tree bark, rock surfaces, and even soil, highlights their ecological versatility (Stokland et al., 2012). As the dominant group in many tropical and subtropical communities, bryophyte species play an important role in water balance, nutrient cycling, soil improvement, and can be bioindicators (Oishi & Hiura, 2017; Moore et al., 2018; Van Zuijlen et al., 2020; Glime, 2021). They also serve as shelter for invertebrates (Pradhan & Khanal, 2021). The prominence of common epiphytic families like Lejeuneaceae and Calymperaceae highlights that mature trees provide viable microhabitats capable of supporting epiphytes and invertebrates, thereby functioning as important biodiversity refugia in urban environments.

The highest bryophyte species richness in this study was recorded on HT2001-11 (*Enterolobium cyclocarpum*), which supported 13 species, eight of which occurred on its exposed roots. This exceeds the 11 species documented on the buttress and exposed roots of HT2003-124 (*Terminalia subspathulata* King) in the Singapore Botanic Gardens (Ho & Wong, 2022), which is comparable to the 10 species recorded in this study on HT2001-12 (*Artocarpus elasticus*). The notably high bryophyte richness on these HTs suggests that trees with extensive buttresses or exposed root systems may provide greater substrate area, moisture retention, and microhabitat heterogeneity, all of which enhance epiphytic bryophyte diversity (Mežaka et al., 2012; Glime, 2021). This aligns with findings that substrate diversity is one of the main factors exerting a strong influence on bryophyte richness (Chen et al., 2017).

HTs and bryophyte conservation. The native status of the host tree was not found to be related to the number of epiphytic bryophytes in this study. Alternatively, the high diversity observed on HT2001-11 may be influenced by favourable localised environmental conditions, such as extensive surrounding vegetation near (but not directly adjacent to) the tree that likely helps buffers microclimatic fluctuations and maintain the moisture levels necessary for bryophyte growth (see also discussion in the next paragraph when dense vegetation is too close). The presence of two nationally 'Endangered' liverwort species and a 'Vulnerable' moss species further highlight the conservation significance of bryophytes found on Heritage Trees. This underscores their role as host tree species for threatened native bryophytes and reinforces the need for enhanced protection measures for Heritage Trees in urban parks such as minimising anthropogenic disturbances and managing microclimates through selective pruning. However, it is possible that some conservation statuses for bryophytes in Singapore (Middleton et al., 2024) may have been inaccurately assessed because of poor understanding of their local distributions and occurrences. For instance, the potential under-sampling of easily overlooked bryophyte species in urban parks like FCP may have resulted in an overestimation of their rarity.

Low bryophyte richness on certain HTs. Heritage Trees might generally be expected to support greater bryophyte diversity because of their substantial size, typically exceeding five metres in girth. However, HT2001-31 (*Maranthes corybosa*) and HT2010-181 (*Ficus elastica*), both of which have atypical girth compared to the rest of the sampled trees, showed the lowest species richness, with only two bryophyte species recorded on each tree. HT2001-31 had the smallest girth in the study at only 3.78 m; its smaller girth likely lacks the extensive microhabitat of the other, larger HTs and cannot be directly compared to them. Additionally, the low richness on HT2001-31 may also be related to its smooth bark (Figure 6b) which likely limits spore attachment and moisture retention, as bark roughness is an important structural factor in influencing epiphytic bryophyte distribution (Tang et al., 2025). Conversely, while HT2010-181 had the largest girth of all sampled trees (19.75 m), this measurement is artificially inflated by its specific growth form which forms extensive aerial roots rather than a single, continuous bole. Furthermore, low bryophyte richness may reflect local site conditions, as dense vegetation directly adjacent to the tree (Figure 7a) probably restricts bryophyte establishment through reduced light penetration and increased competition.

Microhabitat influence on bryophyte richness. Higher bryophyte species richness recorded at tree bases (TB) and tree roots (TR) reflects favourable microhabitats and species ecological preferences. This observation reflects a study by Holz et al. (2002) which found that tree base substrates contribute to overall species richness, while Chen et al. (2017) found that substrate diversity improves bryophyte distribution. Consequently, terrestrial generalists, such as species of *Lopholejeunea*, *Fissidens*, *Taxithelium*, and *Vesicularia*, readily colonise these moist, shaded substrates because of their broad habitat flexibility. Meanwhile, humidity-dependent *Cololejeunea* spp. preferentially thrive near ground level, where reduced airflow, higher moisture and frequent dew deposition maintain the stable, humid conditions essential to their growth and reproduction in the urban environment.

HT-to-HT proximity and bryophyte similarity. Tree-to-tree proximity appears to influence bryophyte species richness to some extent. Notably, HT2014-224 (*Dalbergia oliveri*), located in the centre of an open field (Figure 9), hosted *Acrolejeunea fertilis,* a species found only once in this study, and *Cololejeunea planissima,* a species otherwise only found on HT2001-11 and HT2001-12 (Table 3). *Acrolejeunea fertilis* is a common urban epiphyte species in Singapore, and its restricted occurrence in this study to a single tree is notable, suggesting that the species may be particularly well-adapted to the more exposed, potentially drier microclimatic conditions of solitary trees in open fields, compared to the shadier environments of clustered trees. In contrast, HTs located closer in proximity to each other, such as HT2014-227 and HT2001-31, shared some common bryophytes like *Cheilolejeunea intertexta,* and *Microlejeunea ulicina*. This could be attributed to bryophyte dispersal through spores, which are carried by air currents and germinate once they settle in sufficiently moist environments (Carrington, 1997). While such dispersal may occur between nearby trees, the airborne nature of bryophyte spores are also effective agents for long-distance propagation. Notably, *Cheilolejeunea intertexta* and *Microlejeunea ulicina* were not limited to adjacent HTs but were also found on distant ones. This suggests that, while proximity may facilitate localised dispersal, effective wind propagation enables these species to reach distant trees, finally allowing them to establish wherever suitable microhabitats and local environments conditions are available.

Conclusion and limitations. This study examined bryophyte richness across selected HTs in FCP. The findings indicate that epiphytic bryophytes readily colonise mature trees under favourable conditions, with species richness varying among individual trees. These results highlight the ecological value of large trees in supporting urban biodiversity. By providing stable substrates and microhabitats, mature trees contribute to maintaining bryophyte communities, which in turn support other organisms such as invertebrates within the urban ecosystem. Conservation efforts that focus on the protection and maintenance of mature trees in urban landscapes also simultaneously contribute to bryophyte conservation. Given the influence of microclimate conditions on these communities, tree maintenance practices, such as minimising anthropogenic disturbances from construction activities, frequent repainting of nearby structures, and pesticide application, alongside maintaining adequate light levels through selective pruning, should be considered to maximise epiphytic bryophyte survival. While most recorded bryophytes were common species, the presence of less common taxa demonstrates the value of mature trees in FCP as viable habitats and potentially important refugia within a highly urbanised environment.

