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The first Indian record of *Pogonatum marginatum* Mitt. (Polytrichaceae) from the Western Ghats

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Abstract

Pogonatum marginatum has been previously known from Sri Lanka and Vietnam. It was recently collected in the Agasthyamalai Biosphere Reserve in the Western Ghats (Kerala and Tamil Nadu), this being the first record of the plant in India. We provide a detailed description of the species with figures and a photographic plate, plus novel chloroplast gene sequences of the Indian plant, another specimen of the same species, and a close relative.

Key words: Agasthyamalai, *Pogonatum*, Polytrichopsida, Sri Lanka, Western Ghats

Introduction

Pogonatum P. Beauv. is the largest genus of the family Polytrichaceae with over 50 species (Hyvönen 1989). The genus shows large variation in the size of the gametophytes and includes very reduced plants such as *P. piliferum* (Dozy & Molk.) Touw. This species was originally described by Dozy and Molkenboer (1856) and accommodated in a new genus *Racelopus*. Touw (1986) reduced this and two other genera (*Pseudoracelopus* Broth. and *Racelopodopsis* Thér.) to a section under *Pogonatum*. Hyvönen (1989) followed this treatment in his synopsis. *Pogonatum marginatum* Mitt. is the largest plant of this group, comparable in size to many other species of *Pogonatum*. It can be readily distinguished from *P. rutteri* (Thér. & Dixon) Dixon, a closely related species, by its anisophylly. Superficially it resembles some species of *Fissidens* and thus it may have been overlooked in the field.

While studying the bryoflora of the Agasthyamalai Biosphere Reserve, several collections of this species were made at a couple of locations in the region as listed below. Our identification of these specimens as *Pogonatum marginatum* was further studied with sequence level data of the chloroplast genes *rbc*L and *rps*4 plus partial sequences of the tRNA-Leu (*trn*L) gene, *trn*L-*trn*F intergenic spacer and tRNA-Phe (*trn*F) gene. A detailed description of the species with figures and a photographic plate are also provided in order to supplement the very limited information presented in previous treatments. The Indian specimens are housed at SCCN.

Material and methods

Specimens were examined using dissecting and compound microscopes and compared with existing material, including collections of *Pogonatum marginatum* from Sri Lanka.

Laboratory methods for sequence data were as in Bell & Hyvönen (2010). Novel sequences for *rbc*L, *rps*4 and *trn*L-F were obtained from the Indian material (Kariappa 9850, SCCN!) as well as a specimen of *Pogonatum marginatum* recently collected in Sri Lanka (He 1485, H!) and an exemplar of the closely related *P. camusii* (Thér.) Touw (Menzel *et al*., 4266, H!). All sequences were deposited in Gen Bank (nos. KU852691-99). The new data was added to the chloroplast and mitochondrial matrix from Bell & Hyvönen (2010) and the parsimony analysis described in that study was repeated using the same methods to explore the phylogenetic position and distinctness of the new exemplars.

