



# An account of Section *Crispidium* of *Fissidens* Subgen. *Pachyissidens* in Western Ghats of India with description of a new variety and an extension range

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**ABSTRACT:** The present paper provides an account of section *Crispidium* (Müll. Hal.) Pursell & Brugg.-Nann. of *Fissidens* Hedw. subgenus *Pachyissidens* (Müll. Hal.) Kindb. in Western Ghats, India along with description of a new variety *F. crispulus* var. *nelliampathiae*. *Fissidens subangustus* Fleisch. is also recorded here as new report for Kerala State. A brief taxonomic description, line drawing illustration and identification key to the species of the section are provided to facilitate their future easier identification.

**KEY WORDS:** *Fissidens*, *F. crispulus* var. *nelliampathiae*, India, *Pachyissidens*, taxonomic key, Western Ghats.

## INTRODUCTION

The monotypic family Fissidentaceae Schimp. was established by Schimper (1856) and its infrageneric classifications attempted by many bryologist like Brotherus (1924), Norkett (1969), Bruggeman-Nannenga (1978), Iwatsuki and Inoue (1984), Pursell (1988), Bruggeman-Nannenga *et al.* (1994), Pursell and Allen (1994), Pursell and Bruggeman-Nannenga (2004) and Suzuki *et al.* (2018). The most recent classification by Suzuki *et al.* (2018) is based on combined molecular and morphological evidence and they recognize three subgenera *Pachyissidens*, *Neoamblyothalia* and *Fissidens*. According to Pursell and Bruggeman-Nannenga (2004) which is the widely accepted scheme of classification recognise four subgenera, *Aloma* Kindb., *Fissidens*, *Octodicerus* (Brid.) Broth. and *Pachyissidens* (Müll. Hal.) Kindb., divided on the basis of new taxonomically significant characters such as peristome type, costa type, and number of files of exothecial cells. Subgenus *Fissidens* consists of sections *Fissidens* and *Sarawakia* and subgenus *Pachyissidens* is divided into three sections, *Amblyothallia*, *Crispidium* and *Pachyissidens*. There is no sections for *Aloma* Kindb. and *Octodicerus* (Brid.) Broth. *Crispidium* (Müll. Hal.) Pursell & Brugg.-Nann. is a small section of the subgenus *Pachyissidens* (Müll. Hal.) Kindb., consisting of few species distributed in Asia, Africa, Malaysia, Australasia, and Oceania. The species are characterised by zippelianus-type of peristome. The highly developed axillary hyaline nodules are the conspicuous feature of this section. However, as a note of caution, large axillary hyaline nodules are also present in several species of section *Pachyissidens*. These axillary nodules also occur in other subgenera and sections where they usually are not as well developed. Infertile specimens of section

*Crispidium* are most likely to be confused with those species of section *Pachyissidens* with hyaline axillary nodules since both sections have elimbate leaves and the same type of costa. In such cases, a peristome is needed to establish the proper taxonomic placement. Indeed, these two sections have strikingly different peristomes, but these are not supported by consistent gametophytic differences (Pursell and Bruggemann-Nannenga, 2004). Section *Crispidium* of subgenus *Pachyissidens* contains seven species with two varieties in the Western Ghats. Among the varieties of *Fissidens crispulus* one variety *nelliampathiae* is a new variety described here from Nelliampathi hills in the Western Ghats of Palakkad district.

## MATERIALS AND METHODS

A total of more than 1000 specimens of *Fissidens* were collected during 2013 to 2018 from different microhabitats of the Western Ghats. Among these, the species belonging to section *Crispidium* of the subgenus *Pachyissidens* are included in the present study. Fresh materials were subjected to study whenever possible and herbarium specimens were used in other cases. The external features of the specimens were studied using Stereo dissection microscopes (Labomed Luxeo 4z and Olympus SZ) and anatomical features by compound microscopes (Labomed LX-400, LX-500 & Olympus CX21iLED). Specimens were treated with 1.5 – 3% KOH for 30–60 seconds for better clarity and also for studying cellular characteristics such as cell wall thickness, cellular inclusions, papillosity and mamillosity, cell dimensions, etc. Size of the leaves, cells and capsule were measured by using Pixel Pro & Magnus Pro softwares. The photomicrographs of each species were taken under the compound microscope.



Sections of leaves, stem and seta were also taken for detailed studies. Since the plants are very small, the entire plant is continuously sectioned by placing on a microscopic slide using normal razor blade under dissection microscope. The entire slide was observed under compound microscope and the photographs of correct sections were taken.

## TAXONOMY TREATMENTS

The section *Crispidium* includes seven species and two varieties in Western Ghats. Each species is described in detail with illustration and photographs. Among these one variety of *Fissidens crispulus* var. *nelliampathiae* is reported as a new variety from Nelliampathi hills in the Western Ghats of Palakkad district and *Fissidens subangustus* is recorded as new record for Kerala State.

### Key to the species of the section *Crispidium*

- 1a. Axillary hyaline nodule present; leaves lanceolate or linear lanceolate ..... 2
- 1b. Axillary hyaline nodules absent; leaves oblong lingulate or oblong lanceolate ..... 5
- 2a. Marginal cells differentiated from inner laminal cells ..... *F. javanicus*
- 2b. Marginal cells not differentiated from inner laminal cells ..... 3
- 3a. Dorsal lamina base rounded to wedge shaped ..... 4
- 3b. Dorsal lamina base rounded to fan like ..... *F. lutescens*
- 4a. Stem central strand differentiated; marginal cells of perichaetial leaf not differentiated ..... *F. crispulus*
- 4b. Stem central strand not differentiated; basal marginal cells of vaginant laminae of perichaetial leaf slightly elongated ..... *F. subangustus*
- 5a. Leaf margin having slight deviation at vaginant lamina apex ..... *F. geminiflorus*
- 5b. Leaf margin without deviation at vaginant laminae apex ..... 6
- 6a. Stem axillary hyaline nodules absent ..... *F. excedens*
- 6b. Stem axillary hyaline nodules present ..... *F. polysetulus*

### Key to the varieties of *F. crispulus*

- 1a. Costa percurrent or ending a few cells below apex, laminal cells obscure ..... *F. crispulus* var. *crispulus*
- 1b. Costa shortly excurrent, laminal cell wall distinct ..... 2
- 2a. Leaves 8 pairs or less in number; dorsal lamina base wedge shaped ..... *F. crispulus* var. *robinsonii*
- 2b. Leaves more than 9 pairs; dorsal lamina base not wedge shaped ..... *F. crispulus* var. *nelliampathiae*

*Fissidens crispulus* Brid., Musc. Rec. suppl. 4: 187. 1819. var *crispulus*

### Figs. 1–3

Plants growing in mats, light green, leaf tip curls in herbarium; stem with central strand, 2 or 3 rows of marginal small, thick walled cells and one or two rows of inner large thin walled cells; 4–8 × 1–3 mm, rhizoids smooth, reddish brown, axillary hyaline nodules differentiated, 8–15 pairs of leaves, branched or unbranched; leaves of vegetative stem lanceolate, tip acute, margin crenulate towards tip, 1.00–1.50 × 0.20–0.50 mm, 4 or 5 times long as wide; limbidium absent;

vaginant laminae slightly opened or closed, unistratose, 0.16–0.20 μm wide at base, vaginant laminae basal cells slightly elongated, reaching ±1/2 apical leaf length; dorsal lamina base rounded to wedge-shaped, normally not decurrent, but slightly decurrent in some leaves, 5–7 cell wide, apical lamina and dorsal lamina unistratose; costa prominent, ending 2–5 cells below leaf apex, bryoides type; mid dorsal laminal cells slightly convex with conical mammillae, 11.30–12.63 μm; mid vaginant laminal cells plane, rectangular, 10.90–13.24 × 10.10–11.20 μm; gemmae not found.

Dioicous, perigonia terminal, antheridia 0.30–0.35 mm long; perichaetia terminal, stem 4–6 mm long, perichaetial leaf 1.80–2.20 mm long, leaves differentiated, narrower and longer than vegetative stem leaves, marginal cells of vaginant laminae more or less differentiated, archegonia 5–10, sporophyte not found.

**Diagnostic characters:** *Fissidens crispulus* is characterised by its large, hyaline axillary nodules, lanceolate to narrowly lanceolate, elimbate leaves with acute to mucronate leaf apex, mamillate laminal cells and closed or slightly open vaginant laminae. It can be confused with *F. taxifolius* Hedw. which, however, is easily distinguished by lack of axillary hyaline nodules. It also shows similarity with *F. subangustus* in having prominent axillary hyaline nodules and slightly differentiated marginal cells of sheathing laminae in perichaetial leaves, but differs by presence of distinct mamilla in cells and widely acute to mucronate leaf apex.

**Habitat and General Ecology:** This species is the most common member of Fissidentaceae in Western Ghats in all altitudinal ranges and found in all types of macrohabitat. Its tolerance is very high compared to other species and it can habituate to a wide range of terrestrial, aquatic and epiphytic habitats such as, soil, land cuttings, wet and dry rocks, tree base, roots of higher plants, land cuttings, laterite stones, cement wall, decayed matters and water flowing rocks along with other bryophytes such as *Cyathodium cavernarum* Kunze., *Dumortiera hirsuta* (Sw.) Nees, *Hyophila involuta* (Hook.) A.Jaeger, *Bryum coronatum* Schwägr. etc. and ferns.

**Distribution:** India Andaman & Nicobar Islands, Andhra Pradesh, Assam, Darjeeling, Khasia Hills, Bihar, Chhotanagpur, Darjeeling-West Bengal, Orissa, Western Ghats of Kerala, Karnataka, Goa and Tamil Nadu (Daniels, 2010; Daniels and Daniel, 2013; Daniels and Kariyappa, 2019; Schwarz, 2014; Foreau, 1930,1961; Gangulee, 1971; Lal, 2005; Manjula and Manju, 2016; Montagne, 1842; Nair *et al.*, 2005); East Nepal, Sri Lanka, Myanmar, Thailand, Philippines, Japan, China, Malaysia, Madagascar, Reunion, Singapore, Bioko, Cameroon, Central African Republic, Comoros, Democratic Republic of Congo, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Ivory Coast, Kenya, Malawi, Mauritius, Nigeria, Rodrigues, Rwanda,