This study is limited by a small sample size (eight HTs in one location), which may not fully capture the diversity of epiphytic bryophytes across FCP, Singapore's mature trees, or the Heritage Tree network, comprising 259 trees as of 9 January 2025 (NParks, 2025d). Another limitation was the restricted sampling height, as specimens could only be collected up to two metres above ground level. Future studies should include a broader range of mature tree species, both heritage, and non-heritage, across multiple sites, to better capture variation in bryophyte diversity.

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APPENDIX 1

Bryophyte taxa and their corresponding voucher specimen deposited in SING Herbarium. TB = tree base, TR = tree root, TT = tree trunk, ^{N} = tree species native to Singapore.

HT2001-04 (*Pithecellobium dulce*)	
Taxa	**Voucher**
Cheilolejeunea intertexta	2F-TT
Leucophanes glaucum	2D-TT
Microlejeunea ulicina	2J-TT
Octoblepharum albidum	2B-TT
Syrrhopodon armatus	2G-TT
HT2001-08 (*Samanea saman*)	
Taxa	**Voucher**
Isopterygium albescens	4B-TB
Lejeunea adpressa	4G-TT
Leucophanes glaucum	4A-TT
Octoblepharum albidum	4A-TT
HT2001-11 (*Enterolobium cyclocarpum*)	
Taxa	**Voucher**
Cheilolejeunea intertexta	1E-TT
Cololejeunea planissima	1J-TR
Cololejeunea raduliloba	1P-TR
Cololejeunea wightii	1N-TR
Fissidens crenulatus var. *elmeri*	1L-TR
Isopterygium albescens	1C-TT
Lejeunea adpressa	1G-TT
Leucophanes glaucum	1H-TT
Lopholejeunea nigricans	1R-TR
Microlejeunea ulicina	1B-TB
Octoblepharum albidum	1H-TT
Taxithelium nepalense	1K-TR
Vesicularia reticulata	1Q-TR

HT2001-12^{N} (*Artocarpus elasticus*)	
Taxa	**Voucher**
Cheilolejeunea intertexta	3M-TB
Cololejeunea planissima	3G-TR
Fissidens crenulatus var. *elmeri*	3N-TB
Isopterygium albescens	3O-TB
Lejeunea adpressa	3T-TB
Leucophanes glaucum	3B-TT
Microlejeunea ulicina	3E-TT
Octoblepharum albidum	3A-TT
Syrrhopodon armatus	3C-TT
Taxithelium nepalense	3R-TR
HT2001-31^{N} (*Maranthes corymbosa*)	
Taxa	**Voucher**
Cheilolejeunea intertexta	6B-TT
Microlejeunea ulicina	6C-TT
HT2010-181 (*Ficus elastica*)	
Taxa	**Voucher**
Leucophanes glaucum	7C-Aerial Roots
Microlejeunea ulicina	7A-Aerial Roots

HT2014-224 (*Dalbergia oliveri*)	
Taxa	**Voucher**
Acrolejeunea fertilis	8N-TT
Calymperes tenerum	8Q-TB
Cheilolejeunea intertexta	8X-TR
Cololejuenea planissima	8R-TT
Isopterygium albescens	8W-TR
HT2014-227^{N} (*Mangifera foetida*)	
Taxa	**Voucher**
Calymperes tenerum	5C-TT
Cheilolejeunea intertexta	5D-TT
Microlejeunea ulicina	5D-TT

APPENDIX 2

Morphological images of bryophyte species identified from samples collected on Heritage Trees in Fort Canning Park. All photographs are taken by R. V. Kuan.

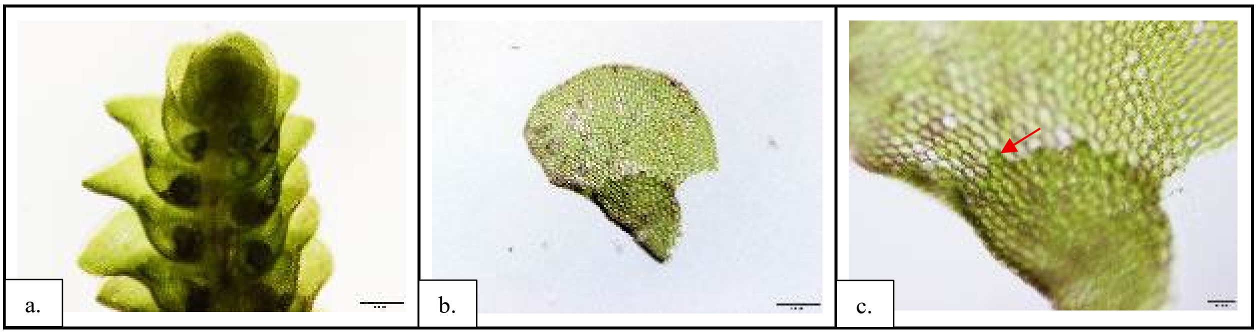

Figure A1. *Acrolejeunea fertilis.* a, Apex of a male branch; b, leaf; c, lobule with teeth (red arrow). All from voucher *8N* (SING).