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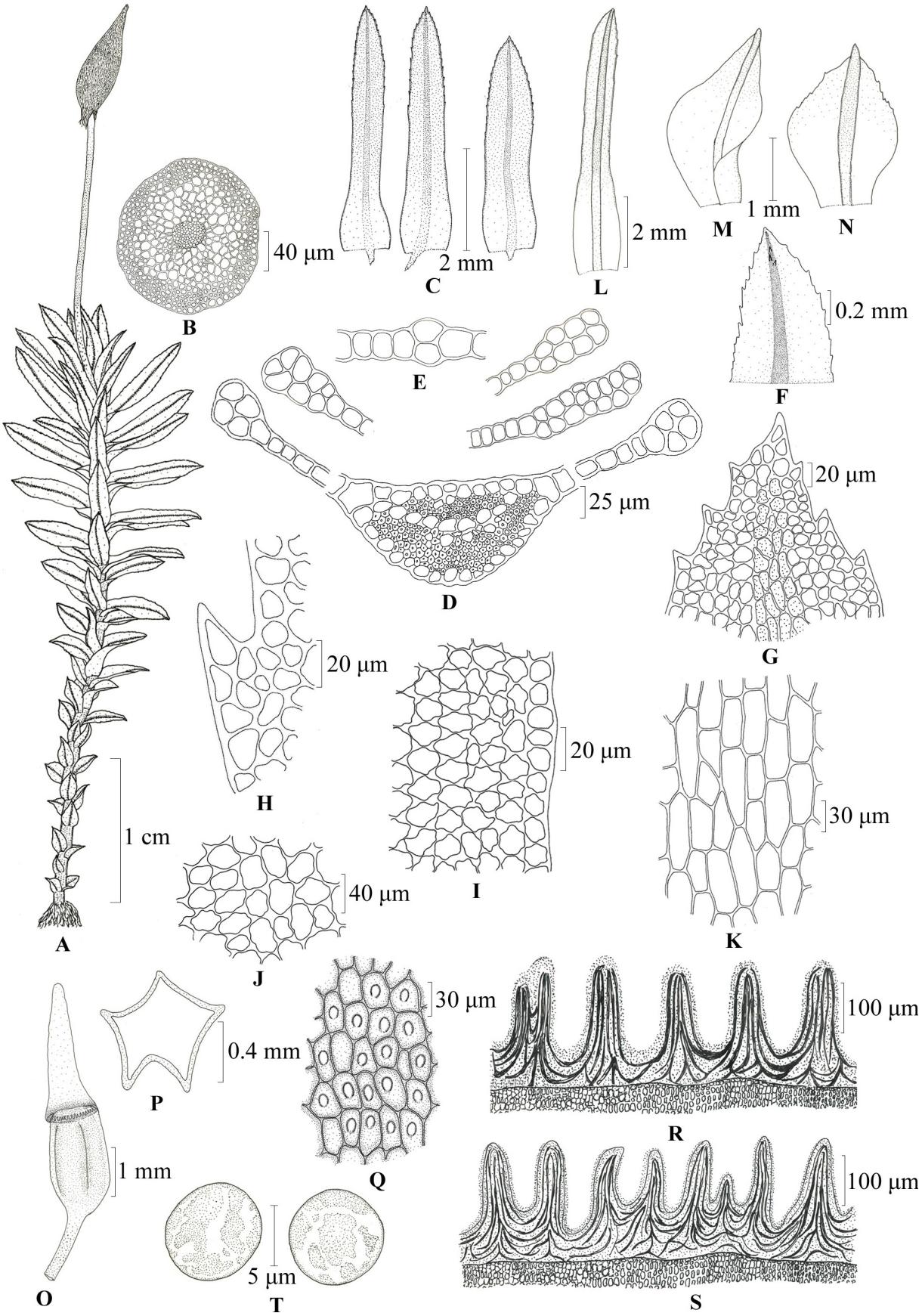

FIGURE 1 (A–T). *Pogonatum marginatu*m Mitt. (Drawn from *K.C. Kariyappa* 9850) A: plant; B: cross section of stem; C: leaves; D–E: cross sections of leaves showing variation in stratification at margin; F: leaf apex; G: leaf apical cells; H: leaf marginal tooth; I–J: leaf median cells; K: leaf basal cells; L: perichaetial leaf; M–N: perigonial leaves; O: capsule with operculum; P: cross section of capsule; Q: exothecial cells of capsule; R: peristome teeth; S: peristome with irregularly divided teeth; T: Spores.

