Taxonomic studies on the family Fissidentaceae Schimp. (Bryophyta) of the Western Ghats

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in partial fulfillment for the requirements for the award of the degree of

Doctor of Philosophy in Botany

by

MANJULA K.M.

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Under the guidance of

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October, 2018

CERTIFICATE

This is to certify that the thesis entitled "**Taxonomic studies on the family Fissidentaceae Schimp. (Bryophyta) of the Western Ghats**" is a research work carried out by Ms. Manjula, K.M., Research Scholar, P.G. & Research Department of Botany under the supervision and guidance of Dr. Manju C. Nair, Assistant Professor of Botany of this College during the period of 2013 - 2018.

(Dr. T. Ramachandran)
PRINCIPAL

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(Dr. Manju C. Nair)
Research Guide

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DECLARATION

I hereby declare that the thesis entitled "**Taxonomic studies on the family Fissidentaceae Schimp. (Bryophyta) of the Western Ghats**" is a bonafide record of research work carried out by me at P.G. & Research Department of Botany, the Zamorin's Guruvayurappan College, Kozhikode, under the guidance of Dr. Manju C. Nair, and no part of this thesis has been previously presented or submitted elsewhere for the award of any degree or diploma or similar title to this or any other University

Place: Z.G. College **(Ms. Manjula, K.M.)**
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Manjula, K.M.

CONTENTS

Plan of the thesis

The thesis starts with the table of content and abbreviations used in the text. Then the chapters are divided into six major sections such as Introduction, Study area, Materials and Methods, Review of Literature, Results & Discussion and Summary & Conclusion appended with Bibliography. A glossary of technical terms for easy use in Bryophyte taxonomy is also provided as Appendix I. Papers published during the study is included as Appendix II.

Chapter I. Introduction - includes general characters and history of the family, phylogeny and intrageneric classification of *Fissidens*, objectives of the present study are included.

Chapter II. Study Area - gives detailed description of its geography, climate and vegetation of the Western Ghats. It is supported with a map.

Chapter III. Review of Literature - includes a general introduction on the work on *Fissidens* under the family Fissidentaceae in the world, India and Kerala.

Chapter IV. Materials and Methods - describes the methodology adopted for collection, herbarium processing and a general outline on the preparation of descriptions, etc. Morphology and terminology used for the identification of the genus *Fissidens* and for taxonomic characterisation in the present study is also provided. Methodology adopted for the ecological studies are also described in this section.

Chapter V. Results & Discussion – the results are summarized under two different headings; Taxonomy and Ecology. Each species is discussed after description as a note.

1. **Systematic treatment of the family Fissidentaceae in Western Ghats** - which forms the major part of the thesis and includes descriptions for the family, genus, subgenera, sections and species. Keys to subgenera, sections and species were also provided. Each species is described with up-to-date nomenclature, including

basiyonym and synonyms, if any, pertaining to India and other parts of the world. The details of protologue, types, detailed description, diagnostic characters, habitat and general ecology, distribution, specimens examined, etc were provided. Details of etymology were also given if available. A note of discussion on each species is provided for all species. Authors of plant names are abbreviated based on Brummit and Powell (1992), and IPNI (www.ipni.org.). Titles of journal are based on Taxonomic literature (Stafleu & Cowan, 1976). The species are arranged according to the latest, revised classification by Pursell and Bruggeman-Nannenga (2004). All the species under each subgenera are arranged alphabetically.

Description of each species is followed by a distribution map showing world distribution. Illustrations and photoplate were provided for each species. Details of habit, and other salient features such as plant morphology, leaves, capsule, spores, etc were also provided. Photos of types and authentic specimens are also provided for some species. Photos of from the field showing the microhabitats of species were also provided for most of them.

2. **Ecology of Fissidentaceae in Western Ghats-** the distribution of the *Fissidens* species in the Western Ghats are analyzed for obtaining the patterns. Cluster analysis was performed based on the incidence data. Sorensen Similarity Index was worked out using the PAST 3.20 software (http://folk.uio.no/ohammer/past) for analysing the patterns of distribution along the gradients of Macrohabitats, microhabitats and altitude.

Chapter VI. Summary & Conclusion: A summary of the work is given, highlighting the details on the contribution by the present study.

A **bibliography** is given at the end citing all the references mentioned in the text and other relevant references pertaining to taxonomic identifications. **Glossary of technical terms** are also provided at the end as Appendix I for easy recognition of taxonomic terms. Papers published during the study is included as Appendix II.

Abbreviations used in the thesis

BLAT	: Blatter Herbarium, Mumbai.
BSI	: Botanical Survey of India
BM	: Natural History Museum
BR	: Brick Wall
BT	: Bark of Trees
CAL	: Central National Herbarium, Culcutta (CNH)
CALI	: Calicut University Herbarium
CO_2	: Carbon di-oxide
cm	: Centi meter
CR	: Crevices of Rocks
CW	: Concrete wall
DDF	: Dry Deciduous Forest
EG	: Evergreen forests
ENP	: Eravikulam National Park
ER	: Exposed roots
FPLN	: Forest Plantations
GR	: Grass Land
HCO_3^-	: Bicarbonate ion
HPLN	: Homestead Plantations
KOH	: Pottassium Hydroxide
KPR	: K.P. Rajesh
LC	: Land Cuttings
LP	: Laterite Plateau
LR	: Large Rocks
LG	: Logs
LSW	: Laterite stone walls
LWG	: Herbarium of NBRI
MH	: Madras Herbarium, Botanical Survey of India, Southern Circle, Coimbatore

MDF	: Moist Deciduous Forest
mm	: milli meter
mM	: milli Molar
NBRI	: National Botanical Research Institute
NP	: National Park
NY	: New York Botanical Garden
pers.comm	: Personal Communication
RF	: Reserve Forest
RM	: Rhizome of ferns
SCCN	: Scott Christian College, Nagercoil
SE	: Semievergreen forest
SEM	: Scanning Electron Microscope
SG	: Sacred Grove
SH	: Shola Forest
SR	: Small Rocks
SS	: Sandy Soil
SMR	: Submerged rocks
SRB	: Scrub Land
TM	: Termite Mount
TR	: Terrestrial on Soil
TG	: Twigs
URB	: Urban areas
WLS	: Wildlife Sanctuary
WR	: Wet rocks
ZGC	: Zamorin's Guruvayurappan College
µm	: Micro meter
**	: Invalid name