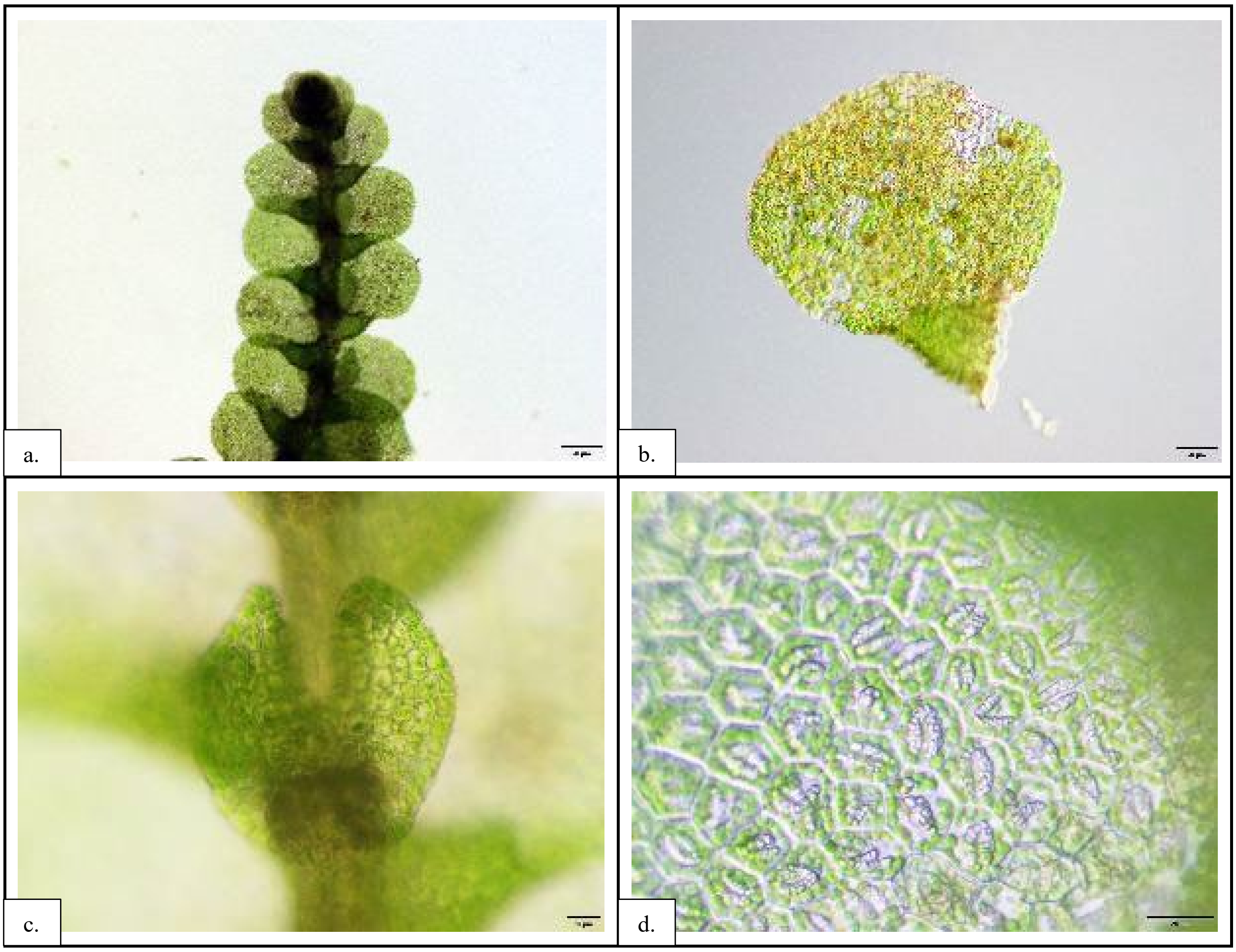

Figure A2. *Cheilolejeunea intertexta.* a, Apex of plant; b, leaf; c, underleaf; d, leaf cells showing large oil bodies. All from voucher *1E* (SING).

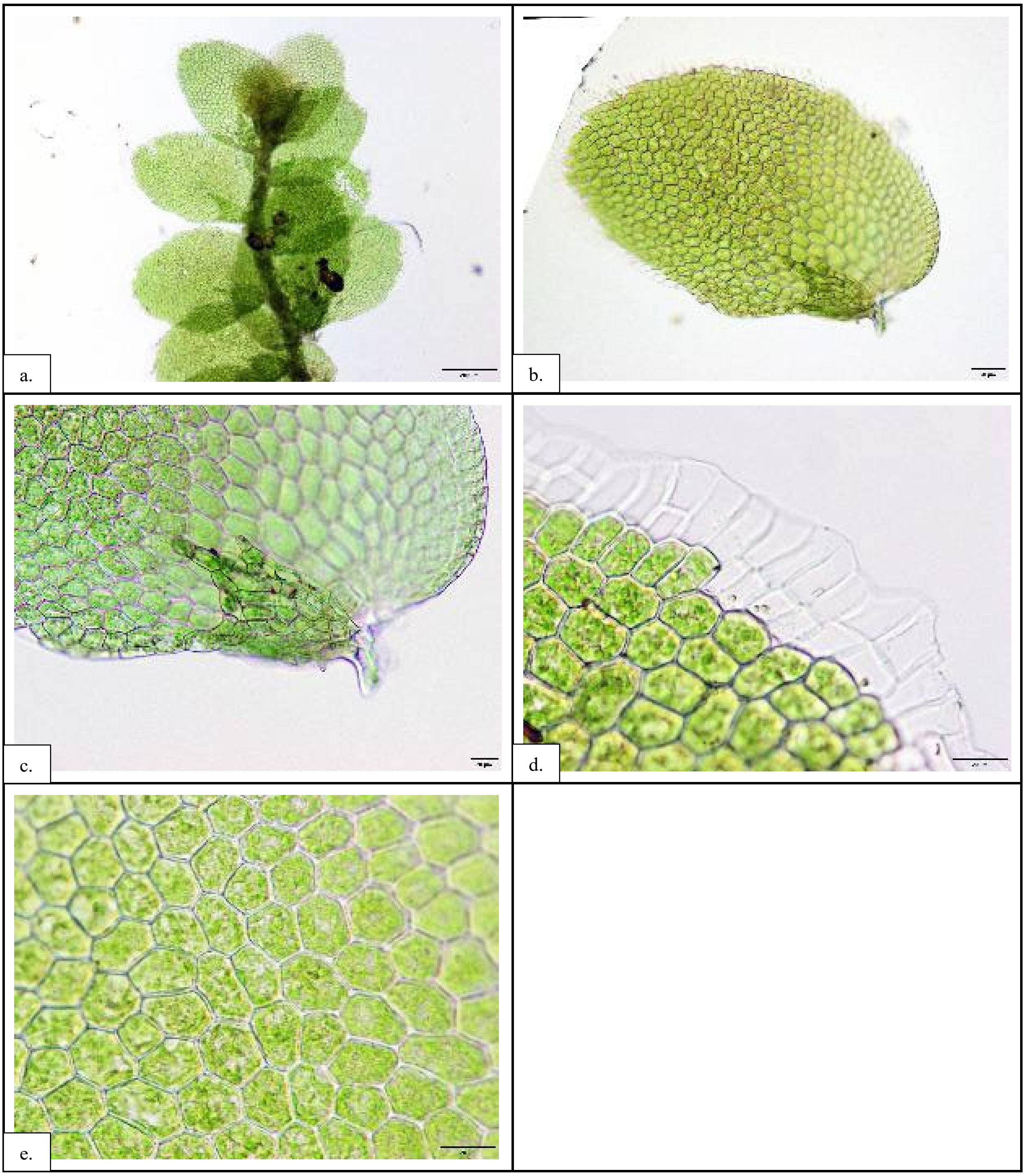

Figure A3. *Cololejeunea planissima*. a, Apex of plant; b, Leaf; c, Leaf lobule; d, Leaf margin; d, Leaf cells. All from voucher *3G* (SING).