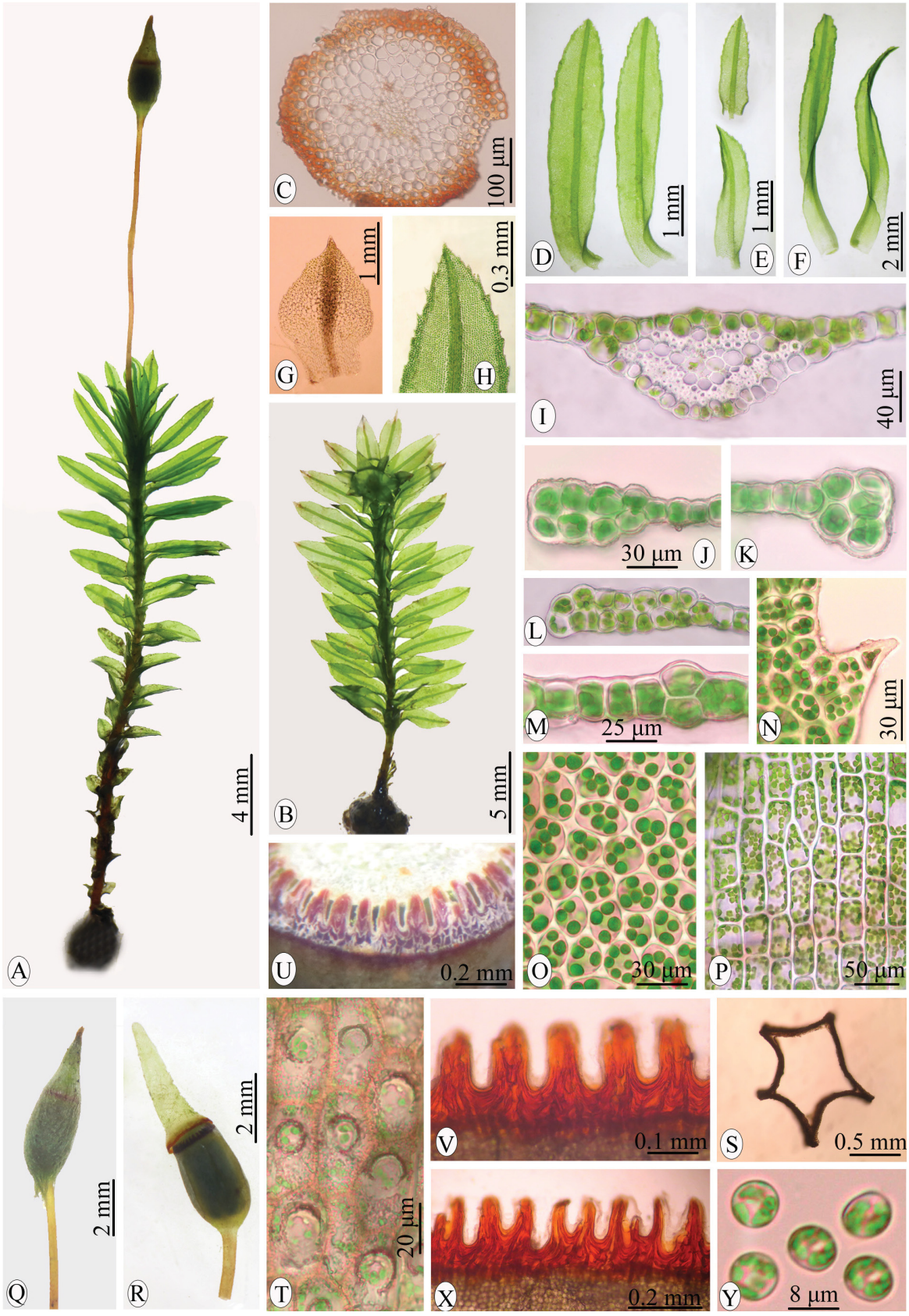

FIGURE 2 (A–Y). *Pogonatum marginatum* Mitt. (Photographed from *K.C. Kariyappa* 9850) A: female plant with sporophyte; B: male plant with inflorescence; C: cross section of stem; D: lateral leaves; E: dorsal leaves; F: perichaetial leaves; G: perigonial leaf; H: apex of lateral leaf; I: cross section of leaf at costa; J–L: cross sections of leaves showing variation in stratification at margin; M: cross section of leaf showing bistratose areas; N: leaf marginal tooth; O: leaf median cells; P: leaf basal cells; Q: capsule with calyptra; R: capsule with operculum; S: cross section of capsule; T: exothecial cells of capsule showing papillae and mamillae; U: portion of capsule mouth with peristome teeth; V: portion of peristome teeth; X: portion of peristome showing irregularly divided teeth; Y: Spores.

Results and discussion

Pogonatum marginatum Mitt., J. Proc. Linn. Soc., Bot. 1(Suppl.): 150. 1859; A. Touw, J. Hattori Bot. Lab. 60: 12. 1986; Hyvönen, Acta Bot. Fenn. 138: 39. 1989. —Type: Sri Lanka (Ceylon), in Hantane, *Gardner* 1223 (NY). *Pseudoracelopus marginatus* (Mitt.) G.L. Sm., Phytologia 18: 403. 1969 & Mem. New York Bot. Gard. 45: 469. 1987. (Figs. 1–2)