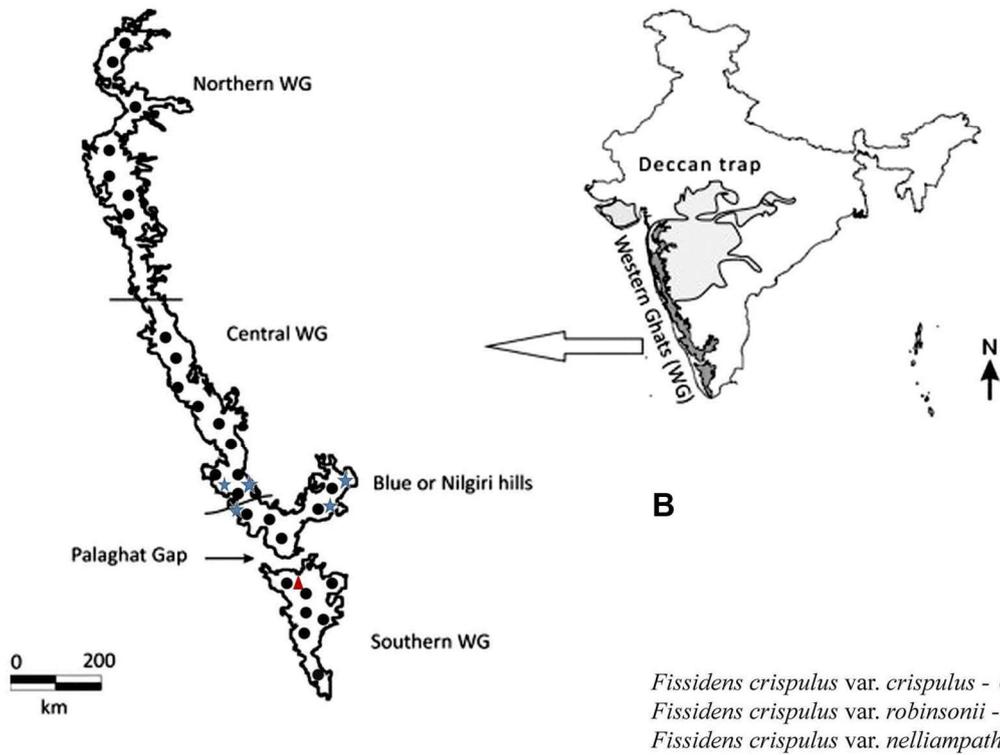
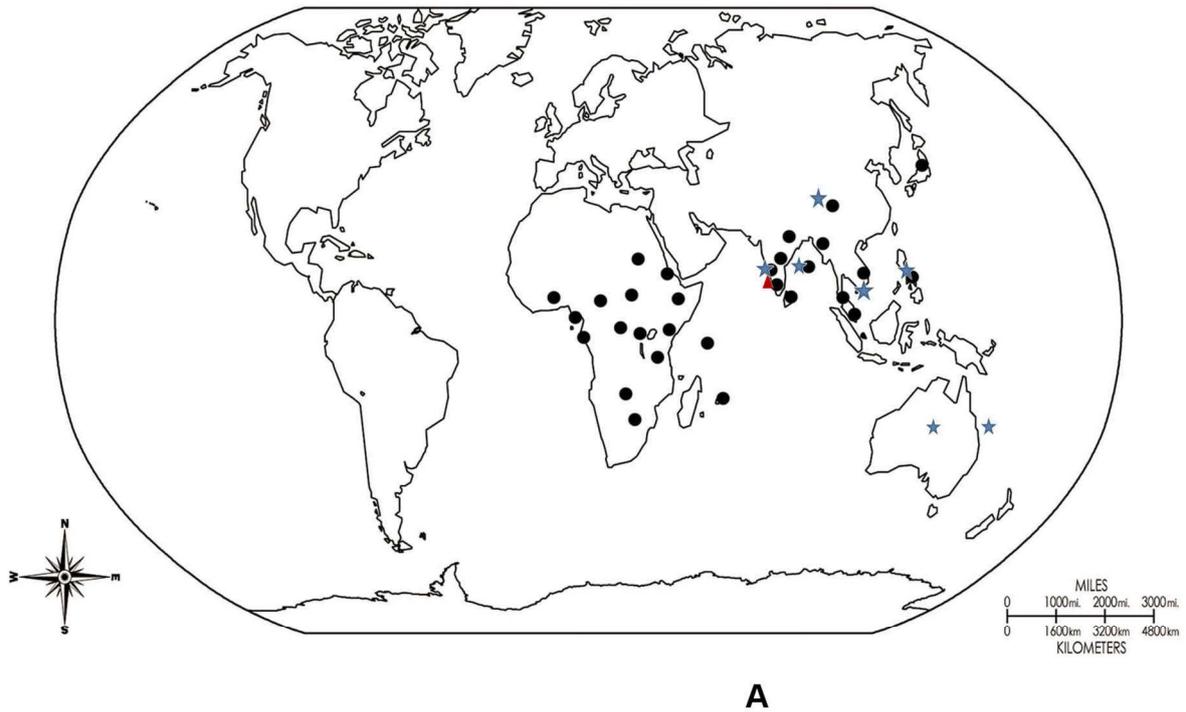
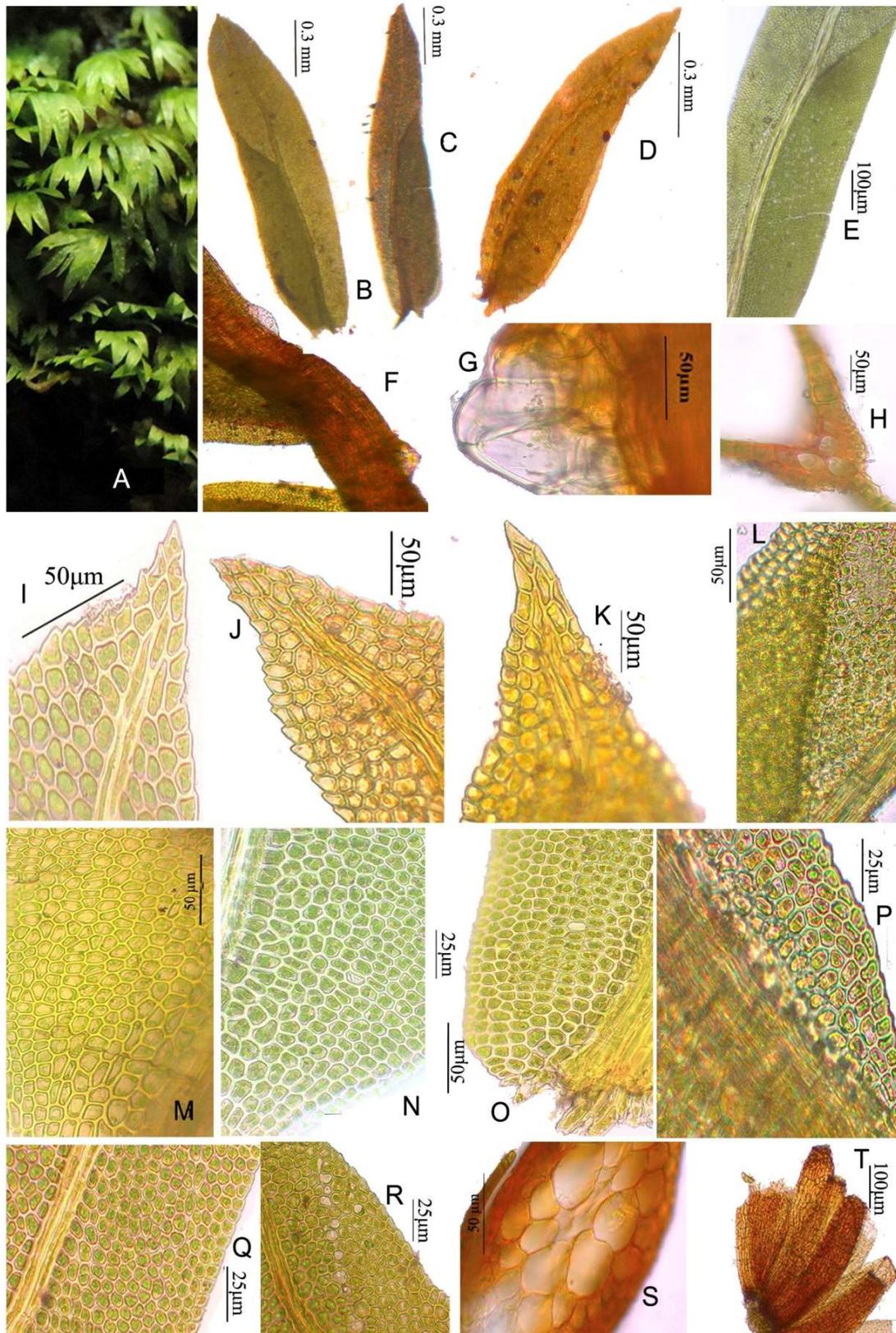
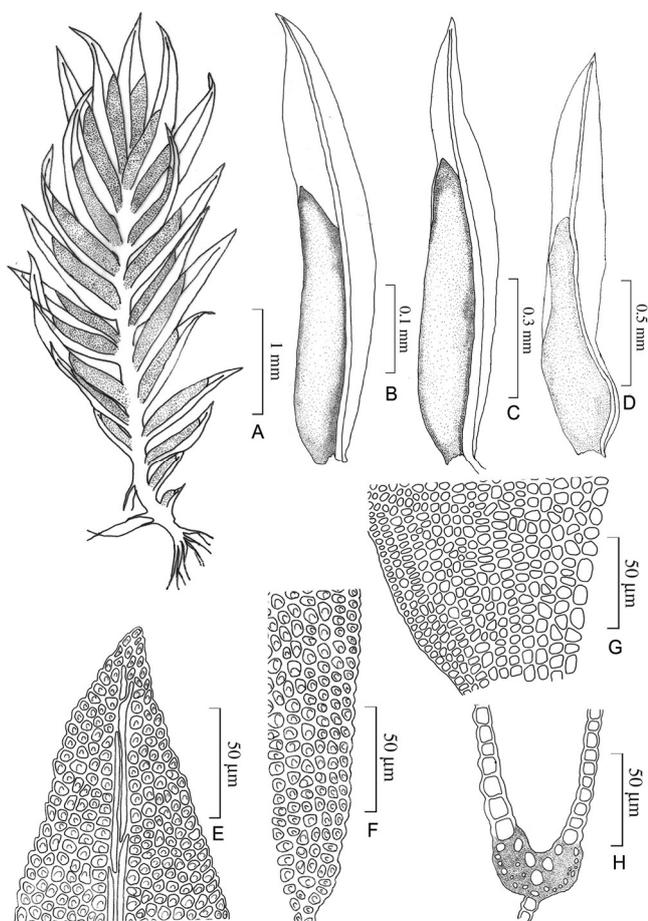


Fig. 1. The distribution of *Fissidens crispulus* with varieties. A. World. B. Western Ghats of India.



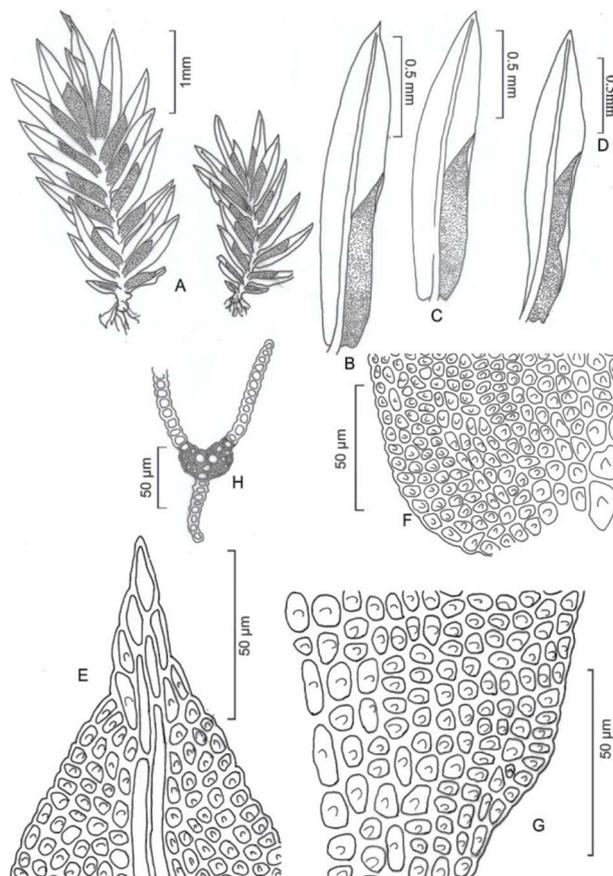
**Fig. 2.** *Fissidens crispulus* Brid. var. *crispulus*; **A**, habit, **B-D**, vegetative leaves, **E**, vaginant laminae, **F & G**, axillary hyaline nodule, **H**, leaf T.S., **I-K**, leaf apex, **L**, vaginant laminae apex, **M & N**, vaginant laminae base, **O & P**, dorsal lamina base near insertion, **Q & R**, laminal cells with leaf margin and costa, **S**, stem T.S., **T**, archegonia (photo from ZGC1138; A & E, K from ZGC671).