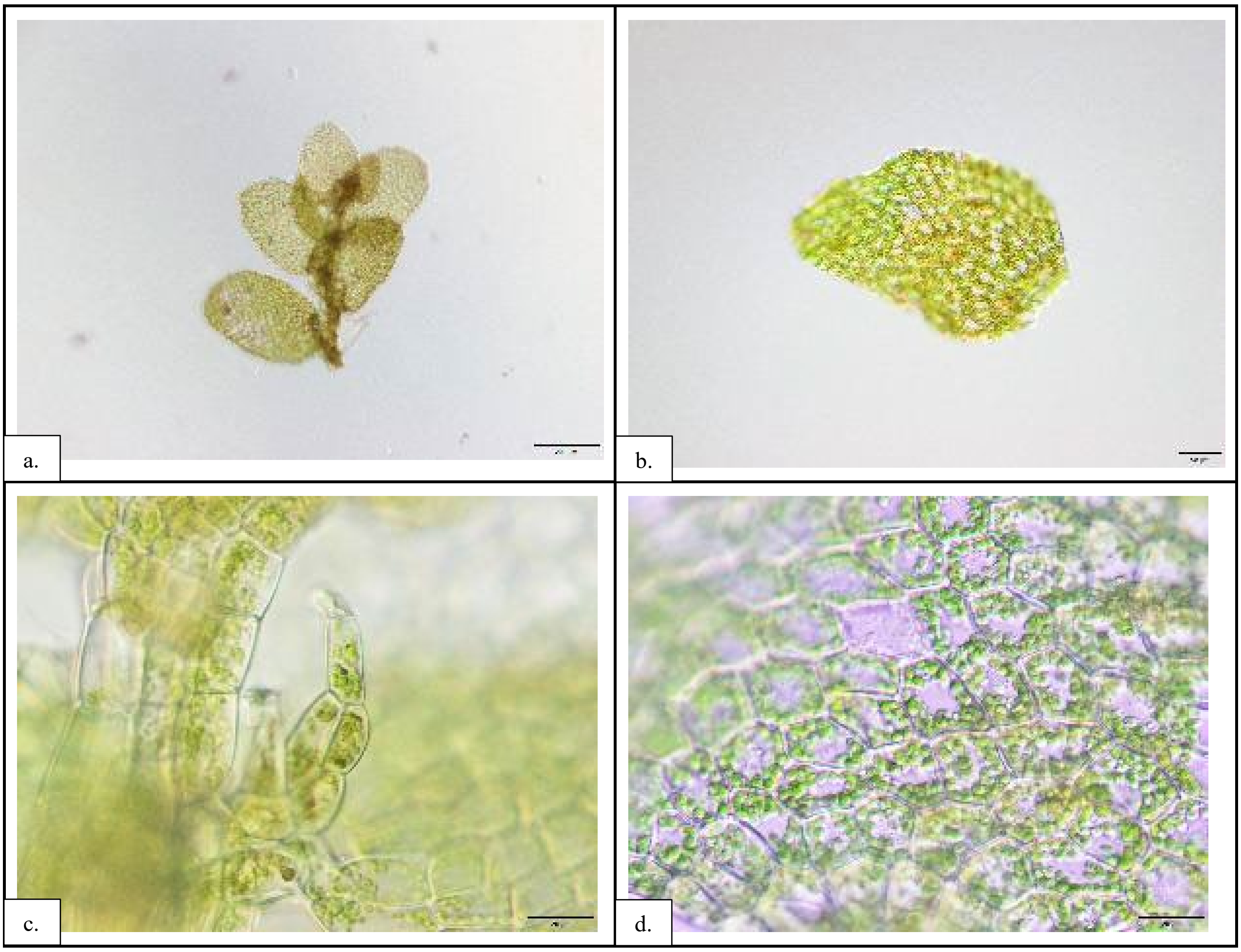

Figure A4. *Cololejeunea raduliloba*. a, Apex of plant; b, Leaf; c, Lobule; d, Leaf cells. All from voucher *1P* (SING).

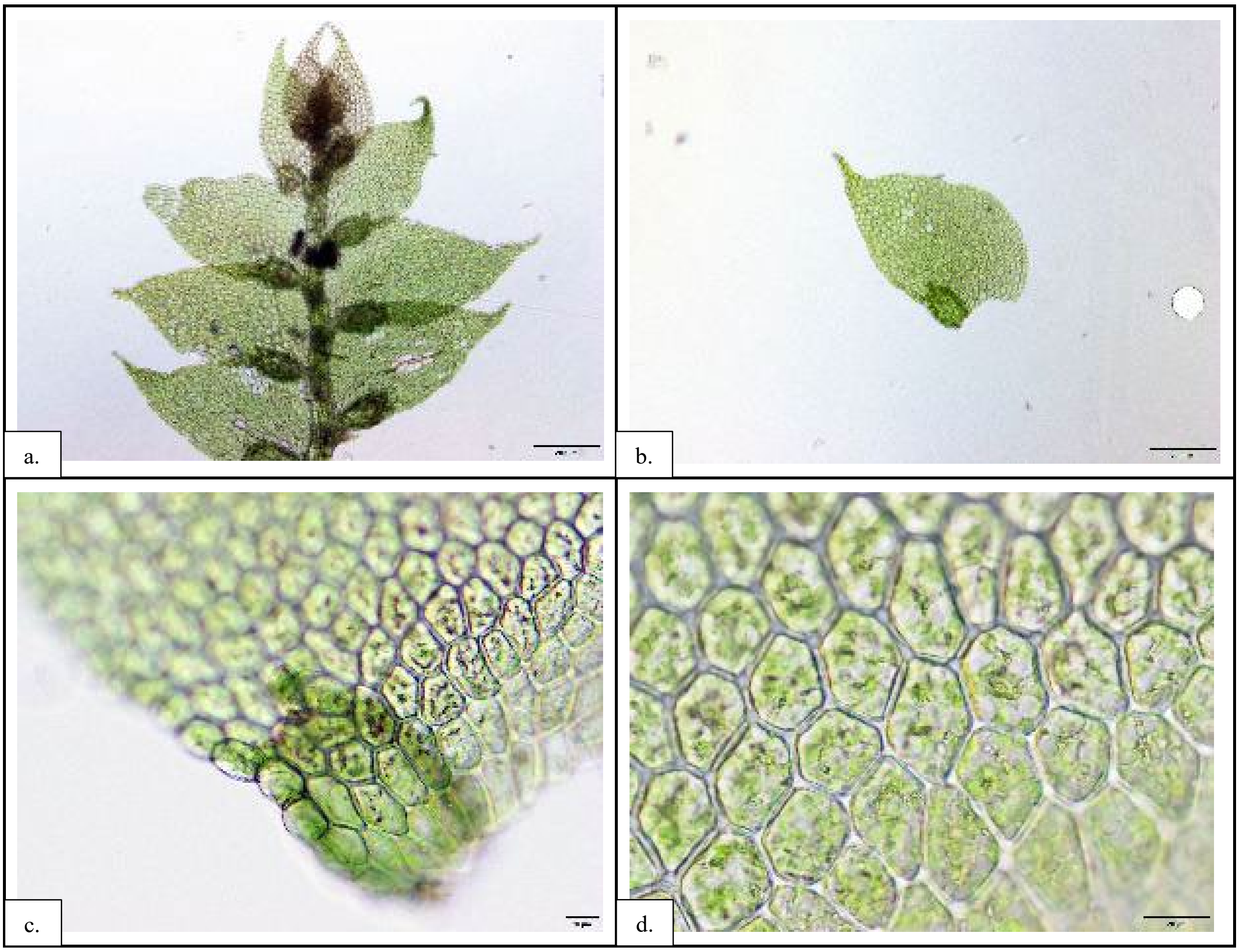

Figure A5. *Cololejeunea wightii*. a, Apex of plant; b, Leaf; c, Lobule; d, Leaf cells. All from voucher *1N* (SING).