Chapter: I

INTRODUCTION

INTRODUCTION

The Fissidentaceae Schimp. are one of the acrocarpic and haplolepideous moss family with a single genus *Fissidens* Hedw. The name "*Fissidens"* is derived from the Latin words '*fissus'*, meaning 'cleft' and '*dens'* meaning 'tooth', referring to split peristome teeth. This is one of the most diversified genera of bryophyta and closely related to Dicranaceae. It is a cosmopolitan genus distributed mainly in the tropics. The genus was established by Hedwig (1801) in Species Muscorum and recognised four species of *Fissidens viz., F. asplenioides* Hedw., *F. palmatus* Hedw., *F. polypodioides* Hedw. and *F. semicompletus* Hedw. Among these, first three species are collected by Swartz from Jamaica and placed in the genus *Hypnum.* Report of *F. semicompletus* is based on original description from Dillenius (1741). Infact, Hedwig (1791-1792) himself described and illustrated these four species before Species Muscorum (1801) in which, this genus is validly published. Based on Hedwig (1791-1792) Bridel (1798) also reported a new addition *F. acacioides* Schrad. from Patagonia in South America, the species was also invalid which is validated by Schrader (1803). Brotherus (1924b) reported a total of 700 species of *Fissidens* all over the world, while recent estimates modified the record of this genus to 450 species worldwide (Crosby *et al.,* 2000) of which, 79 valid species occurs in India (present observation).

The most important characters of the genus *Fissidens* are the distichous nature of the plant body, the adaxial end near the leaf base is differentiated into two vaginant laminae, which clasp the stem, presence of sheathing laminae or vaginant laminae, presence of limbidia in most of the species and peristome of sporophyte. In some members the stem is dimorphic where fertile plants shorter with fewer pairs of leaves and sterile plants with larger stems and the vaginant laminae joined at the distal end is acute in nature. Vaginant laminae are unequal in size in most species. The smaller one is called minor lamina and the larger is the major lamina, which

appears to be a continuation of the apical or ventral lamina. In some species vaginant laminae are equal in size. Limbidial cells are present in some species, in which the marginal leaf cells are differentiated into a band of unistratose to multistratose prosenchymatous stereid cells and are hyaline to yellowish in colour. There are three basic costal types such as bryoides, oblongifolius, and taxifolius types based on transverse sections of costa (Bruggeman-Nannenga, 1990). Oblongifolius type with three stereid bands; two lateral and one adaxial in the proximal part of the leaf. In the bryoides type and taxifolius type, there are two lateral stereid bands in the proximal part of leaf. In oblongifolius type there are 16 peripheral guide cells and five large central cells separating the three stereis bands. In the taxifolius-type four or more peripheral guide cells and as many as five large central cells separating the stereid bands are seen, while in the bryoides type there are two peripheral guide cells and usually just a single large central cell. In some species like *F. hyalinus* Hook. & Wilson and *F. enervis* Sim the costa is absent. But in very few species such as in *F. exilis* Hedw. there is reduced costa. The surface of laminal cells in *Fissidens* may vary in species, unipapillose, pluripapillose, smooth or plane and bulging mamillose cells. A mamillose cell and unipapillose cells are indistinguishable; both have a single hollow protuberance, but in the mamillose type the cells are more or less rounded while unipapillose cells shows sharp-points. Pluripapillose cells are characterised by the presence of a few small, localised thickenings. *F. pellucidus* Hornsch. is the only species in which one or more oil-like droplets in cell lumina, called guttulae is seen (Salmon, 1899). The nature of guttulae is not known. Papillae and guttulae can easily be mistaken.

There are many studies related to the peristome teeth of *Fissidens* but, the studies by Allen (1980); Bruggeman-Nannenga and Berendsen (1990), strongly support that the variations in peristome teeth are useful in determining natural relationships in *Fissidens.* Allen (1980) studied the variations of peristome based on trabeculae and lamellae of dorsal and ventral surfaces in 19 species of *Fissidens*, including two subgenera, by using scanning electron microscope and distinguished seven types of peristomes such as bryoides, scariosus, obtusifolius, zippelianus, similiretis, taxifolius and subbasilaris. Peristome types such as bryoides, scariosus,

taxifolius, zippelianus and similiretis are represented in the members of the present study area. In the bryoides and taxifolius types, the trabeculae on the exterior surface of the undivided parts are higher and distinct from the lamellae. But in the scariosus and similiretis types the trabeculae on the exterior surface of the undivided parts are indistinct from the equally high or higher lamellae. In the taxifolius type, the ornamentation on the exterior surface of the area of bifurcation of the undivided parts changes gradually, while in the other types there is a sudden change. The distal ends may also vary in each type. In the bryoides and scariosus types spirally thickened, in similiretis type they are squamose and taxifolius type have protruding or nodose trabeculae with spiral or vertical lamellar thickenings. Some species shows anomalous peristomes that do not fit into any of the above types. Capsule in most of the species are exserted on elongate setae. But, in *F. fontanus* (Bach. Pyl.) Steud., *F. macrosporus* Dixon and in *F. longtonianus Z.* Iwats. & Tad. Suzuki, the setae are short so that the capsule is immersed and not extending beyond the perichaetial leaves.

Bruggeman-Nannenga and Berendsen (1990) recognised nine types of peristomes in this genus such as, bryoides type, fasciculatus type, sainsburia type, scariosus type, similiretis type, taxifolius type, zippelianus type, obtusifolius type and subbasilaris type. Pursell and Bruggeman-Nannenga (2004) modified these divisions and reduced into four basic types *viz.*, similiretis type, taxifolius type, bryoides type and scariosus type. They also remarked that variations are common among these basic peristome types.