**Fig. 3.** *Fissidens crispulus* Brid. var. *crispulus*; **A.** vegetative plant, **B & C.** vegetative leaves, **D.** perigonal leaf, **E.** leaf apex with costa, **F.** dorsal lamina cells near insertion, **G.** vaginant laminae base, **H.** leaf t.s. (drawn from ZGC1138; A & E, K from ZGC671)

Seychelles, Sierra Leone, Sudan, Tanzania, Togo, Zambia, Zimbabwe (Iwatsuki and Suzuki, 1982; Li and Iwatsuki, 2001; O'Shea, 2006).

**Specimens examined:** India, Kerala; Idukki district (Munnar), 5 Feb. 2014, *K.P.Rajesh* (ZGC 995), *Manjula* (ZGC 993), *Manju & Manjula* (ZGC 992, ZGC 999a); Thrissur district (Way to Valparai from Vazhachal), 2 Mar. 2015, *Manjula* (ZGC 4141); Palakkad district (Nelliampathi, 10°53'55" N, 76°68'37" E, 1200m), 13 Jul. 2014, *Manjula*, *K.M.* (ZGC 1138A), Silent Valley NP (Near Sairandri), *Manjula* (ZGC 1001, ZGC 1002); Malappuram district (Canoli plot, Nilambur, 11°26'62" N, 76°20'59" E, 40m), 24 Jul. 2014, *Manjula* (ZGC 671); Kozhikode district (Marippuzha, 11°44'98" N, 76°09'80" E, 637m), 18 Jul. 2013, *Manjula*, *K.M.* (ZGC 612B, ZGC 613, ZGC 614, ZGC 616); Wayanad district (Vellamunda, 11°73'22" N, 75°93'93" E, 1140m), 20 May. 2014, *Manju*, *C.N.* (ZGC 1031B), (Kuruva dweep, 11°82'184" N, 76°08'792" E, 900m), 25 Sep. 2013, *Manjula*, *K.M.* (ZGC 858), (Periya, 11°83'56" N, 75°85'63" E, 744m); Kannur district, Aralam WLS (Valayamchal, 11°55'24.1" N, 75°47'54" E, 63m), 9 Jan. 2015, *Manjula* (ZGC 4017); Karnataka, Uduppi district (Hebri, 13°45'876" N, 74°99'247" E, 76m), 26 Sep. 2013, *Manjula* (ZGC 855A); Goa, Cancona, (Cotigao Wildlife Sanctuary, 88 m), 15 Aug. 2015 *Manjula & Deepa* (ZGC 15124); Maharashtra, Mahabaleshwar, 868 m. 10 Nov. 2016. *Manjula* (ZGC 16202), Nashik (Brahmagiri hills, 1020 m), 16. Sep. 2017, *Manjula* (ZGC 7756).



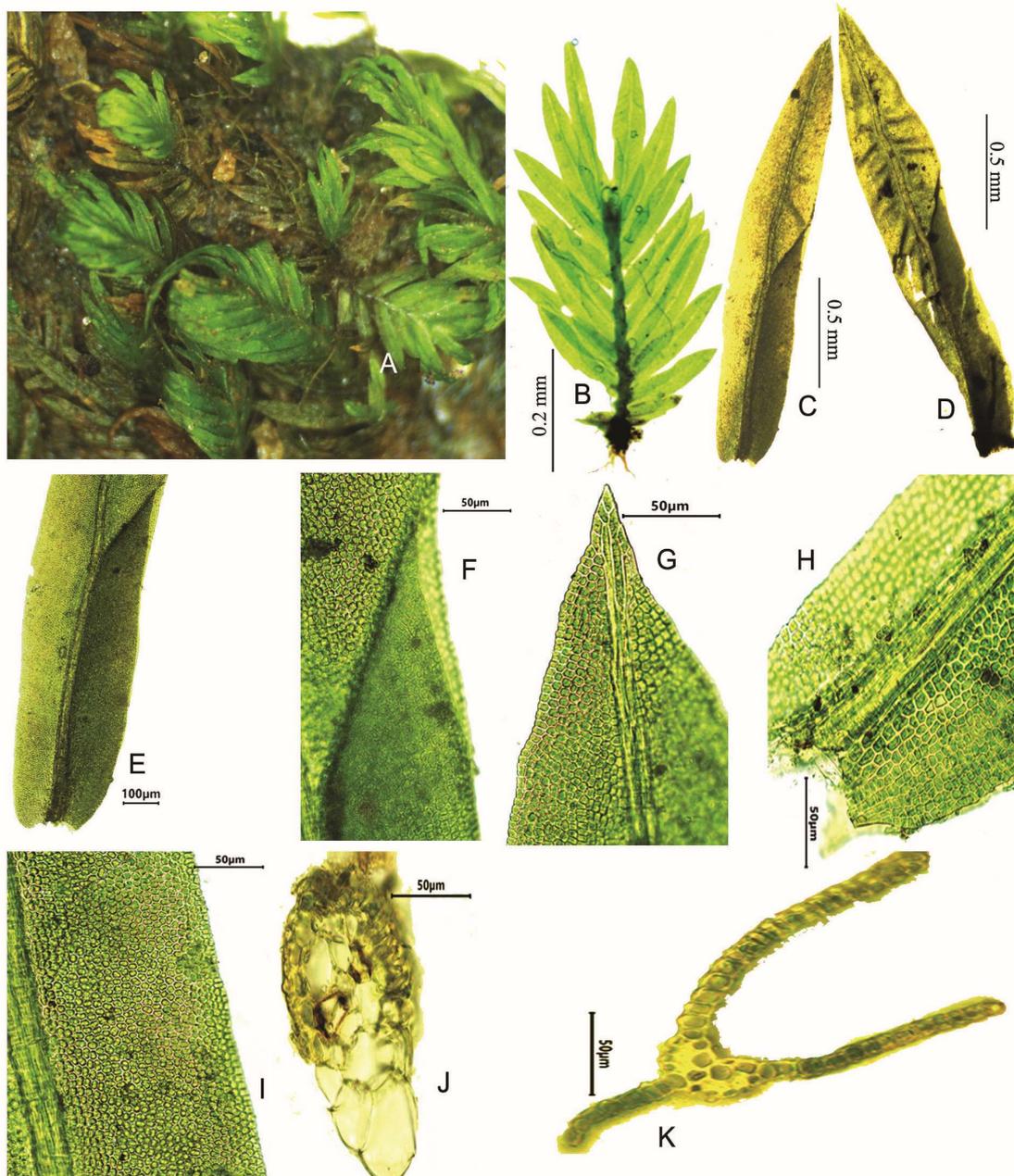
**Fig. 4.** *Fissidens crispulus* var. *nelliampathiae* K.M. Manjula & Manju, var. nov.; **A.** vegetative plant, **B & C.** vegetative leaves, **D.** perichaetial leaf, **E.** leaf apex, **F.** dorsal lamina cells near insertion, **G.** vaginant laminae base, **H.** leaf T.S. (drawn from ZGC15814)

*Fissidens crispulus* var. *nelliampathiae* K.M. Manjula & Manju, var. nov.

**Figs. 1 & 4–5**

**Type:** India, Kerala, Palakkad District (Nelliampathi, 1210m), 10 Nov. 2015, *Maya C. Nair* (ZGC 15814) (Holotype: CALI, Isotypes: ZGC, CAL).

Plants 0.7–1 mm, growing in dense tufts, unbranched, proliferation present in some plants; axillary hyaline nodules differentiated; rhizoids smooth, brownish; leafy stems 3.0–5.0 × 2.0–2.8 mm, central strand slightly differentiated, 8–11 pairs of leaves; leaves 1.40–1.64 × 0.29–0.31 mm, lanceolate, 7 times larger than width, leaf apex acute or apiculate, margin serrate; limbidium absent; vaginant laminae slightly open, 0.76–0.96 mm long, 0.11–0.16 mm wide at base, vaginant laminae ½ the length of leaf, uniseriate; dorsal lamina usually rounded, 6–10 cell wide, dorsal lamina and apical lamina uniseriate; costa stout, shortly excurrent; laminal cells irregularly rounded–hexagonal to irregularly polygonal, mamillate, thin-walled, obscure, mid vaginant laminal cells plane or slightly convex, 13.44–14.31 × 8.18–12.21 μm, mid dorsal laminal cells slightly convex, 11.09–



**Fig. 5.** *Fissidens crispulus* var. *nellampathiae* K.M. Manjula & Manju, var. nov.; **A.** habit, **B.** fertile plant, **C.** vegetative leaf, **D.** perichaetial leaf, **E.** vaginant laminae, **F.** vaginant laminae apex, **G.** leaf apex, **H.** vaginant laminae base, **I.** leaf margin, **J.** stem T.S., **K.** leaf T.S. (photo from ZGC15814)

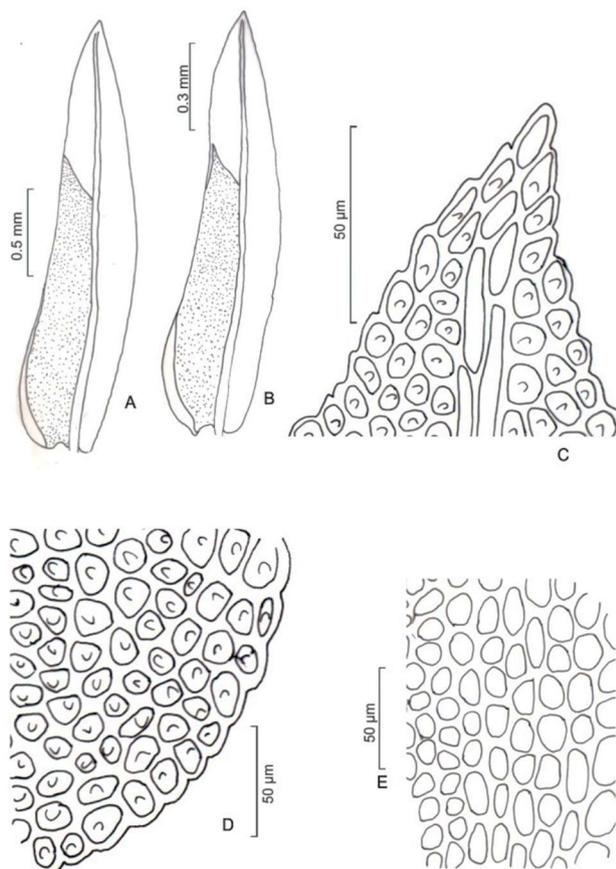
$13.23 \times 8.34\text{--}10.27 \mu\text{m}$ , vaginant laminal cells larger toward the base near costa,  $14.56\text{--}18.18 \times 5.21\text{--}7.16 \mu\text{m}$ ; gemmae not found. Perigonia not found; Perichaetial plant  $4.0\text{--}5.0 \times 2.0\text{--}2.8 \text{ mm}$ , 5–11 pairs of leaves, perichaetium terminal, perichaetial leaves long,  $1.93\text{--}2.33 \times 0.28\text{--}0.33 \text{ mm}$ ; archegonium  $0.24\text{--}0.33 \text{ mm}$  long; sporophyte not found.

**Diagnostic characters:** This species is characterised by presence of axillary hyaline nodules, lanceolate leaves with acute or apiculate apex, mammillose laminal cells, limbidium absent and perichaetia in terminal cluster. This

species shows similarity to typical variety of *F. crispulus* in having elimbate, linear lanceolate leaves and mammillose laminal cells but differs in having decurrent base of dorsal lamina and small, obscure laminal cells. This species also resembles *F. taxifolius* var. *calcuttense* in round dorsal lamina base and mammillose laminal cells while differs in the absence of axillary nodule and costa which is percurrent or ending below leaf apex.