Plants dioicous, caespitose, 3–4 cm high, pale to dark green. Stems simple, 0.3–0.4 × 0.26–0.36 mm in cross section, ovate, with a central strand; cortical cells 3- or 4-layered, 4–8 × 4–6 µm, thick-walled, reddish-brown; medullary cells 8–36 × 8–24 µm, rounded-hexagonal, thin-walled. Leaves anisophyllous, 3-rowed with 2 patent, complanate, lateral rows and a distinct dorsal, smaller row, 3–5 × 0.9–1.1 mm, canaliculate and curled when dry, almost flat, crispate, ovate-lanceolate to lingulate-lanceolate when wet, clasping stem, not sheathing at base, thickened and bordered by 2–8 rows of 2- or 3-stratose cells, serrulate to serrate in the apical 1/3 of the margin approximately, broadly acute at apex, not lamellate; marginal teeth blunt to sharp, sharper towards apex, larger ones sometimes 3- or 4-celled, with apical cell often larger and more translucent than lower ones; lower leaves lax, scale-like, clasping stem, not complanate; dorsal leaves smaller, erectopatent; apical and median laminal cells 10–25 × 10–15 µm, rounded-quadrate to rounded-hexagonal, with walls thickened at corners, smooth; those at base 40–100 × 20–30 µm, rectangular, with uniformly thickened walls, smooth, hyaline; cuticle longitudinally striolate; costa ending just below apex and confluent with the thickened border, occasionally 2–4-toothed at apex dorsally, chlorophyllous, green, with distinct dorsal and ventral stereid bands; lamina occasionally with longitudinally 2-stratose cells. Perigonial leaves 2–3 × 1.5–2 mm, ovate-acuminate, entire, often recurved below on one side, not thickened at margin, faintly toothed at apex; costa excurrent; paraphyses 5–8-celled. Perichaetial leaves 6–8 × 0.7–0.9 mm, similar to vegetative leaves, narrower, erectopatent to patent at apex. Setae apical, 1–1.7 cm high, 0.3–0.4 mm thick, straight, sometimes wavy, scabrous. Capsules erect to inclined, 5–6 × 1.2–1.5 mm, cylindric-ovoid, pentagonal, mamillose, with a single mamilla each on exothecial cells. Peristome with 32 double teeth, often irregularly divided giving the appearance of a greater number; teeth 0.20–0.24 × 0.06–0.1 mm, with dark brown striations, hyaline at margin, with a low basal membrane. Opercula 3–3.5 × 0.7–1 mm, conic-rostrate, white, red-tinged at base, translucent. Calyptrae 6–7 × 1.8–2 mm, ovoid, acuminate, pilose, enclosing capsule, whitish to pale-brown. Spores 6–8 µm, round, practically smooth when studied with light microscope, pale-brown.

Habitat: Terricolous (on roadside cuts) in moist evergreen forests, 600–1100 m.

Distr.: Sri Lanka, Vietnam and India: Western Ghats of Kerala (Kollam) and Tamil Nadu (Tirunelveli).

Specimens examined: India, Western Ghats: Tamil Nadu, Tirunelveli Dist., Mundanthurai, Inchikuli, ca 612 m, 2.2.2010, *K.C. Kariyappa*161, 162; Kerala, Kollam Dist., Shankili forest, Pandimottai, ca 250 m, 2.6.2009, *K.C. Kariyappa* 1,2; ca 300 m, 8.7.2014, *K.C. Kariyappa* 9831, 9846, 9850, 9852, 9854, 9855. Sri Lanka, Southern and Central Prov., 0–1 220 m, *Thwaites* 258 (BM!), Sri Lanka, Sabaragamuwa, Sinjahara Natural Reserve, mixed *Dipterocarpus* forest, trail to Moulawella peak, alt. 470 m, *He* 1485;1587 (H!).

Discussion

The Indian material of *Pogonatum marginatum* enabled study of several features of this species that have not been documented previously, e.g. spore surface. The spores appeared smooth under the light microscope but in *P. marginatum*, as in all species of the *Racelopus* group, they actually have small cone-like structures evenly distributed on the surface as illustrated for example in Smith (1974) for *Polytrichum*. This is an apomorphy of the *Racelopus* group as other *Pogonatum* species have granulose spore surfaces.

Our novel chloroplast sequences further confirmed the identity of the plant. Sequences of *rbc*L and *rps*4 from the Indian material were identical to those obtained for the specimen from Sri Lanka, while there was only a single nucleotide difference in the *trn*L-F region. This is not surprising in the case of the relatively conserved *rbc*L and *rps*4 coding regions, although even in these genes there are small differences between *Pogonatum marginatum* and closely related species of the same group. However, the Indian and Sri Lankan specimens were also completely identical even in the intron of the *rps*4 gene as well as in the *trn*L-F region, excepting the single substitution in the latter. To put this into perspective, when all currently available samples of the genus are compared for the *trn*L-F region after Clustal X (Larkin *et al*. 2007) alignment using the default settings, 15% of the sites are parsimony informative. Clearly such

values are alignment/topology specific (e.g. Wheeler 2012), although further discussion of this matter is beyond the scope of the current study.