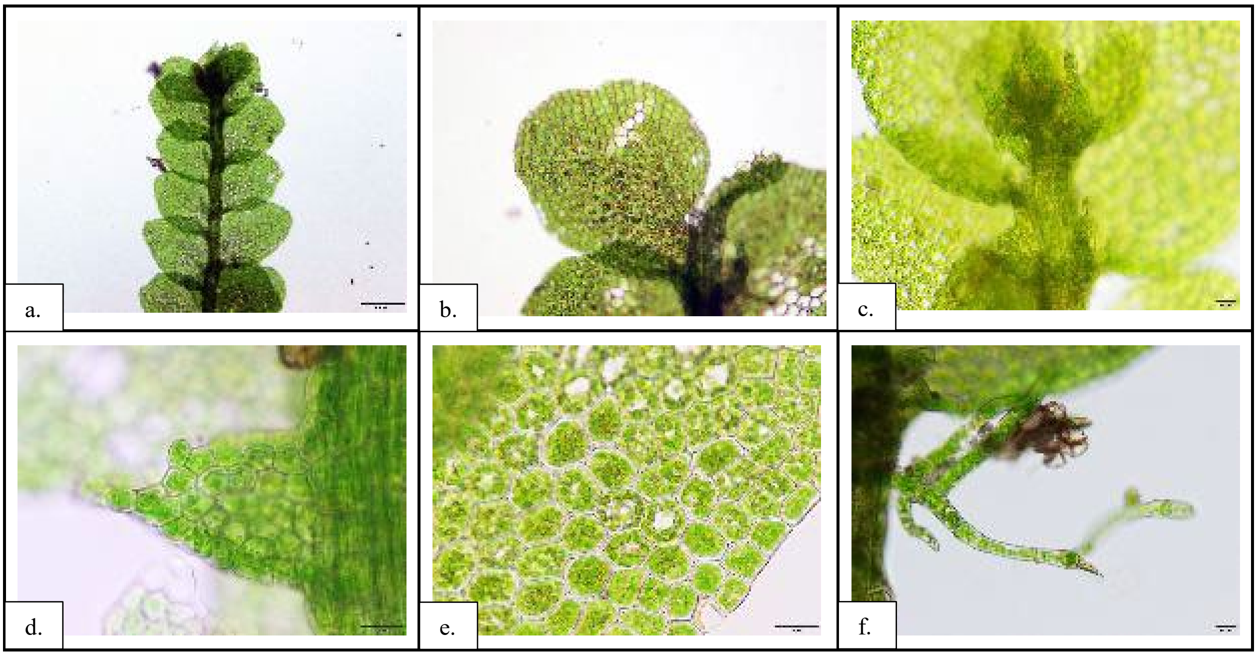

Figure A6. *Lejeunea adpressa*. a, Apex of plant; b, Leaf; c, Underleaves; d, Lobule; e, Leaf cells; f, protonema. All from voucher *1G* (SING).

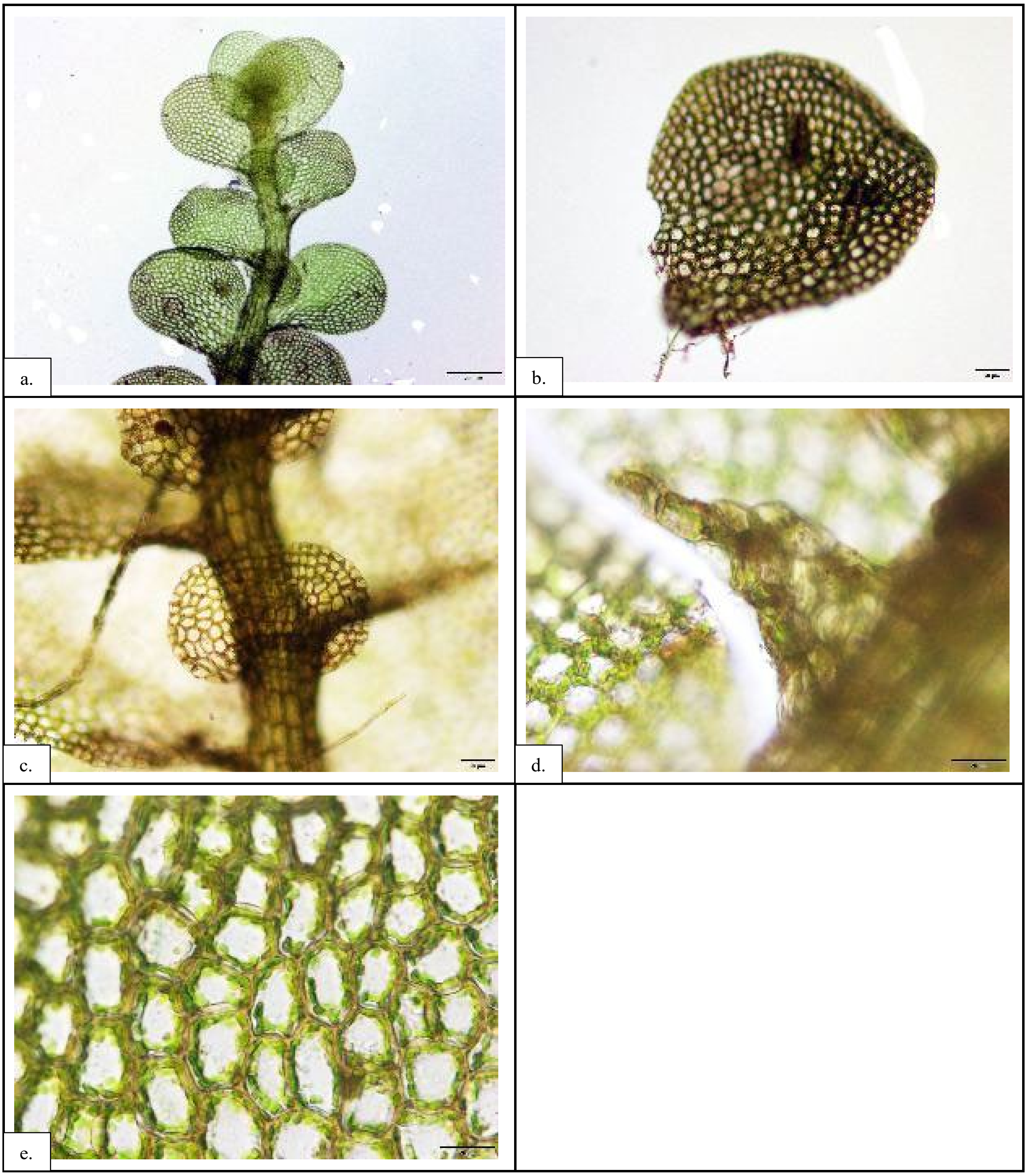

Figure A7. *Lopholejeunea nigricans*. a, Apex of plant; b, Leaf; c, Underleaf; d, Lobule; d, Leaf cells. All from voucher *1R* (SING).