**Distribution:** Endemic to Kerala.

**Habit and General Ecology:** On land cuttings in shaded areas of evergreen forest.



**Fig. 6.** *Fissidens crispulus* var. *robinsonii* (Broth.) T.C. Tan & Choy; **A&B.** vegetative leaves, **C.** leaf apex, **D.** dorsal lamina cells near insertion, **E.** vaginant laminae base (drawn from Manju120159).

*Fissidens crispulus* var. *robinsonii* (Broth.) B.C. Tan & Choy, J. Bryol. 24: 47. 2002.

#### Figs. 1 & 6–7

Plants yellowish-green, brownish when old, rhizoids smooth, basal axillary hyaline nodules differentiated; stem more or less creeping, 4–7 mm long, with 5–7 pairs of leaves, central strand prominent, differentiated; leaves narrowly lanceolate in the upper part, up to 1.5 mm, lowermost leaves much smaller, narrow–elongate, base of dorsal laminae rounded to wedge shaped, margins finely serrulate, limbidium absent; vaginant laminae unequal, reaching 3/4 of leaf length, not terminating on the nerve; costa shortly excurrent, stout, strong, unistratose; cells of apical and dorsal laminae rounded–quadrate to rounded–hexagonal,  $7.0\text{--}10.5 \times 5\text{--}8 \mu\text{m}$ , thick walled, mamilllose, walls clear, cells of extreme base of vaginant laminae larger,  $15\text{--}20 \times 10\text{--}14 \mu\text{m}$ , thick walled, apical lamina and dorsal lamina unistratose; gemmae not found.

Fertile parts not found.

**Diagnostic characters:** *F. crispulus* var. *robinsonii* (Broth.) Iwatsuki & Li is characterised by its plants with axillary hyaline nodule, linear lanceolate leaves, slightly

excurrent costa and differentiated central strand of stem.

**Habitat and General Ecology:** On land cuttings in plantations and moist deciduous forests growing in dense tufts with creeping stem. *Fissidens crispulus* Brid. var. *crispulus* is a widely distributed species in all microhabitats, but the distribution of variety *robinsonii* is restricted to plantations and moist deciduous forest. This species is also growing as pure vegetation.

**Distribution:** India (Andaman & Nicobar Islands, Kerala, Tamil Nadu (Daniels, 2010; Daniels and Daniel, 2005, 2013; Daniels and Kariyappa, 2019; Manju *et al.*, 2008; Nair *et al.* 2005); Australia (Queensland) China, Malaysia, New Caledonia, Oceania, Philippines (Beever, 2014; Li and Iwatsuki, 2001).

**Specimens examined:** India: Kerala, Wayanad district, Wayanad Wild life sanctuary, 1978 plantation 883 m, *MCN 84348* (CALI!); Kozhikode district, Kakkayam (750 m) *Manju 120159* (CALI!)

*Fissidens excedens* Broth., Rec. Bot. Surv. India 1(12): 315. 1899.

#### Figs. 8–10

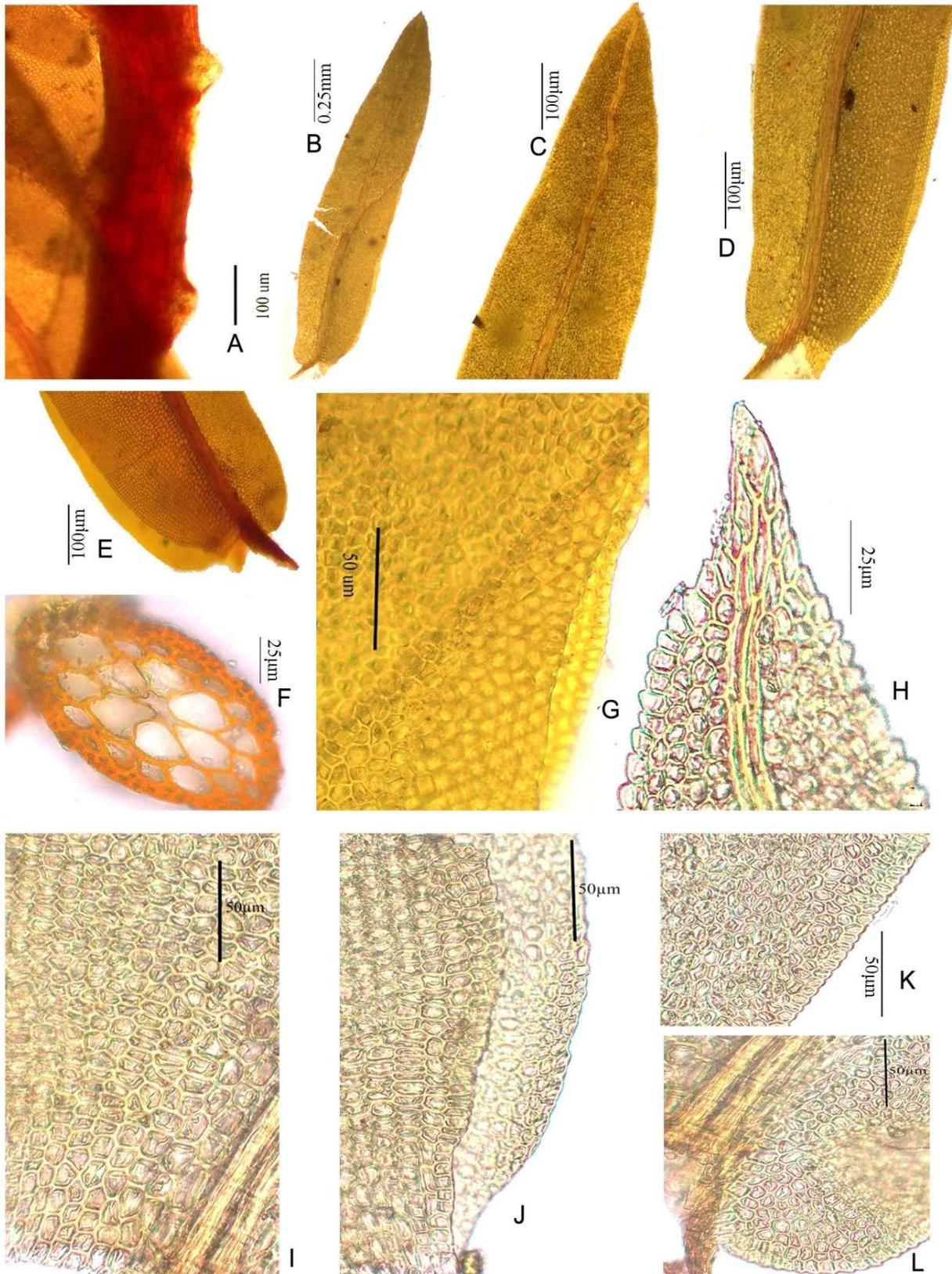
Plants light green colour, usually not branched, rhizoids smooth, basal; axillary hyaline nodules absent; 11–14 pairs of leaves, oblong lingulate, apex acute with short apiculus, leaves 1.8–2.0 mm long with broad base, margin crenate; limbidium absent on all laminae; costa strong, excurrent in short apiculus, costa have a bending on vaginant laminae, vaginant laminae 0.9–1.3 mm long, reaching more than half of leaf length, vaginant laminae apex slightly open, minor lamina unequal, unistratose; dorsal lamina margin crenate, base up to 13 cells wide, base rounded, not decurrent, joins to costa near the insertion of leaf, apical lamina and dorsal lamina unistratose; laminal cells irregularly polygonal, cell wall moderately thickened, mamilllose,  $0.9\text{--}1.0 \mu\text{m}$  long, laminal cells near costa elongated; gemmae not found.

Fertile parts, most probably rhizautoicous, *perigonial* branch at the base of sterile plants, up to three pairs of leaves, *perigonial* leaves linear lanceolate, antheridia terminal; *perichaetium* not found; sporophyte not found.

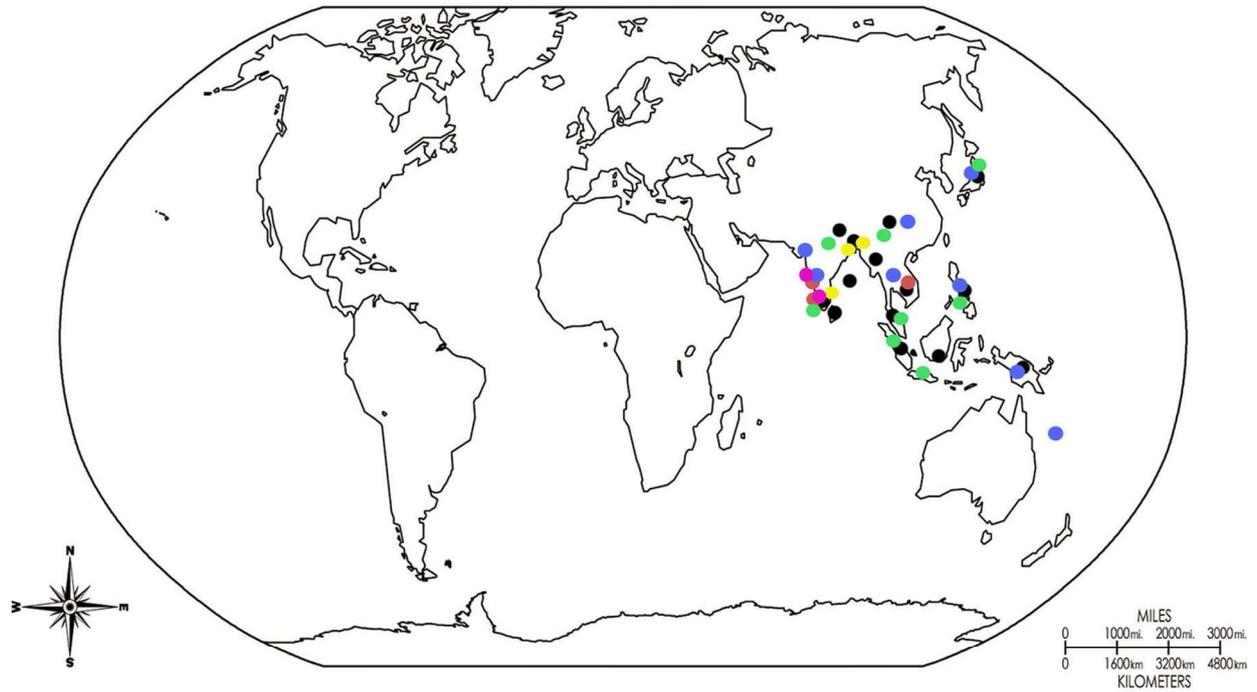
**Diagnostic characters:** *F. excedens* Broth. is characterised by its large plants without axillary hyaline nodules, oblong lingulate leaves, excurrent costa and mamilllose laminal cells. This species shows similarity with *F. crispulus* Brid. in mamilllose laminal cells and crenate leaf margin but the latter differs in the presence of axillary hyaline nodule and oblong lingulate leaves. *F. excedens* also confused with *F. taxifolius* in leaf apex, mamilllose cells and absence of axillary hyaline nodule while this species have more number of leaves with oblong lingulate leaves and unequal vaginant laminae apex.

**Note:** The type was collected by Brotherus (1899) from South India. But we could not locate the type during the present study. The present description is based on the authentic specimen from CAL.