Important studies during nineteenth century revealed many unresolved glitches within this family and it demanded intra generic classification of *Fissidens.* Mueller (1848-1849) published one of the first schemes of classification of *Fissidens.* He introduced four sections *viz.*, *Hydrofissidens* Muell. Hal., *Pachyfissidens* Muell. Hal., *Areofissidens* Muell. Hal., and *Eufissidens* Muell. Hal. Later many workers including Mueller (1850-1851 & 1901) and Mitten (1859 & 1869) amended this classification. *Octodiceras* Brid. proposed for a group of aquatic species, was based on a misinterpretation of Hedwig's illustration of the peristome

of *F. semicompletus* Hedw. Montagne (1837) was the first to recognise this erroneous interpretation and substituted the name *Conomitrium* for this group, based on the form of single peristome of 16 teeth. Kindberg (1897) recognised Fissidentaceae as a monogeneric family with four subgenera; *Aneuron* Kindb., *Pachyfissidens* Muell. Hal., *Aloma* Kindb. and *Eufissidens* Kindb. Subgenus *Aloma* is again divided into three sections; *Camptodontii* Kindb., *Obtusifolii* Kindb. and *Adiantoidei* Kindb. The most widely accepted classification of family Fissidentaceae is proposed by Brotherus (1901) based on Mueller (1901). Brotherus (1924a) again modified and elaborated this system of classification. He described four genera in the family Fissidentaceae with four subgenera and 12 sections. This scheme of classification is recognised as much elaborated and artificial by many workers such as Crum and Steere(1957), Florscheutz (1964), Iwatsuki (1985), Pursell (1988) and Bruggeman-Nannenga and Berendsen (1990). Norkett (1969) suggested a number of changes to improve these systems of classifications and divided the genus to four subgenera, eight sections, four subsections, two series and two subseries. Iwatsuki (1985) used chromosome number in the classification for the first time. He described six subgenera in genus *Fissidens* primarily based on chromosome number. After many changes and modifications Pursell and Bruggeman-Nannenga (2004) presented a new scheme for intrageneric classification of *Fissidens* including four subgenera such as *Pachyfissidens* (Muell. Hal.) Kindb., *Octodiceras* (Brid.) Broth., *Fissidens* and *Aloma* (Muell. Hal.) Kindb. There is no sections for *Aloma* and *Octodiceras*. The subgenus *Pachyfissidens* is divided into three sections *Amblyothallia* Muell. Hal., *Crispidium* Muell. Hal., and *Pachyfissidens*. Subgenus *Fissidens* Hedw. is divided into two sections, *Fissidens* Hedw. and *Sarawakia* (Muell. Hal.) Pursell & Brugg.-Nann. Among these, subgenus *Aloma* (Muell. Hal.) Kindb. and *Pachyfissidens* (Muell. Hal.) Kindb. with all the three sections (*Pachyfissidens* (Muell. Hal.) Kindb., *Amblyothallia* Muell. Hal. and *Crispidium* Muell. Hal.) and section *Fissidens* of subgenus *Fissidens* are represented in the Western Ghats.

The first published record of *Fissidens* from the Western Ghats was from the Nilgiri hills in Tamil Nadu by Montagne (1842). He recorded three species of

Fissidens viz., F. anomalus Mont., *F. bryoides* Hedw. and *F. crispulus* Brid. (as *F. tamarandifolius* var. *crispulus* Brid.). The second report appeared after more than 55 years by Brotherus (1899), who recorded seven species from Karnataka. Later, several authors such as Dixon (1914, 1921), Srinivasan (1974), Vohra *et al.* (1982), Mohamed *et al.* (1986), Ellis (1992a&b), Nair *et al.* (2005), Daniels and Daniel (2003a&b, 2013), Daniels *et al*. (2018), etc. were made random collections of *Fissidens* from the Western Ghats. A total of 115 species of *Fissidens* were reported by different authors from India. Among these 36 were synonymised under their respective names. From the Western Ghats a total of 82 species and 17 varieties and two subspecies were reported (Dandotiya *et al.*, 2011; Lal, 2005; Manju *et al.*, 2008b and Daniels, 2010; Daniels & Daniel, 2013; Daniels *et al*., 2018). Among these, 24 species and two varieties were synonymised under different names by different authors. Due to errors in compilation the list prepared by Dandotiya *et al.* (2011) and Lal (2005) appear bulky, with many more species than originally reported from India. Among the 82 species 17 varieties and two subspecies; 59 species, 10 varieties and two subspecies are validly published in Western Ghats. (Gangulee, 1971; Lal, 2005; Manju *et al.*, 2008b; Daniels, 2010, Dandotiya *et al*., 2011; Daniels & Daniel, 2013) Dandotiya *et al*. (2011) did not mention anything about the collection localities, but by just listing the species. This is evident that the studies on this group is gravely neglected compared to other groups especially in our country. It is mainly due to the lack of literature for identification, small size of the plants, seasonal appearance of fertile parts, the less direct economic potentials and associated glory. This trend may badly lead to deterioration of bryophyte habitat, being replaced by huge buildings or urbanization due to an increasing pressure of population and other anthropogenic activities. The chances are higher for those species in unexplored areas, which may perish and disappear before being documented.

The members of the family Fissidentaceae Schimp. are very specific in their requirements for certain microenvironmental conditions such as pH of the substratum, temperature, light availability, water availability, chemical nature of substrate, etc. They also act as good ecological indicator species. Thus, this group

attracts much attention recently from applied ecologists and conservation biologists. Despite this intrinsic interest and potential for scientific study, a major limitation in the use of bryophytes as study materials for evolutionary and ecological processes has been the lack of basic floristic and alpha taxonomic knowledge of the plants in many regions, especially in the tropics. The present study on *Fissidens*, aims to present a detailed view on the diversity and distribution of this group in the Western Ghats. The Taxonomic studies on the family Fissidentaceae has not attempted by anybody in India. Hence the present study is the first of its kind attempt to document the diversity of this group from the hot spot area, the Western Ghats. This thesis brings novelties and new distribution records for Asia, India, Western Ghats and Kerala. This documentation may kick start further studies on other aspects such as the pharmacological, anti-microbial properties, molecular studies, etc.