The parsimony analysis based on the matrix from Bell & Hyvönen (2010) produced the same number of equally parsimonious trees as in that study (1536) with a length of 1774 (as compared with 1664 in the original study). The topology of the consensus (Nixon & Carpenter 1996) tree was identical, excepting the positions of the new exemplars, which appeared in a clade with *P. neesii*, although with a bootstrap support value of less than 50%. The three new specimens formed a group with the maximal bootstrap support value of 100%, with *P. camusii* sister to a clade comprising the Sri Lankan and Indian exemplars of *P. marginatum* also with a bootstrap value of 100%.

Pogonatum marginatum is so far known only from India, Sri Lanka and Vietnam. Occurrence on Mauritius still has to be considered as doubtful. As discussed by Touw (1986), the record could be a case of mislabeling resembling the one reported by Hyvönen (1989) for *P. cirratum* Brid. subsp. *macrophyllum* (Dozy & Molk.) Hyvönen. However, there are a number of species occurring on Mauritius (e.g. *Radulina hamata* (Dozy & Molk.) W.R. Buck & B.C. Tan and *Trachyphyllum inflexum* (Harv.) A. Gepp.) that are widely distributed in tropical Southeast Asia and beyond (e.g. Buck 1979, Frahm *et al*. 2009, Tan *et al*. 2007), thus occurrence of *P. marginatum* on the island would not be surprising. Sri Lanka and the Western Ghats in Peninsular India are generally treated as a single biodiversity hotspot (Gunawardene *et al*. 2007). However, high local endemism has been observed in many animals recently studied (Bossuyt *et al*. 2004). The two areas belong to the same Indian craton that was originally part of the 250 million-year-old Gondwanaland. It is currently assumed that this plate approached Eurasia during early to mid-Tertiary, ca 35–57 My BP (Ali & Aitchison 2008). The Western Ghats and Sri Lanka were connected until the Miocene (Biswas & Pawar 2006), and even during the last 500,000 years, due to changes in sea level, these two areas have been repeatedly in connection (Karanth 2003). It has been postulated that Indochina also has its origin as part of Gondwana (Ridd 1971), but the area has an extremely complex geological history and parts of Indochina are assumed to have already collided with southern China by the middle or late Triassic (Ridd 1980). The two areas (the Western Ghats plus Sri Lanka and Indochina) today share similar ecological conditions and wet subtropical forests, and although now separated they were part of a continually wet biome until ca 1.6–5 My BP (Karanth 2003), while a disjunct range reminiscent of that of *P. marginatum* has been observed in many animals and plants (Karanth 2003). The restricted distribution of *P. marginatum* in just three countries in South and Southeast Asia and its occurrence in the evergreen wet forests of the Western Ghats stresses further the need for conservation of these forested areas, especially the evergreen forests, because any disturbance resulting in the opening of the forest canopy could lead to loss of humidity and threats to sensitive and delicate bryophytes such as *P. marginatum*.

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References

Ali, J.R. & Aitchison, J.C. (2008) Gondwana to Asia: Plate tectonics, paleogeography and the Biological connectivity of the Indian sub-continent from the Middle Jurassic through latest Eocene (166–35 Ma). *Earth-Science Reviews* 88: 145–166. http://dx.doi.org/10.1016/j.earscirev.2008.01.007

Bell, N.E. & Hyvönen, J. (2010) Phylogeny of the moss class Polytrichopsida (BRYOPHYTA): generic-level structure and incongruent gene trees. *Molecular Phylogenetics and Evolution* 55: 381–398. http://dx.doi.org/10.1016/j.ympev.2010.02.004

Biswar, S. & Pawar, S.S. (2006) Phylogenetic tests of distribution patterns in South Asia: towards an integrative approach. *Journal of Biosciences* 31: 95–113. http://dx.doi.org/10.1007/BF02705240