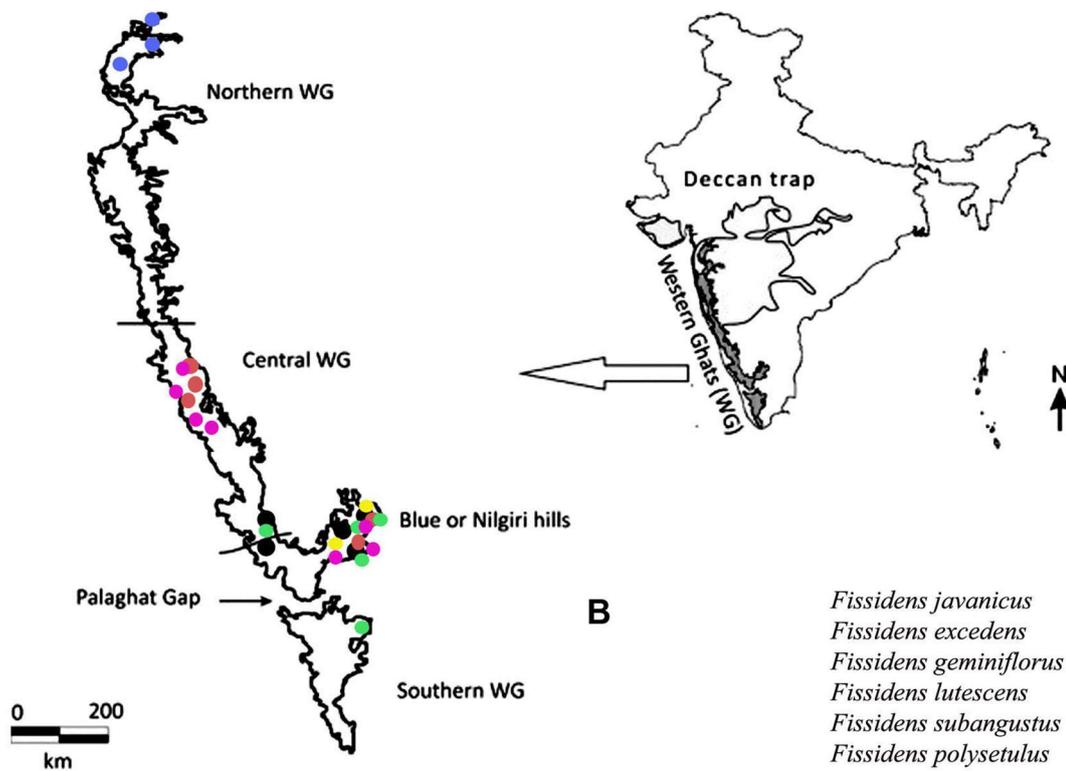
**Habitat and General Ecology:** On rocks and stones in evergreen forests at an altitude above 1800 m.



**Fig.7.** *Fissidens crispulus* var. *robinsonii* (Broth.) B.C. Tan & Choy.; **A.** axillary hyaline nodule, **B.** leaf, **C.** leaf apex, **D** & **E.** leaf base showing vaginant laminae, **F.** stem T.S., **G.** vaginant laminae apex, **H.** leaf apex, **I** & **J.** vaginant laminae base, **K.** leaf margin, **L.** dorsal lamina base near insertion (photo from *Manju120159*).



**A**



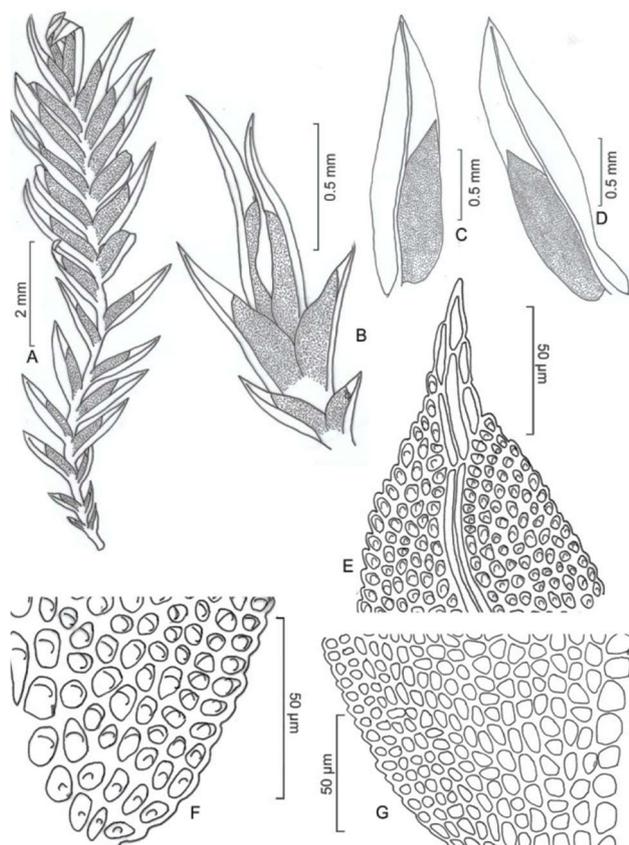
**B**

- Fissidens javanicus* ●
- Fissidens excedens* ●
- Fissidens geminiflorus* ●
- Fissidens lutescens* ●
- Fissidens subangustus* ●
- Fissidens polysetulus* ●

**Fig. 8.** Distribution of Section Cripidium of *Fissidens* subgenus *Pachyfissidens* (6 species) **A.** in the World. **B.** in Western Ghats.



**Fig.9.** *Fissidens excedens* Broth.; **A.** vegetative plant, **B.** fertile branch, **C & D.** vegetative leaves, **E & F.** perichaetium, **G & H.** vaginant laminae, **I & J.** leaf apex, **K & L.** vaginant laminae apex, **M & N.** leaf base near insertion (photo from *Foreau 1 CALI*).



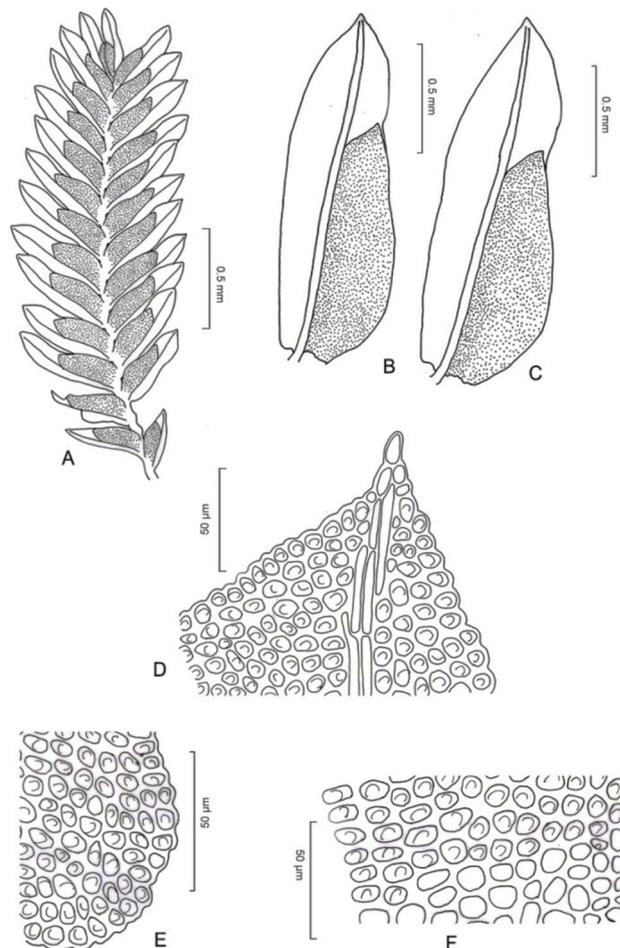
**Fig. 10. *Fissidens exceedens*** Broth.; **A.** vegetative plant, **B.** fertile plant, **C & D.** vegetative leaves, **E.** leaf apex, **F.** dorsal lamina cells near insertion, **G.** vaginant laminae base (drawn from Foreau 1 CAL!).

**Distribution:** India (Karnataka, Tamil Nadu), Thailand (Brotherus, 1899; Dixon and Potier de la Varde, 1927, 1930; Foreau, 1930, 1961; Schwarz, 2014; Tixier, 1979).

**Specimens examined:** India, Tamil Nadu, Palni Hills, Shembaganur, 1850 m, July, 1958, *G. Foreau* (*Foreau-1*) (CAL!), 1959, *G. Foreau s.n.* (CAL!).

***Fissidens geminiflorus*** Dozy & Molck., Pl. Jungh. 316. 1854. **Figs. 8 & 11–12**

Plants yellowish green, slender, unbranched, 3.0–12.0 × 3.2–5.0 mm, small branch like proliferations are present, stem reddish brown in herbarium; rhizoids basal, smooth; 6–17 pairs of leaves, slightly imbricating near leaf insertion; stem axillary hyaline nodule absent; leaves spreading, oblong lanceolate, basal leaves reduced or scale like, 1.0–1.5 × 0.5–0.7 mm, leaf base broad, margin more or less smooth, slight curve at vaginant laminae apex, leaf apex acute with short apiculus; costa strong, reaching upto apex or shortly excurrent; limbidium absent on all laminae; vaginant laminae broad, reaching 1/2 – 2/3 of leaf length, apex mostly closed or rarely slightly open, unistratose; dorsal lamina base round, not decurrent, apical lamina and dorsal lamina unistatose; laminal cells irregularly



**Fig. 11. *Fissidens geminiflorus*** Dozy & Molck.; **A.** vegetative plant, **B & C.** vegetative leaves, **D.** leaf apex, **E.** dorsal lamina cells near insertion, **F.** vaginant laminae base (drawn from Larse et al. 2299 BM!).

quadrate to polygonal, mamilliose, cell wall moderately thick walled, cells of vaginant laminae base near costa elongated 10–12 μm long; gemmae not found.

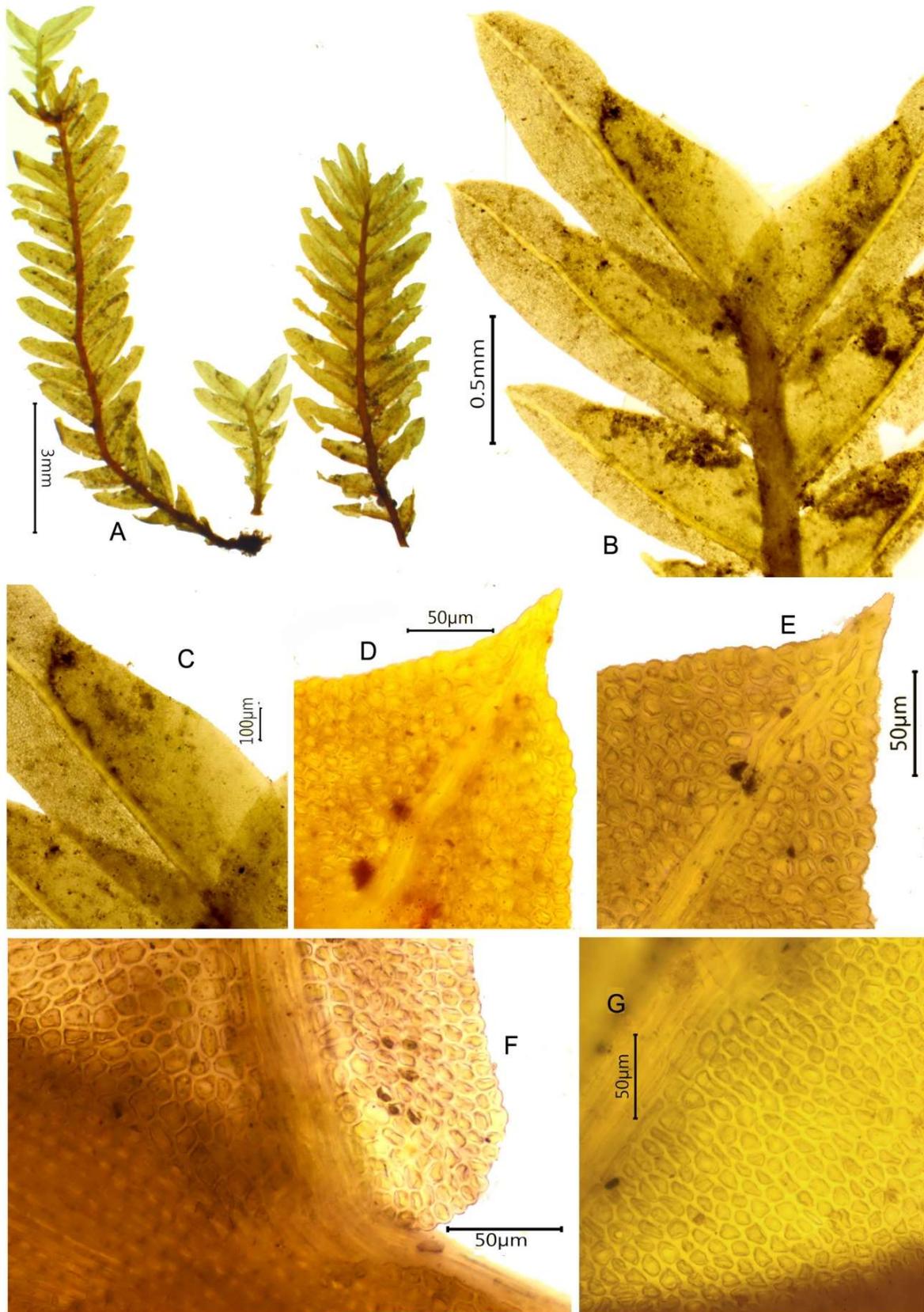
Fertile parts not found.