Objectives

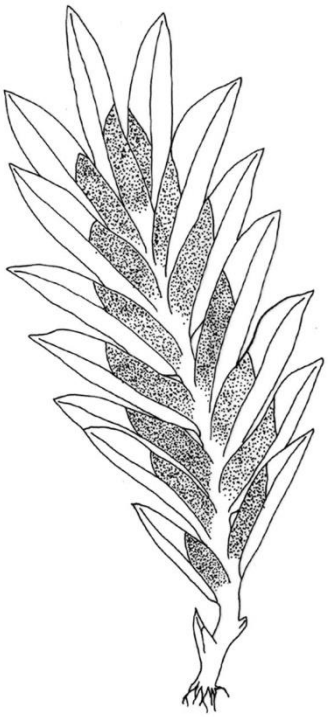
1. A comprehensive field study on the family Fissidentaceae (Bryophyta) of the Western Ghats, in different seasons.

2. Studies on the ecological and economic aspects of the Fissidentaceae of the Western Ghats.

3. Preparation of taxonomic account of the Fissidentaceae, giving up to date nomenclature.

4. Preparation of description, illustration, providing anatomical and morphological details of all the species of Fissidentaceae from the Western Ghats.

5. To assess the problems and prospects of conservation of the family Fissidentaceae in the Western Ghats.



Chapter: II

STUDY AREA – The Western Ghats

STUDY AREA - The Western Ghats

The Western Ghats also known as Sahyadri hills or Sahya mountains is the 1,490 km long and 48-220 km wide unbroken hill chain with the exception at the Palakkad Gap and Goa gap (Map 1).

Western Ghats forms a treasure trove of biodiversity and the water tower of Peninsular India, tracks parallel to the West coast of India from the river Tapti (about $10^0$09' 60.00"N) of Gujarat in the north to Kanyakumari (about $77^0$03' 60.00" E) of Tamil Nadu in the South. On the West, the Ghats steeply drop away to the coastal plains, but merge rather gently through a series of hills with the Deccan plateau. The area is designated as a world heritage site by UNESCO and is one of the hotspots of biological diversity in the world (Myers *et al*., 2000). It is the most influential geomorphic feature in the Peninsular Indian region which determines the climate, vegetation and culture of the states of Maharashtra, Goa, Karnataka, Kerala and Tamil Nadu. Western Ghats harbours a wide variety of plant and animal species along with several endemic and endangered species.

The Western Ghats ranges about 60,000 km² (23,166 sq m) and the forest ranges over 30%. Anamudi located in the Eravikulam National Park of Idukki district is the highest point in the Western Ghats. The elevation of the area is about 2,695 m (8,842 ft) and the lowest point is in the Palakkad Gap, of about 300 m (984 ft). The average elevation in Western Ghats is around 1,200 m.

The major hill range starting from the north is the Sahyadri (the benevolent mountains) range. The range is called Sahyadri in northern Maharashtra and Sahyaparvatam in Kerala. The Biligirirangans, southeast of Mysore in Karnataka, meet the Shevaroys (Servarayan range) and Tirumala range farther east in Tamil Nadu, linking the Western Ghats to the Eastern Ghats. In the south the range is known as the Nilagiri malai in Tamil Nadu. Nilagiri Hills is home to the hill station Ootacamund (Ooty). In the southern part of the range is the Anaimalai Hills, in Western Tamil Nadu and Kerala. The other highest peaks in Kerala are Chembra Peak 2,100 metres (6,890 ft), Banasura Peak 2,073 metres (6,801 ft), Vellarimala

2,200 metres (7,218 ft) and Agasthyamala 1,868 metres (6,129 ft). Doddabetta is 2,623 metres (8,606 ft) is the highest peak in Tamil Nadu next to Anamudi. Mullayanagiri is the highest peak in Karnataka with 1,950 metres (6,398 ft).

The Western Ghats in Kerala is home to many unique floristic and faunal elements. Most part of it remains under forest cover. A large extent of its original forest tracts had been converted to a number of tea and coffee plantations.

It has distinct regions with characteretic floristic composition. The areas such as Konkan coast (Konkan), Kanara and Malabar are with distinct vegatational features. The foot hills form another set of unique floristic areas, such as Desh in Maharastra, Malnad in Karnataks, etc. The Biligirirangan Hills of Western Ghats of Karanataka meets with the Eastern Ghats, another prominent hill chain in the Penisular India.

Western Ghats ensures a humid and tropical in the area. Its lower parts and to some extant of altitude are with tropical climate. However, as the altitude increases it transform to temperate climate, and goes beyond subzero resulting frost during winter months. The mean temperature may be around 15°C (60°F).

The Western Ghats include two biosphere reserves, 13 National parks, more than 55 wildlife sanctuaries to protect the flora and fauna and many endemic and endangered species. Large tracts of Reserve Forests are also seen in the Western Ghats, ensuring the continuity of the tracts at most places. With its diverse vegetation types, ranging from decidous forests to the hilltop montane forests, and grasslands, and located at the meeting point of states such as Kerala, Karnataka and Tamil Nadu remain as one of the large tract of biodiversity in the Western Ghats. The Western Ghats in Kerala is also well-known for its species rich large tracts of vegetation cover. It’s vegetation types also ranging from dry decidous to evergreen and misty shola forests (Nair, 1991).

In Kerala part of Western Ghats there are five National Parks and 14 Wildlife Sanctuaries. In Karnataka part five National Parks and 21 Wildlife Sanctuaries covering nearly 16% of its natural vegetation cover. Five National

Parks, 15 Wildlife Sanctuaries, 15 bird Sanctuaries and two Conservation Reserves besides four Tiger Reserves are in Tamil Nadu. Goa has five Wildlife Sanctuaries and one National Park. In Kerala, Idukki district has the maximum number of protected areas. The Eravikulam National Park in Kerala occupies the region variously termed as the High Ranges or the Kannan Devan hills forming a contiguous stretch of mountains to the south. This 90 km² National Park surrounds the Mankulam Range, the Mannavan Shola in Marayoor range and three recently established National Parks, the Pambadum shola NP, Anamudi shola NP and Mathikettan shola NP. It is also contiguous with the Chinnar Wildlife Sanctuary comprising of lower hills on the eastern rain shadow region, with typically dry forest formations. It enjoys a tropical to subtropical climate due to the effects of elevation, with temperatures between 5°C and 35°C, with occasional frost in winter in the uppermost reaches. Map 1. shows the outline of the study area, the Western Ghats. Plates (1-17) shows different collection areas in Western Ghats.