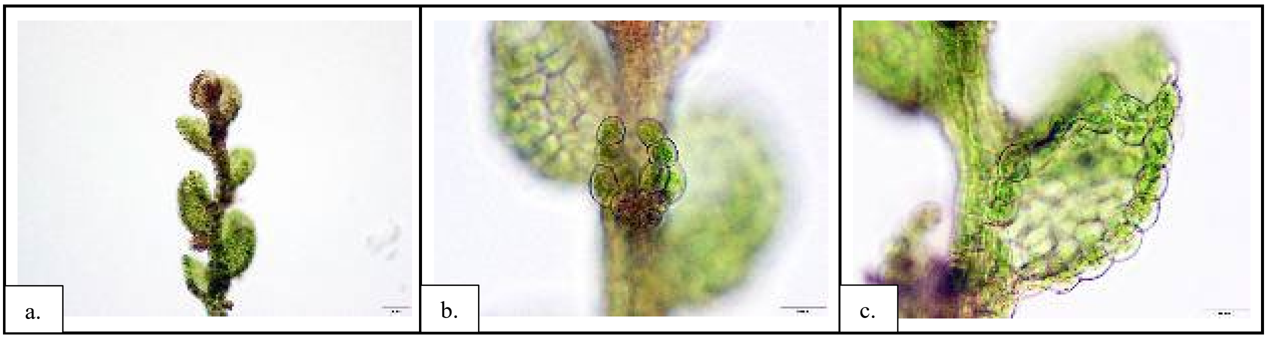

Figure A8. *Microlejeunea ulicina*. a, Apex of plant; b, Underleaf; c, Lobule. All from voucher *2J* (SING).

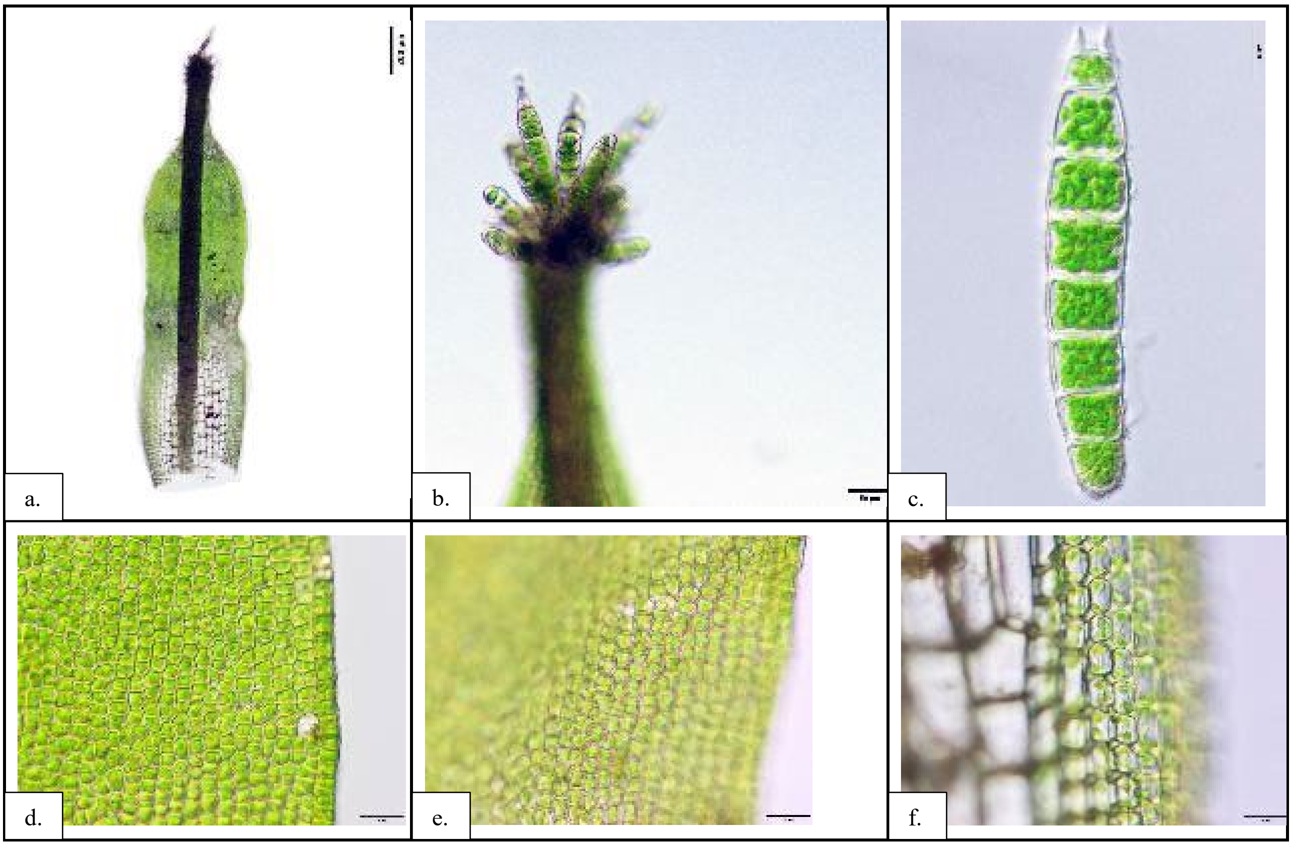

Figure A9. *Calymperes tenerum.* a, whole leaf; b, apex of leaf with gemmae; c, a gemma; d, apical leaf cells, d, median leaf cells; e, basal leaf cells with uneven thickened cell walls. All from voucher *8Q* (SING).

Figure A10. *Leucophanes glaucum*. a, Apical leaf; b, basal cross section; c, apical top right cells; d, bottom right cells; e, whole leaf. All from voucher *3C* (SING).