**Diagnostic Characters:** This species is characterised by plants with spreading oblong lanceolate leaves, leaves elimbate, acute apex with short apiculus, laminal cells mamilliose. This species is allied to *F. crispulus* in mamilliose laminal cells, elimbate leaves and acute apex. But *F. geminiflorus* is characterized by oblong lanceolate leaves, absence of axillary hyaline nodules and slightly curved margin at vaginant laminae apex.

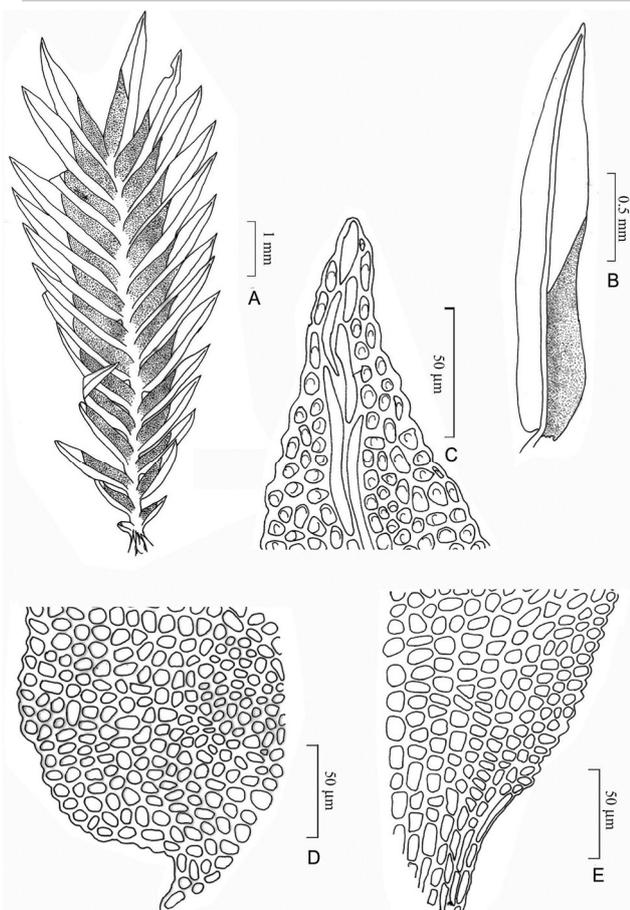
**Habitat and General Ecology:** Plants growing on large rocks at an altitudinal range of 120–720m in evergreen forest.

**Distribution:** India (Maharashtra, Western Ghats of Gujarat), China, Fiji, Japan, New Guinea, Philippines, Thailand (Lecointe and Geissler, 1990; Tan and Iwatsuki, 1991; Iwatsuki and Suzuki, 1996).

**Specimen examined:** Kannur, Aralam WLS, (60m) Babu, 1396 (ZGC); Thailand (No details), Larse et al. 2299 (BM!).



**Fig.12.** *Fissidens geminiflorus* Dozy & Molk.; **A.** vegetative plants, **B.** vegetative leaves, **C.** vaginant laminae, **D & E.** leaf apex, **F.** dorsal lamina base near insertion, **G.** vaginant laminae base (photo from *Larse et al.* 2299 BM!).



**Fig. 13. *Fissidens javanicus*** Dozy & Molk.; **A.** vegetative plant, **B.** vegetative leaf, **C.** leaf apex with costa, **D.** dorsal lamina cells near insertion, **E.** vaginant laminae base (drawn from *Kerr 305* BM!).

*Fissidens javanicus* Dozy & Molk., *Bryol. Jav.* 1:11. 1855. **Figs. 8 & 13–14**

Plants green, yellowish green to brownish; leafy stems simple, but usually with innovations from the axils of upper leaves, 8–18 mm long, 2.3–4.0 mm wide; axillary hyaline nodules well developed; central strand only slightly differentiated; leaves in 18–38 pairs, densely arranged; middle to upper leaves linear-lanceolate to lanceolate, 2.0–2.7 × 0.30–0.45 mm, acuminate at apex, the upper half of leaves usually more or less rugose; base of dorsal laminae often rounded; vaginant laminae ca. 1/2 of the leaf length, upper part equal to somewhat unequal; costa stout, slightly excurrent; margins crenulate; margins of apical and dorsal laminae forming a thick band of 2–3 cells wide and 2–3 cells thick; margins of vaginant laminae forming a thinner band 2–3 cells wide and 1 cell thick; cells of apical and dorsal laminae sub-isodiametric, 7–9 μm wide, thick-walled, mammillose; cells of vaginant laminae similar to those of apical and dorsal laminae, but slightly larger and well demarcated with thicker cell walls.

Fertile parts not seen.

**Diagnostic characters:** *Fissidens javanicus* is characterised by margins of apical and dorsal laminae forming a thick band of 2–3 cells wide and in cross section 2–3 cells thick and the laminal cells are mammillose. This species is similar to *F. crispulus* in climbate leaves, mammillose laminal cells and presence of axillary nodule on stem but differentiated by the distinct leaf marginal cells of *F. javanicus* which is evident in all leaf along with comparatively larger leaves.

**Habit and General Ecology:** On large rocky patch where water drips regularly along with hornworts and liverworts in homestead plantations.

**Distribution:** India (Andaman Island, Assam, Tamil Nadu (Daniels and Kariyappa, 2007; Gangulee, 1971); China, Indonesia, Japan, Java, Malaysia, Myanmar, Nepal, New Guinea, Philippines, Sri Lanka, Thailand (Li and Iwatsuki, 2001) (Map 6A & 6B).

**Specimens examined:** Tamil Nadu, Way to Valparai from Vazhachal, (70m), *Manjula* (ZGC4141b; East Indies, Archipelagi Indici, Ser.II. No. 50–100, 1899, *Fleisch 79* (CAL!); Thailand, *A. Kerr 305* (BM!).

*Fissidens lutescens* Broth., *Rec. Bot. Surv. India* 1(12): 311–329. 1899. **Figs. 8 & 15–16**

Plants in mats, rhizoids smooth, axillary and basal; stem erect, mostly unbranched, 3–5 × 1.7–2.0 mm, axillary hyaline nodules present; leaves linear lanceolate, 1.3–1.7 × 0.6–0.8 mm, margin entire, apex widely acute; climbate; costa not excurrent, reaching 2–4 cells below apex; vaginant lamina reaching more than half of leaf length, vaginant laminae unequal, minor lamina open, unistratose; dorsal lamina base round, fan like, not decurrent, margin more or less smooth except leaf apex, dorsal lamina and apical lamina unistratose; laminal cells irregularly quadrate to hexagonal, 9.0–10.2 μm long, cell wall moderately thick walled, mammillose, vaginant laminae basal cells near costa large, 13–16 μm; gemmae not found.

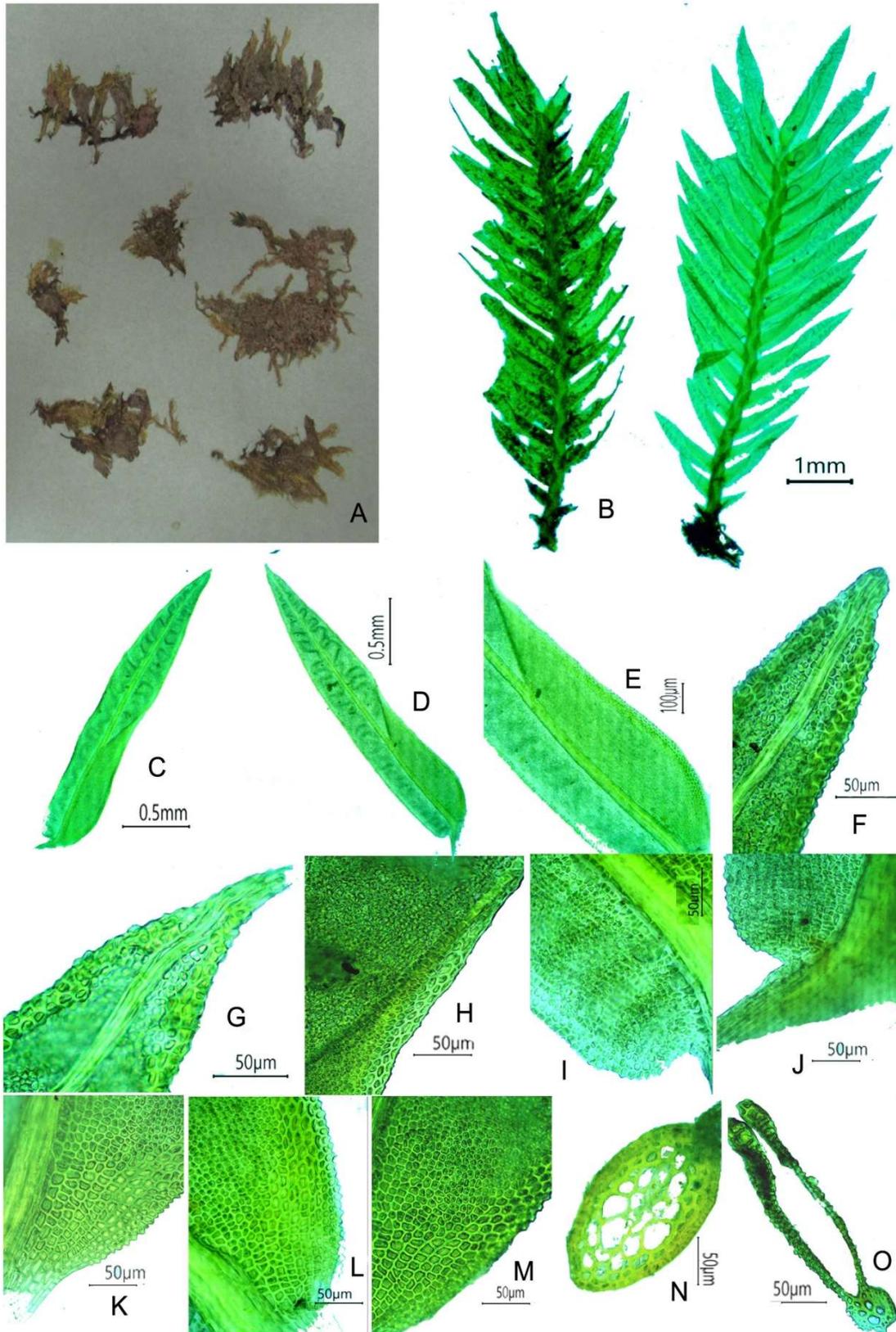
Fertile parts not found

**Diagnostic characters:** *Fissidens lutescens* is characterised by presence of axillary hyaline nodules on stem, linear lanceolate leaves, widely acute leaf apex and mammillose laminal cells. This species is similar to *F. crispulus* in leaves, mammillose cells and stem axillary hyaline nodule but differs in having widely acute leaf apex, costa not excurrent and fan like dorsal lamina base.