Vegetation in the Western Ghats (modified with reference to Champion & Seth, 1968)

The broad classification of vegetation does not, however, coincide with the geological landscapes, but seems to be more associated with topography and climatic conditions, particularly the length of the dry season. Considering the moist regime and distribution of bryophyts, the vegetation of the area are usually divided into six major categories, *viz*., evergreen, semi-evergreen, shola-glassland system, plantation, moist deciduous and dry deciduous.

i. Tropical Wet Evergreen forests (Evergreen Forests)

This type usually occupies at the altitudinal zone of 200-1,500 m above msl. It is with more than 5,000 mm annual rainfall. Physiognomically the evergreen forests of northern parts and southern parts of Western Ghats are different. The Wayanad area, lies in the middle, is a transition zone from the moist *Cullenia* dominated forests in the south Western Ghats to the drier, Dipterocarp dominated forests in the north (Rodgers & Panwar, 1988). At the upper reaches the evergreen forsts transforms into shola forests of montane nature, with distinct species

composition. The evergreen forests offers a lot of microhabitats and congenial environment for the rich growth of Bryophytes.

The montane evergreen forests are diverse in species, seen as strata and rich in epiphytes such as mosses, lichen, ferns, etc (Puri *et al*., 1989; Ganesh *et al*., 1996). These type of forests are characterised by the endemic tree species which forms half of the total tree species. The families such as Dipterocarpaceae and Ebenaceae are most prominent. The distribution of richness and endemism is not uniform within this forest type, with some areas having higher concentrations of endemics than others. The evergreen forests are distributed in all states of Western Ghats. The Bryophytes forms a major vegetation in evergreen forests and which enhance the microclimate of the area.

ii. West Coast Tropical Semi Evergreen forests (Semi-Evergreen Forests)

Semi-evergreen forests also occur through out the the Western Ghats, usually at an altitudinal zone of about 300-900m (IIRS, 2002). This forest type includes secondary evergreen Dipterocarp forests, lateritic semi-evergreen forests, bamboo brakes, and riparian forests as described by Champion and Seth (1968). The structure and composition of these forests varies widely from north to south and especially from east to west. The dominant species include species such as *Aporosa cardiosperma* (Gaertn.) Merr., *Celtis timorensis* Span., *Careya arborea* Roxb., *Elaeocarpus tuberculatus* Roxb., *Holigarna arnottiana* Hook.f., *Hydnocarpus pentandra* (Buch.-Ham.) Oken, *Hopea parviflora* Bedd., *Lagerstroemia microcarpa* Wight, *Memecylon umbellatum* Burm.f., *Mesua ferrea* L., *Olea dioica Roxb., Syzygium lanceolatum* (Lam.) Wight & Arn., *Terminalia paniculata* Roth. and *Vateria indica* L. Semi-evergreen forests lies next to evergreen forests in the diversity of trees and endemism (IIRS, 2002). These forest also harbour a good number of bryophyte species which is a mixture of evergreen and moist deciduous species.