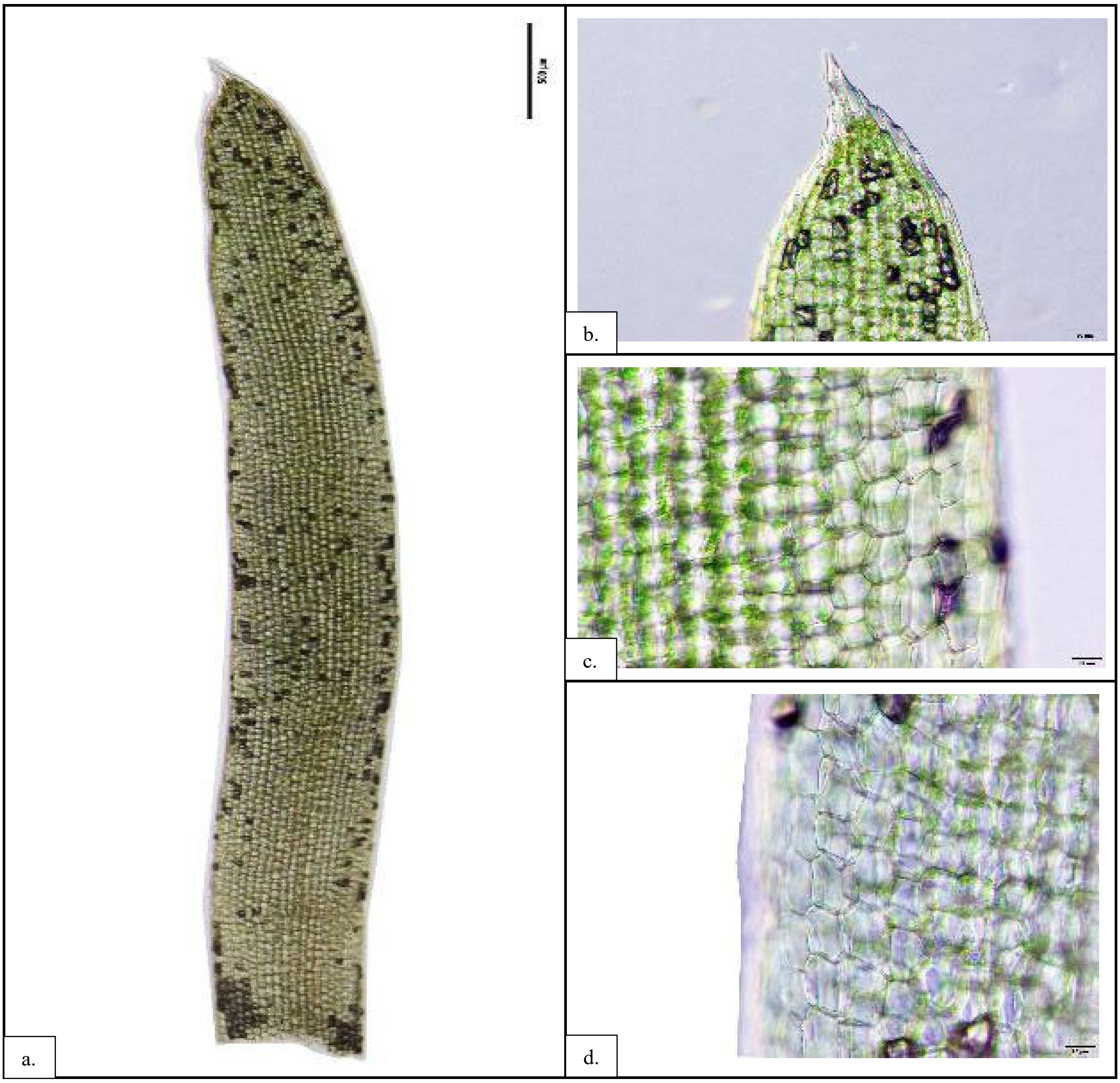

Figure A11. *Octoblepharum albidum*. a, Apical; b, Middle; c, Base; d, Whole leaf. All from voucher *4B* (SING).

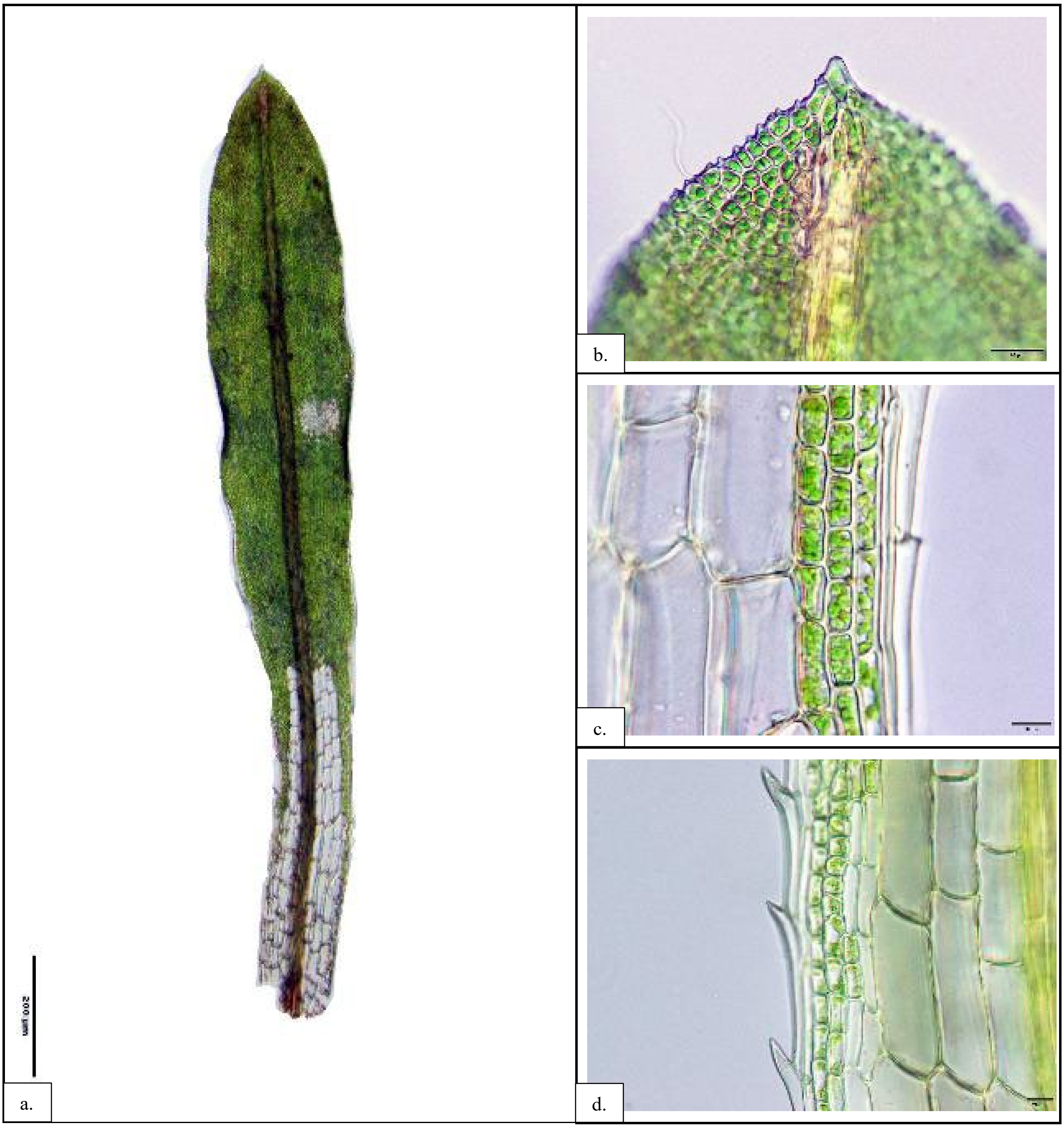

Figure A12. *Syrrhopodon armatus*. a, whole leaf; b, apical; c, basal cells; d, papillae. All from voucher *2E* (SING).