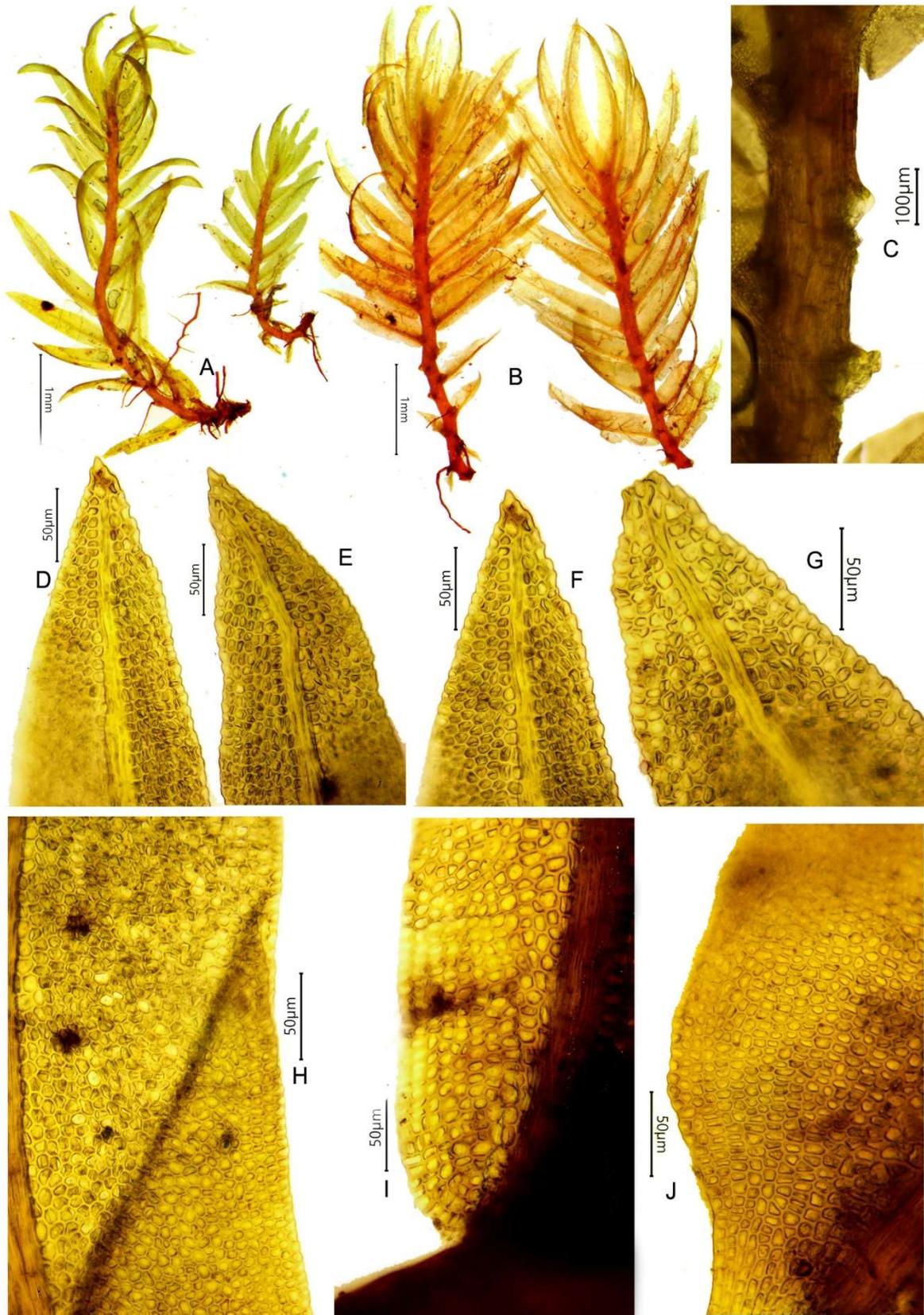
**Habitat and General Ecology:** On land cuttings in low altitude areas in moist deciduous forest.

**Distribution:** India: Karnataka; Tamil Nadu, Tirunelveli, Courtallam (Dixon and Potier de la Varde, 1927, 1930; Foreau, 1964; Daniels, 2010).

**Specimen examined:** India, Tamil Nadu, Courtallam, Tirunelveli, *Foreau 13* (BM!); Karnataka; Banks near Verajpet, *Coorg, Walker 159* (BM!).



**Fig. 14.** *Fissidens javanicus* Dozy & Molk.; **A.** habit in herbarium, **B.** vegetative plants, **C & D.** vegetative leaves, **E.** vaginant laminae, **F & G.** leaf apex, **H.** vaginant laminae apex, **I & J.** dorsal lamina base near insertion, **K-M.** vaginant laminae base, **N.** stem T.S., **O.** leaf T.S. (photo from *Kerr m 305 BM!*).



**Fig.15.** *Fissidens lutescens* Broth.; **A & B.** vegetative plants, **C.** axillary hyaline nodule, **D-G.** leaf apex, **H.** vaginant laminae apex, **I.** dorsal lamina base near insertion, **J.** vaginant laminae base (photo from *Foreau 13 BM!*)

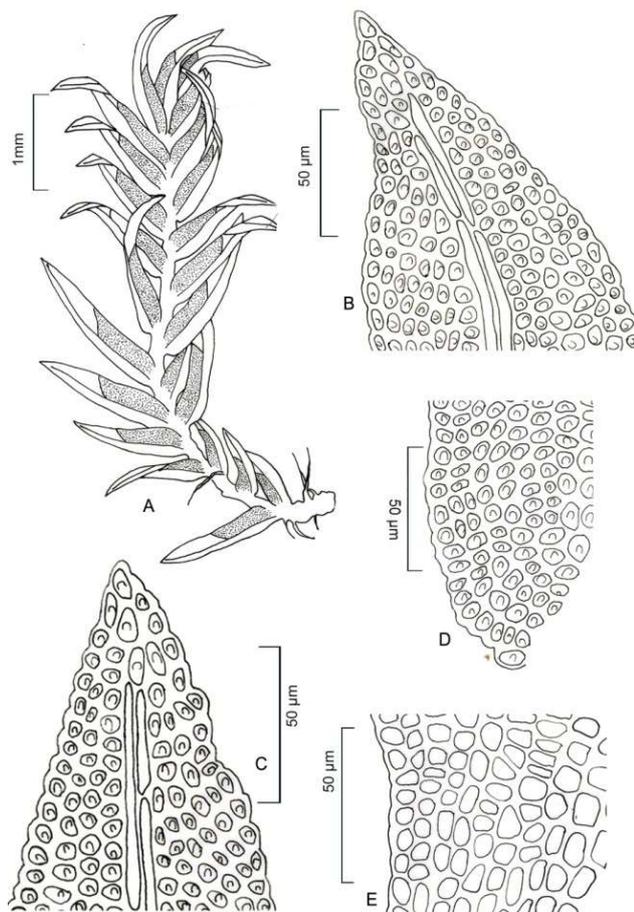


Fig. 16. *Fissidens lutescens* Broth.; A. vegetative plant, B & C. leaf apex, D. dorsal lamina cells near insertion, E. vaginant laminae base (drawn from Foreau 13 BM!)

*Fissidens polysetulus* Müll. Hal. ex Nork. & Gangulee, Moss. E. India 1(2): 525. F. 248. 1971.

#### Figs. 8 & 17

Plants caespitose, 5–9 mm long, yellowish green to dark green; rhizoids basal, smooth; stem usually simple, rarely branched, central strand absent, thick cortical cells and thin, large medullary cells; axillary hyaline nodule present; leaves lanceolate to oblong lanceolate, 7–11 pairs, margin entire, leaf apex acute in short apiculus; limbidium absent on all leaves; costa strong, excurrent, ends in short apiculus at leaf apex; vaginant laminae equal, minor lamina closed, more than half of leaf length, unistratose; dorsal lamina base round, fan like, not decurrent, dorsal lamina and apical lamina unistratose; laminal cells irregularly rounded to polygonal, mamillate, obscure, up to 10 µm long; gemmae not found.

Perigonium not found, perichaetial plants similar to vegetative plants, perichaetium terminal, perichaetial leaf much longer, 1.8–2.0 mm long, vaginant laminae base broad, marginal cells at base of vaginant laminae slightly elongated but not cartilaginous as limbidium; sporophyte not found.

**Diagnostic characters:** *F. polysetulus* is characterised by presence of axillary hyaline nodules, absence of stem central strand, lanceolate to oblong lanceolate leaves, closed vaginant laminae, costa excurrent in short apiculus, dorsal lamina base spread but not decurrent. This species is similar to *F. crispulus* in mamillate laminal cells, elimbate leaves and presence of axillary nodules on stem while differs in the dorsal lamina base which is fan like and the strong, excurrent costa with short apiculus.

**Habitat and General Ecology:** On soil in homestead and evergreen forest plantations in medium altitude areas.

**Distribution:** India: Sikkim, West Bengal, Western Ghats of Tamil Nadu (Gangulee, 1971; Daniels *et al.*, 2018), endemic.

**Specimen examined:** India: Tamil Nadu, Coimbatore dist., Valparai (820m) A.E.D. Daniels 8915 (SCCN!); India, Sikkim, Darjeeling (6000ft), Kurz 2192 (CAL!).