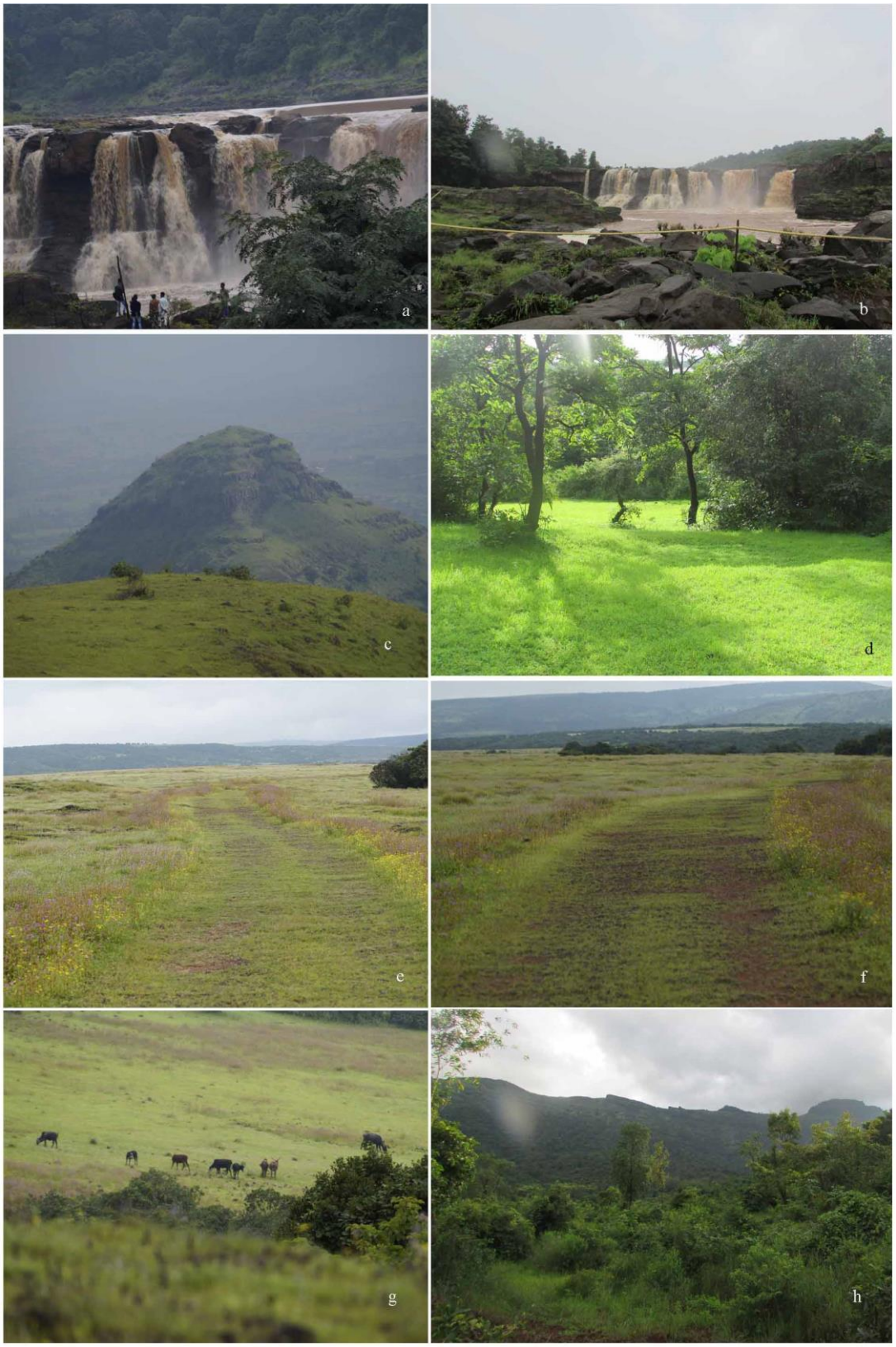


Plate 1. Macrohabitats in Western Ghats; a&b. Gira falls in Gujarat; c. Dhara hills, way to Gujarat from Nashik; d. way to Amboli Ghats in Maharashtra; e-g. Choukul in Maharashtra; h. Rajghat fort in Maharashtra.

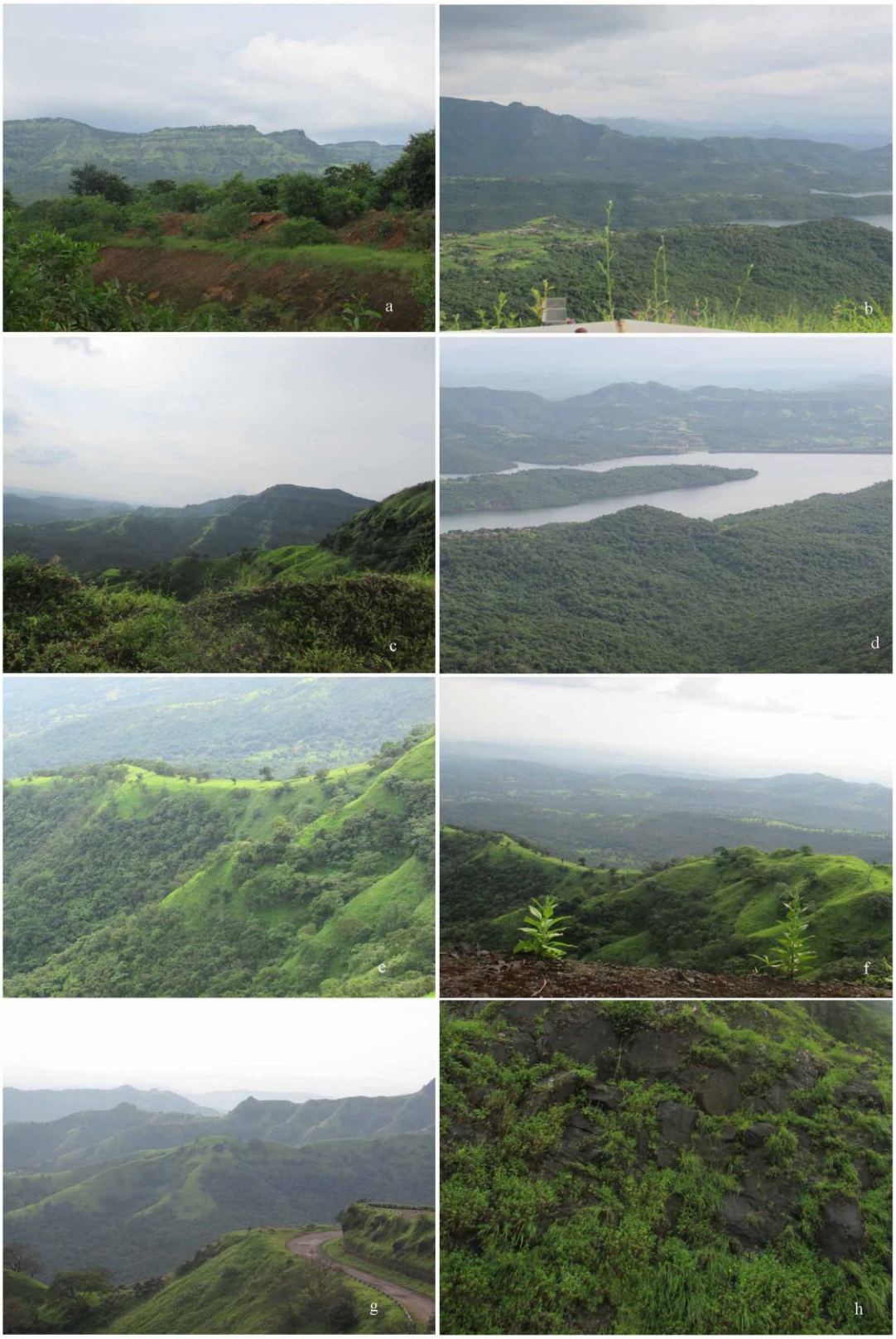


Plate 2. Macrohabitats in Western Ghats; a-h. Anaskura in Kolhapur (Maharashtra).