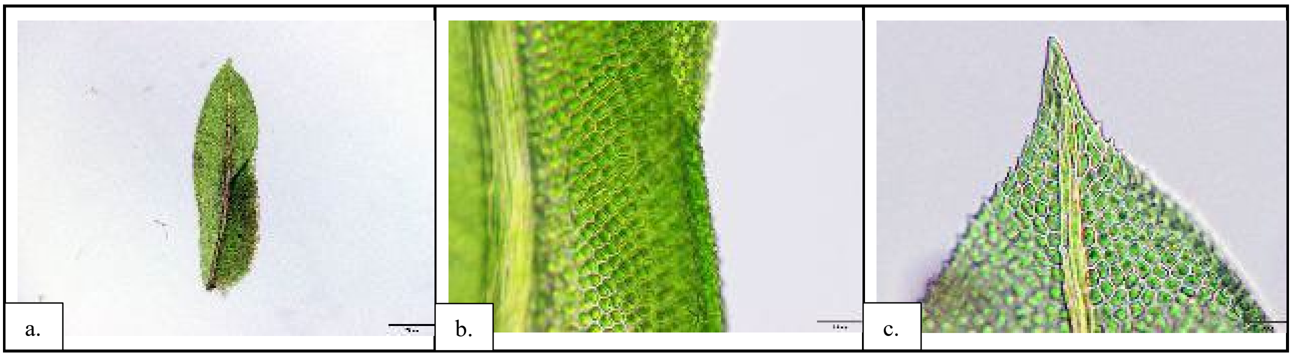

Figure A13. *Fissidens crenulatus* var. *elmeri*. a, whole leaf; b, folded basal showing papillae; c, apical. All from voucher *3J* (SING).

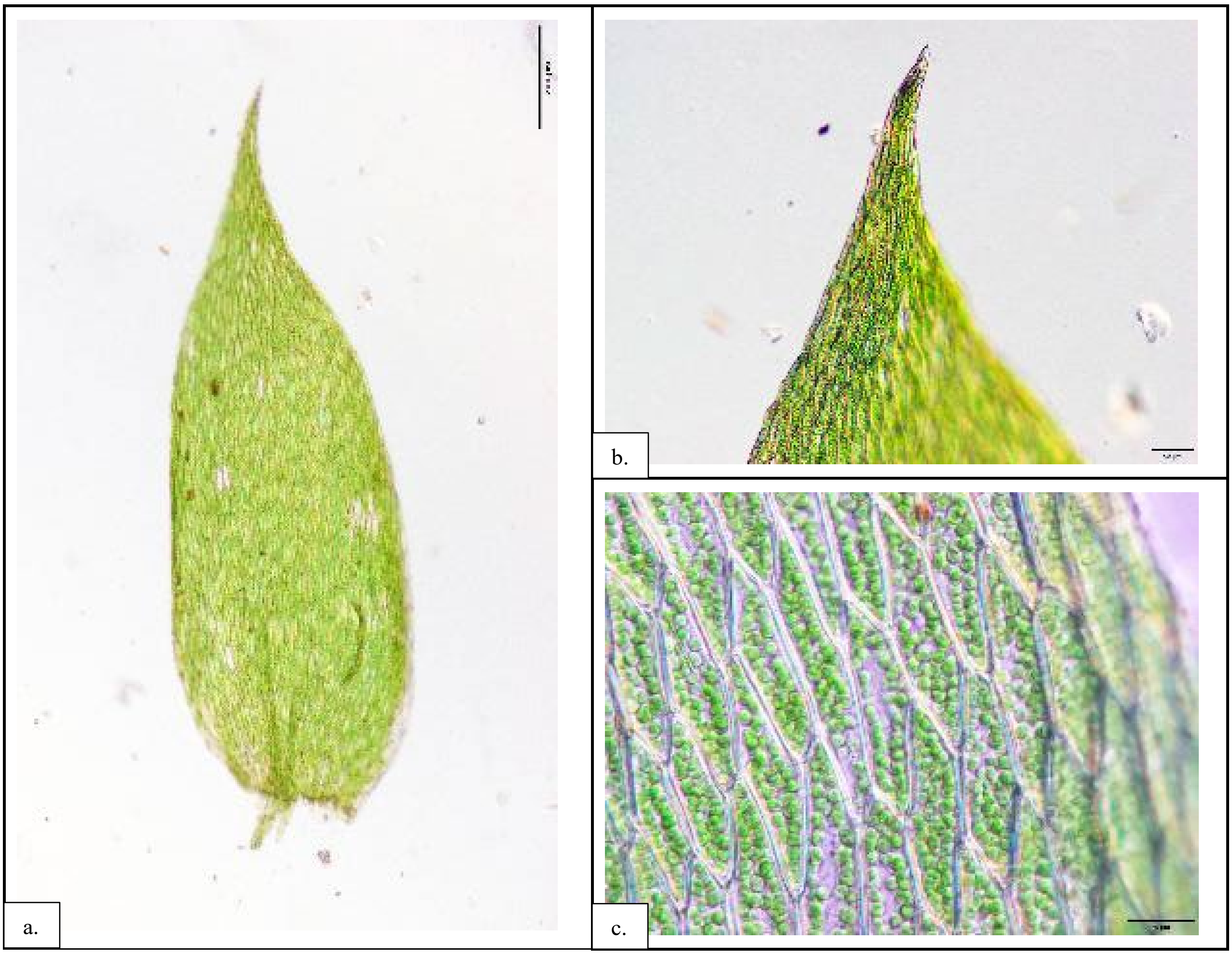

Figure A14. *Vesicularia reticulata*. a, Whole leaf; b, apical; c, middle cells. All from voucher *1Q* (SING).

Figure A15. *Isopterygium albescens*. a, whole leaf; b, apical; c, middle with cells. All from voucher *4B* (SING).

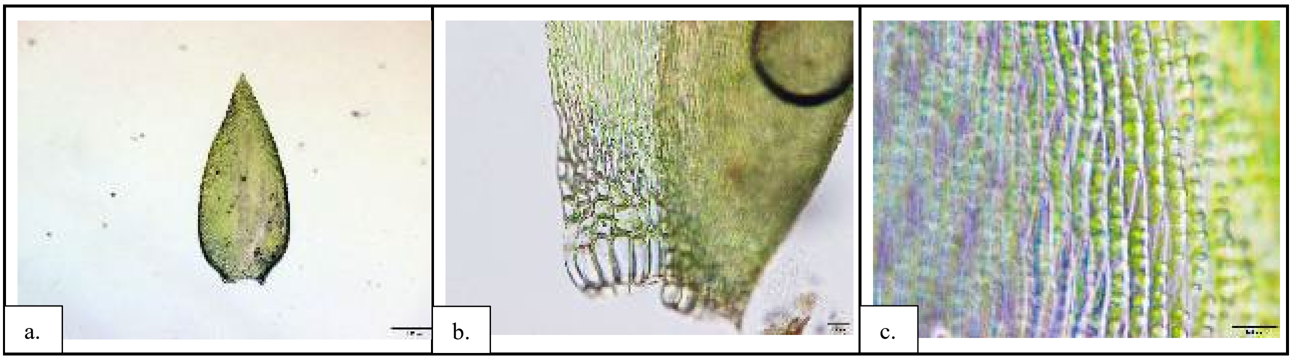

Figure A16. *Taxithelium nepalense*. a, whole leaf; b, alar region at basal corners of leaf; c, leaf cells showing papillae in a row. All from voucher *1K* (SING).