Bossuyt, F., Meegaskumbura, M., Beenaerts, N., Gower, D.J., Pethiyagoda, R., Roelants, K., Mannaert, A., Wilkinson, M., Bahir, M.M., Manamendra-Arachchi, K., Ng, P.K.L., Schneider, C.J., Oommen, V.O. & Milinkovitch, M.C. (2004) Local endemism within the

Western Ghats–Sri Lanka biodiversity hotspot. *Science* 306: 479–481.
http://dx.doi.org/10.1126/science.1100167

Buck, W.R. (1979) A revision of the moss genus *Trachyphyllum* Gepp (Thuidiaceae). *Brittonia* 31: 379–394.
http://dx.doi.org/10.2307/2806131

Dozy, F. & Molkenboer, J.M. (1854–1861) *Bryologia Javanica, seu description muscorum frondosorum Archipelagi Indici*, Vol. I. Lugduni-Batavorum: E.J. Brill. Leiden,161 pp.

Frahm, J.-P., O´Shea, B.J. & Ho, B.-C. (2009) The moss flora of Mauritius. *Archive for Bryolog* 51: 1–26.

Gunawardene, N.R., Daniels, A.E.D., Gunatilleke, I.A.U.N., Gunatilleke, C.V.S., Karunakaran, P.V., Nayak, K.G., Prasad, S., Puyravaud, P., Ramesh, B.R., Subramanian, K.A. & Vasanthy, G. (2007) A brief overview of the Western Ghats-Sri Lanka biodiversity hotspot. *Current Science* 93: 1567–1572.

Hyvönen, J. (1989) A synopsis of the genus *Pogonatum* (Polytrichaceae, Musci). *Acta Botanica Fennica* 138: 1–87.

Karanth, K.P. (2003) Evolution of disjunct distributions among wet-zone species of the Indian subcontinent: testing various hypotheses using a phylogenetic approach. *Current Science* 85: 1276–1283.

Larkin, M.A., Blackshields, G., Brown, N.P., Chenna, R., McGettigan, P.A., McWilliam, H., Valentin, F., Wallace, I.M., Wilm, A., Lopez, R., Thompson, J.D., Gibson, T.J. & Higgins, D.G. (2007) Clustal W and Clustal X version 2.0. *Bioinformatics* 23: 2947–2948.
http://dx.doi.org/10.1093/bioinformatics/btm404

Mitten, W. (1859) Musci Indiae Orientalis. *Journal of the Proceedings of the Linnean Society, Botany* 1 (Supplement): 1–171.
http://dx.doi.org/10.1111/j.1095-8339.1859.tb02466.x

Nixon, K.C. & Carpenter, J.M. (1996) On consensus, collapsability, and clade concordance. *Cladistics* 12: 305–321.
http://dx.doi.org/10.1111/j.1096-0031.1996.tb00017.x

Ridd, M.F. (1971) South-East Asia as a part of Gondwanaland. *Nature* 234: 531–533.
http://dx.doi.org/10.1038/234531a0

Ridd, M.F. (1980) Possible Palaeozoic drift of SE. Asia and Triassic collision with China. *Quarterly journal of the Geological Society of London* 137: 635–640.
http://dx.doi.org/10.1144/gsjgs.137.5.0635

Smith, G.L. (1969) New combinations in Polytrichaceae. *Phytologia* 18: 403.

Smith, G.L. (1974) New developments in the taxonomy of Polytrichaceae: Epiphragm structure and spore morphology as generic characters. *Journal of the Hattori Botanical Laboratory* 38: 143–150.

Smith, G.L. (1987) Notes on Asiatic Polytrichaceae I, II. *Memoirs of the New York Botanical Garden* 45: 466–469.

Tan, B.C., Koponen, T. & Norris, D.H. (2007) Bryophyte flora of the Huon Peninsula, Papua New Guinea. LXX. Sematophyllaceae (Musci) 1. *Acanthorrhynchium*, *Acroporium*, *Clastobryophilum*, *Pseudopiloecium*, *Radulina* and *Trichosteleum. Annales Botanici Fennici* 44: 35–78.

Touw, A. (1986) A revision of *Pogonatum* sect.*Racelopus*, sect. nov., including *Racelopus* Dozy & Molk., *Pseudoracelopus* Broth. and *Racelopodopsis* Thér. *Journal of the Hattori Botanical Laboratory* 60: 1–33.

Wheeler, W.C. (2012) *Systematics: a course of lectures*. Wiley-Blackwell. New York, 426 pp.
http://dx.doi.org/10.1002/9781118301081