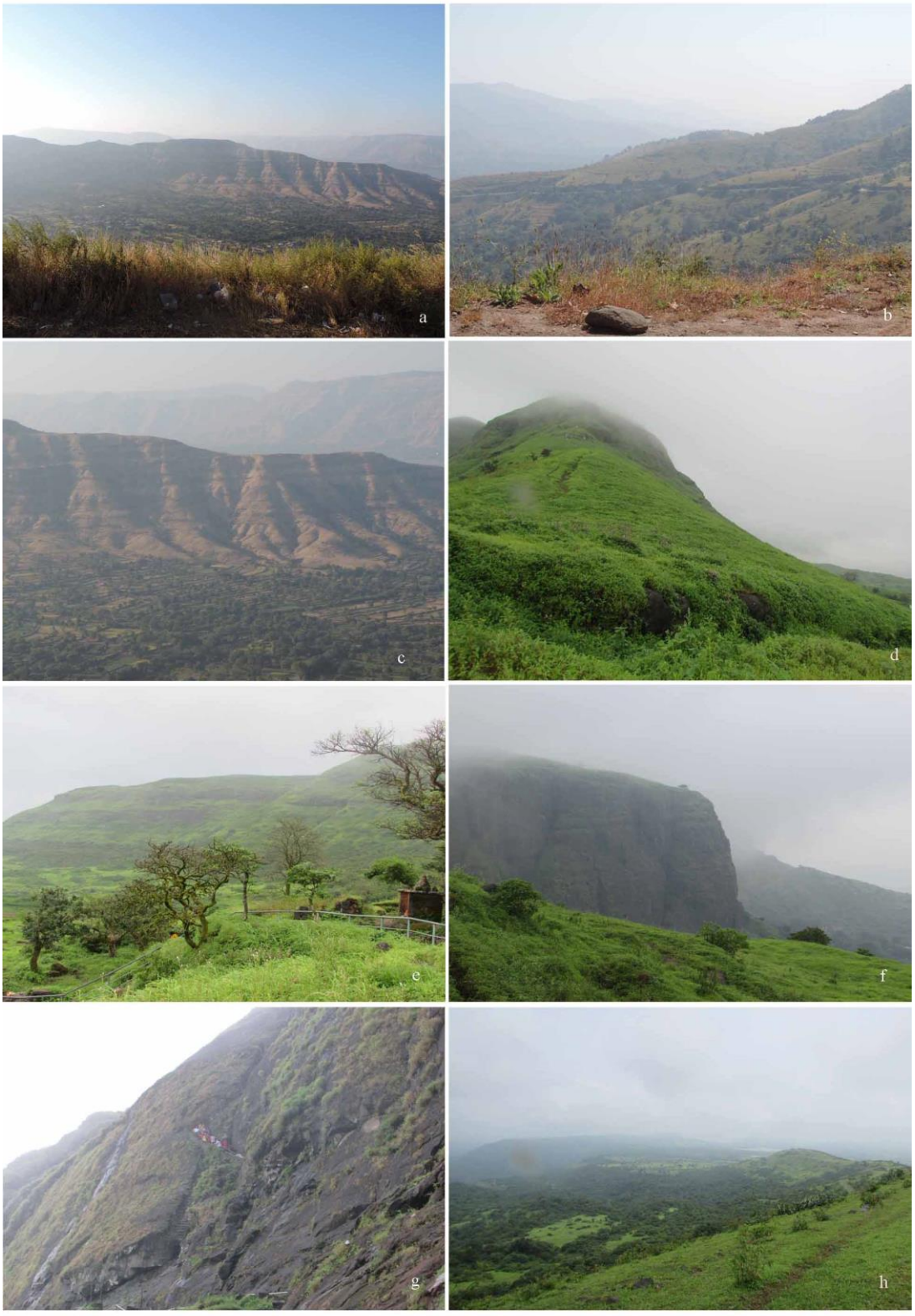


Plate 3. Macrohabitats in Western Ghats; a-c. Mahabaleshwar, d-h. Brahmagiri Hills, Nashik (Maharashtra

Plate 4. Macrohabitats in Western Ghats; a-d. C0tigao Wildlife Sanctuary, e-h. Bhagwan Mahaveer National Park (Goa).

Plate 5. Macrohabitats in Western Ghats; a. Agumbe Ghats, b&c. Hulikal Ghats, d-h. Kodachadri (Karnataka)

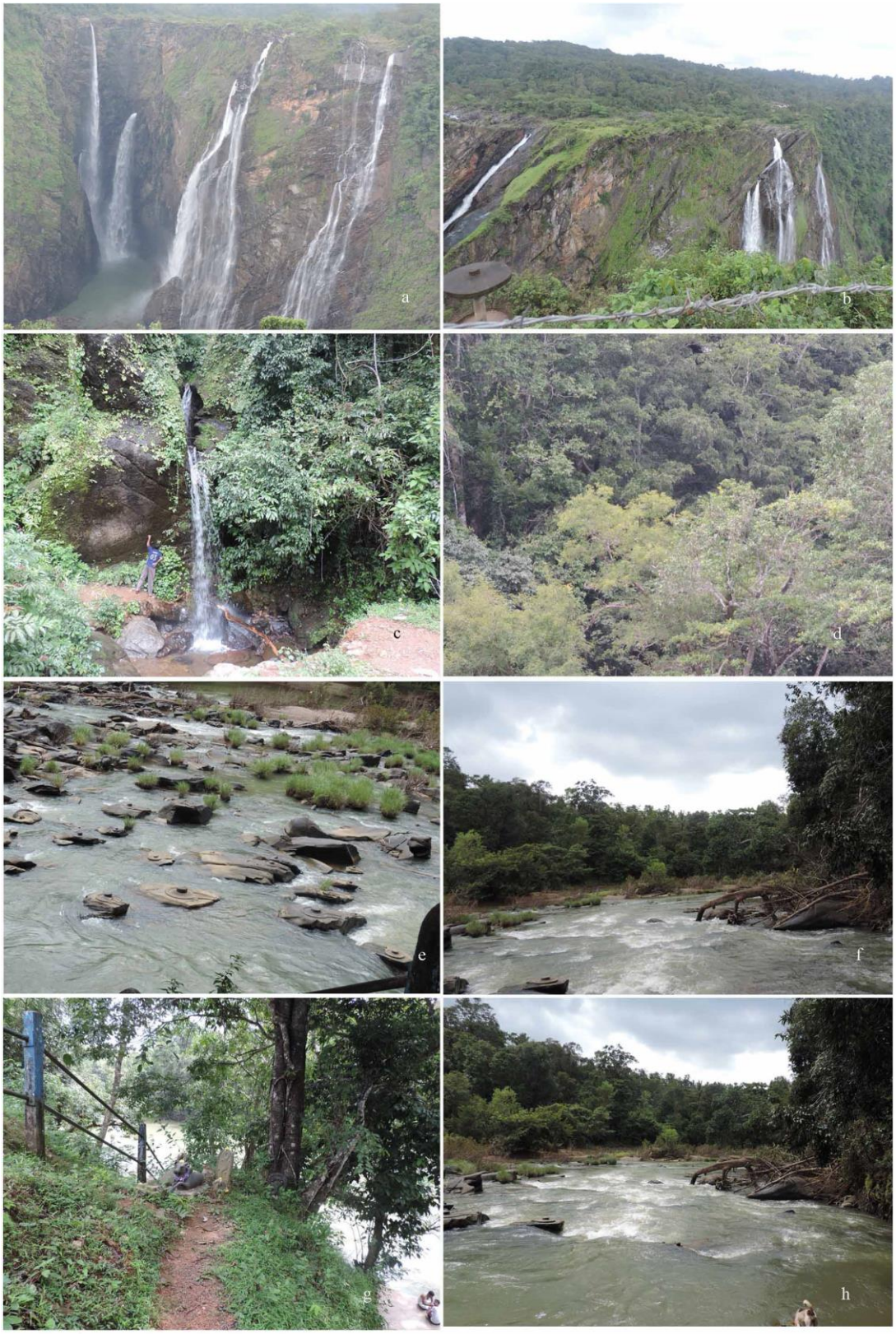


Plate 6. Macrohabitats in Western Ghats; a-d. Jog falls, e-h. Sahasralinga (Karnataka).