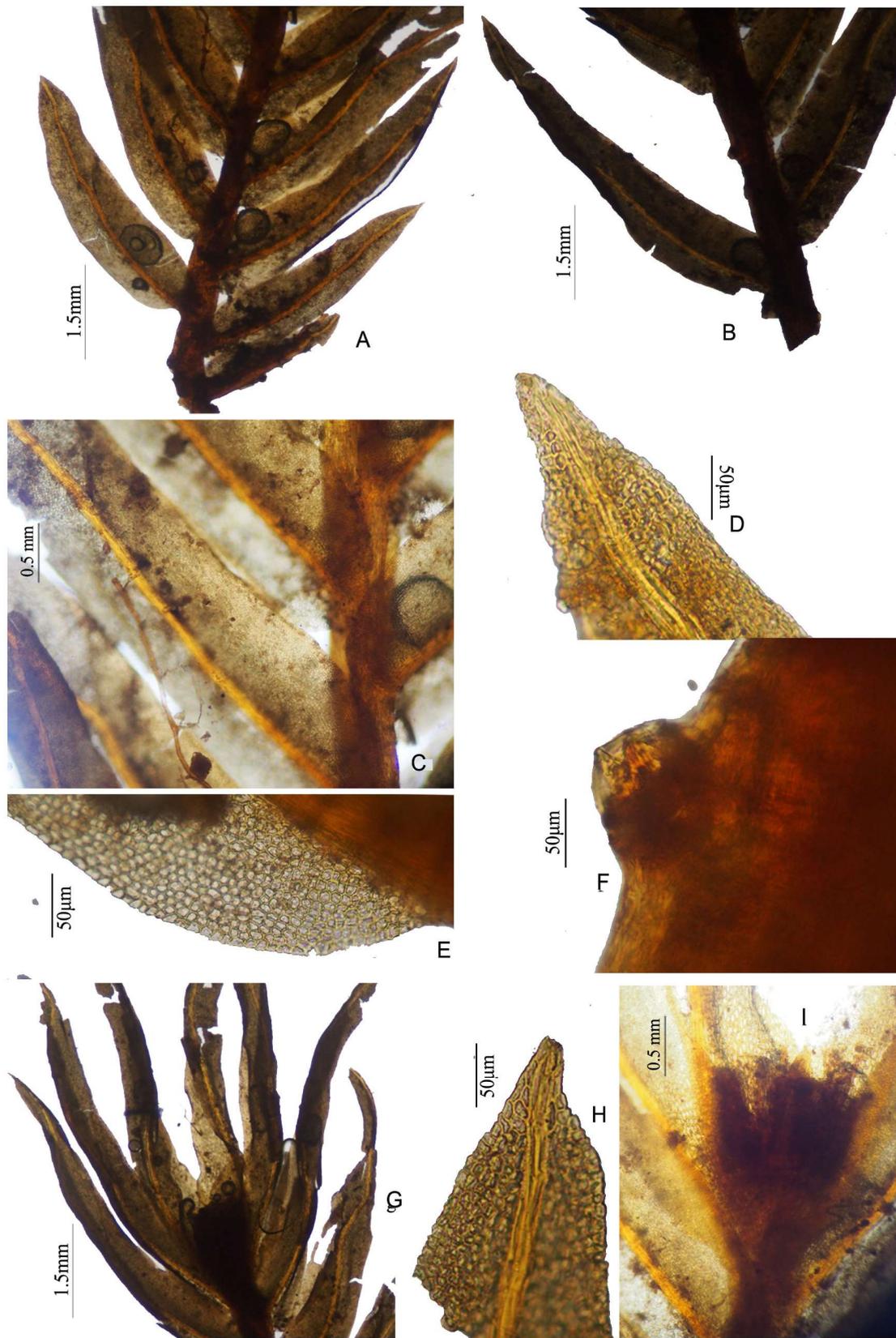
*Fissidens subangustus* Fleisch., Die Musci der Flora von Buitenzorg. 1: 47. 1904.

#### Figs. 8 & 18–19

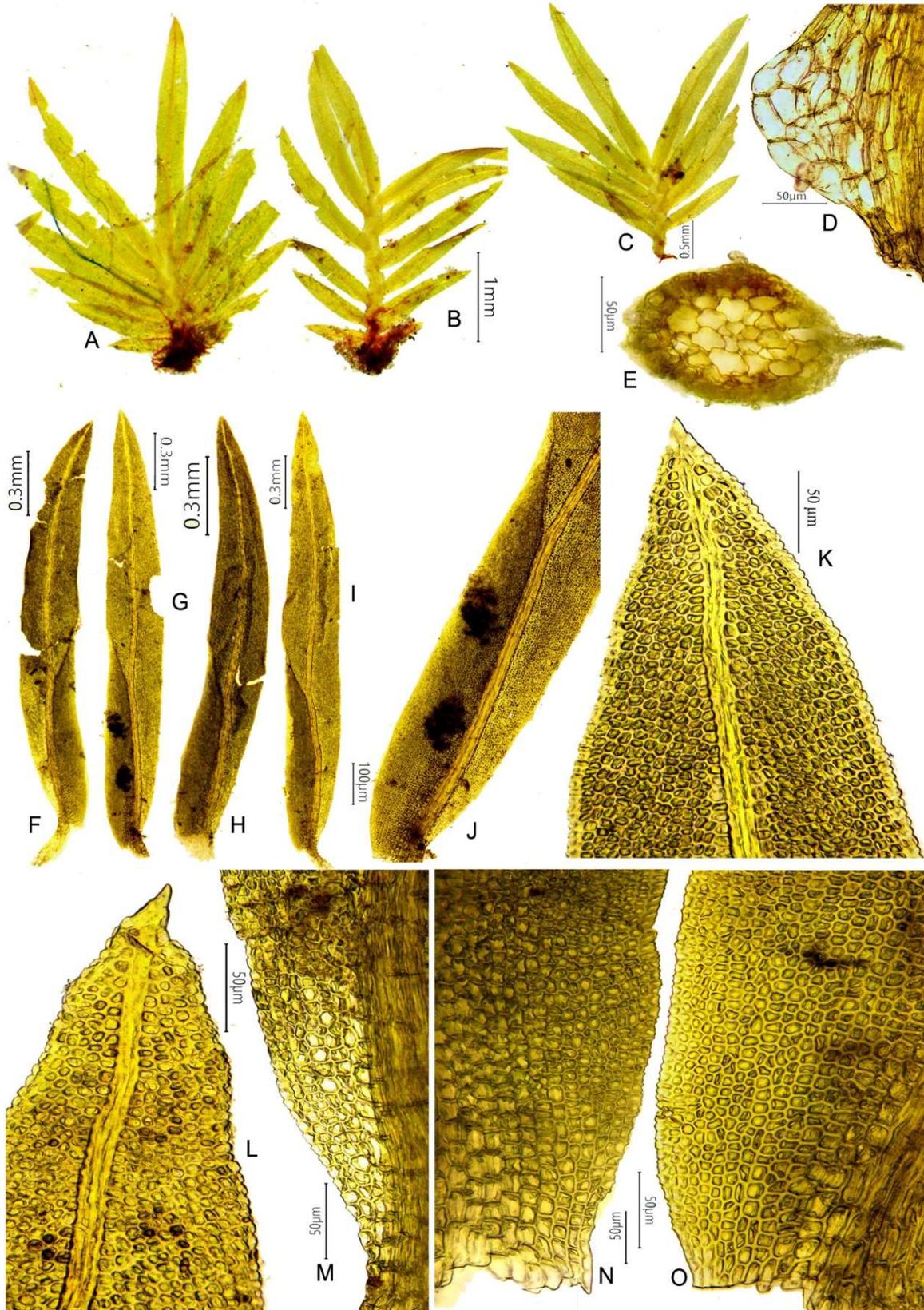
Plants small, green to dark green, leafy stems simple, 4–5 mm long, 2.0–2.5 mm wide; rhizoids smooth, basal; axillary hyaline nodules well differentiated; cortical stem cells small, thick-walled; central strand not differentiated; leaves in 6–11 pairs, lower leaves small, upper leaves much larger, densely arranged, distinctly curled at apex when dry, upper leaves narrowly lanceolate, 2.5–3.0 mm × 0.25–0.37 mm, narrowly acute at apex, margins minutely crenulate throughout by projections of laminal cells; limbidia not differentiated on most of the leaves, but marginal cells of vaginant laminae of perichaetial leaves more or less elongated; vaginant laminae about 1/2 the leaf length; base of dorsal laminae wedge-shaped, not decurrent; costa stout, percurrent; cells of apical laminae round to rounded-hexagonal, 5–10 µm long, thin-walled to moderately thickened, bulging, unipapillose or 1–3 minute papillae, cells of vaginant laminae similar to those of apical laminae, but slightly larger and much larger near costa; gemmae not found.

Fertile parts, dioicous; perigonium not seen; perichaetium terminal on stems, setae 8–10 mm long, smooth; capsule slightly inclined, exothecial cells thin walled, peristome spirally thickened with minute papillae, spores almost smooth.

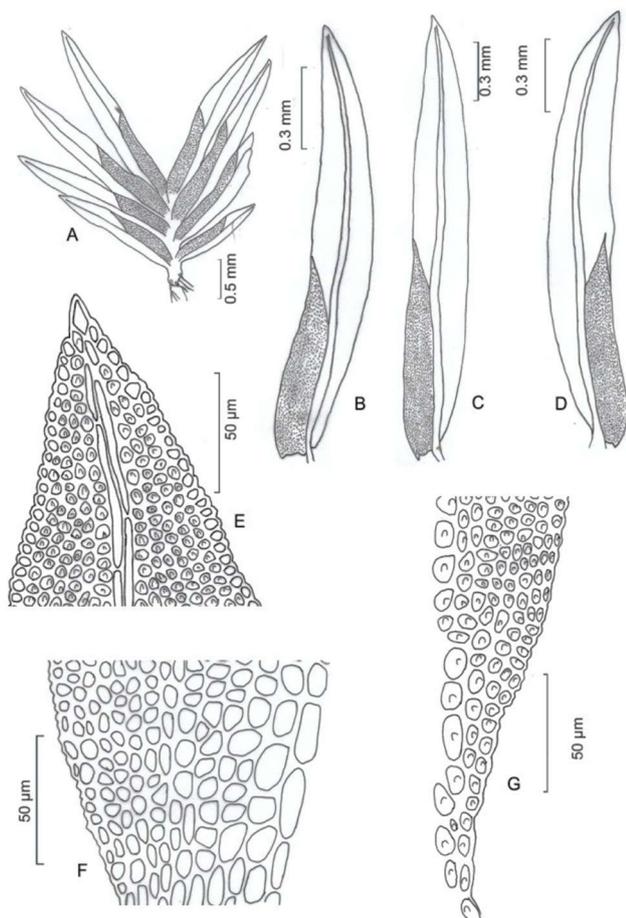
**Diagnostic characters:** *Fissidens subangustus* is characterised by well developed axillary hyaline nodules, acute to narrowly acute leaf apex, multipapillose laminal cells. This species looks rather similar to *F. crispulus* by the distinct axillary hyaline nodules, lanceolate leaves with acute apex. However, the leaves of the present species differ in the strongly curled apices when dry and rounded-hexagonal laminal cells with 1–3 minute papillae.



**Fig. 17.** *Fissidens polysetulus* Kurz.; **A & B.** vegetative leaves, **C.** vaginant laminae base, **D.** leaf apex, **E.** dorsal lamina base near insertion, **F.** axillary hyaline nodule, **G.** perichaetial branch, **H.** perichaetial leaf apex, **I.** perichaetium (photo from *Kurz 2192 CAL!*)



**Fig.18.** *Fissidens subangustus* M. Fleisch.; **A-C.** vegetative plants, **D.** axillary hyaline nodule, **E.** stem T.S., **F-I.** vegetative leaves, **J.** vaginant laminae, **K & L.** leaf apex, **M.** dorsal lamina base near insertion, **N & O.** vaginant laminae base (photo from *Ber42 CAL!*).



**Fig. 19.** *Fissidens subangustus* Fleisch., **A.** vegetative plant, **B-D.** vegetative leaves, **E.** leaf apex, **F.** vaginant laminae base, **G.** dorsal lamina cells near insertion (photo from *Ber* 42 CAL!).

**Habitat and General Ecology:** On wet rocks, cliffs, on soil and land cuttings in stream side mainly in evergreen forest associated with *F. crispulus* var. *robinsonii* in low altitude areas.

**Distribution:** India: Eastern Himalaya, Tamil Nadu, Kerala (Daniels, 2010; Daniels and Daniel, 2003, 2013; Gangulee, 1971), China, Japan, Java, Malaysia, Philippines, Sumatra (Iwatsuki and Suzuki, 1982; Li and Iwatsuki, 2001; Tan and Iwatsuki, 1991). The present collection is a new record to Kerala.

**Specimens examined:** India, Kerala, Kannur district, Aralam WLS, Meenmutti, 11°56'65.5"N, 75°52'90"E, 800 m, 17 Sep. 2015, *Manjula* (ZGC 1564); Tamil Nadu, Thirunelveli, Mundanthurai, 240 m, 30 Jul. 1999. *Daniels, A.E.D. 628A!*. NEFA, Foot hills of Aka Hills, 100–300 m, Nov.–Dec. 1933, *N.L.Ber* (*Ber* 42) (CAL!).

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