Plate 7. Macrohabitats in Western Ghats; a&b. Kalathagiri, c-h. Badra Wildlife Sanctuary (Karnataka).

Plate 8. Macrohabitats in Western Ghats; a&b. Harihara pura, c-h. Kudremukh National Park (Karnataka)

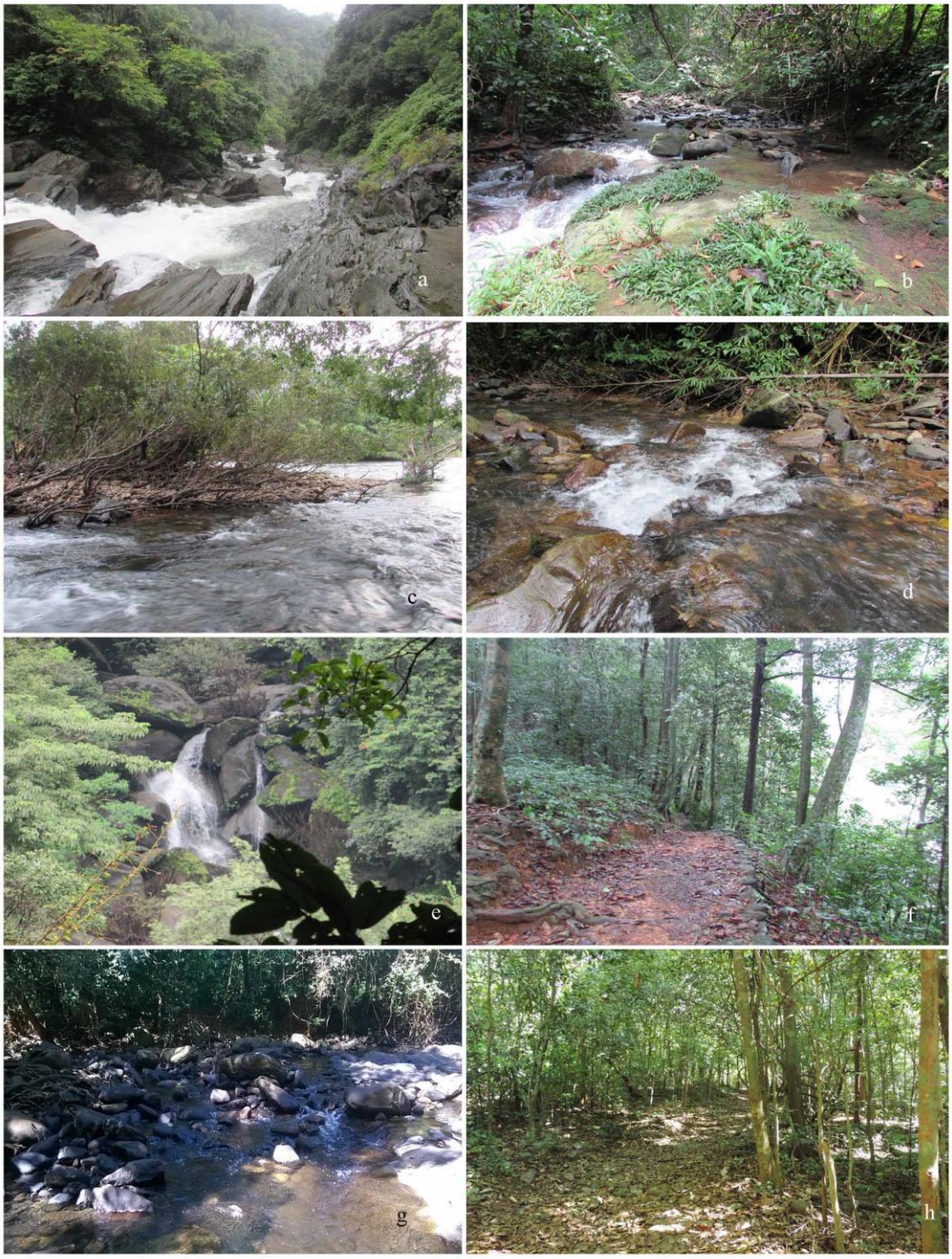


Plate 9. Macrohabitats in Western Ghats; Aralam Wildlife Sanctuary in Kannur district, a&e. water falls, b,d&g. stream sides, c. riverine area, f. forest path, h. forest floor.

Plate 10. Macro & micro habitats in Western Ghats; Silent Valley National Park in Palakkad district; a-c. riverine areas, d-f. water flowing rocks, g. wet rock with exposed roots of trees, h. shady rocks, i. land cuttings, j-l. different forms of epiphytes, m&n. grass lands, o. cemant wall.

Plate 11. Macro & microhabitats in Western Ghats; a-h. Nelliyampathy hills of Palakkad district, a. grass land, b. open land inside forest, c&e. rocky outcrops, d. forest path, f. water flowing rocks, g. epiphytic forms, h. stream.

Plate 12. Palghat Gap; a-d. Gap in Western Ghats at Palakkad & Coimbatore, e. Western Ghats a view from Palghat Gap.

Plate 13. Macrohabitats in Western Ghats; a-c. Chinnar Wildlife Sanctuary, d. Munnar, e-h. way to Eravikulam, g-h. Eravikulam National Park in Munnar (Idukki district)

Plate 14. Macrohabitats in Western Ghats; a-h. Kothamangalam range in Ernakulam district.

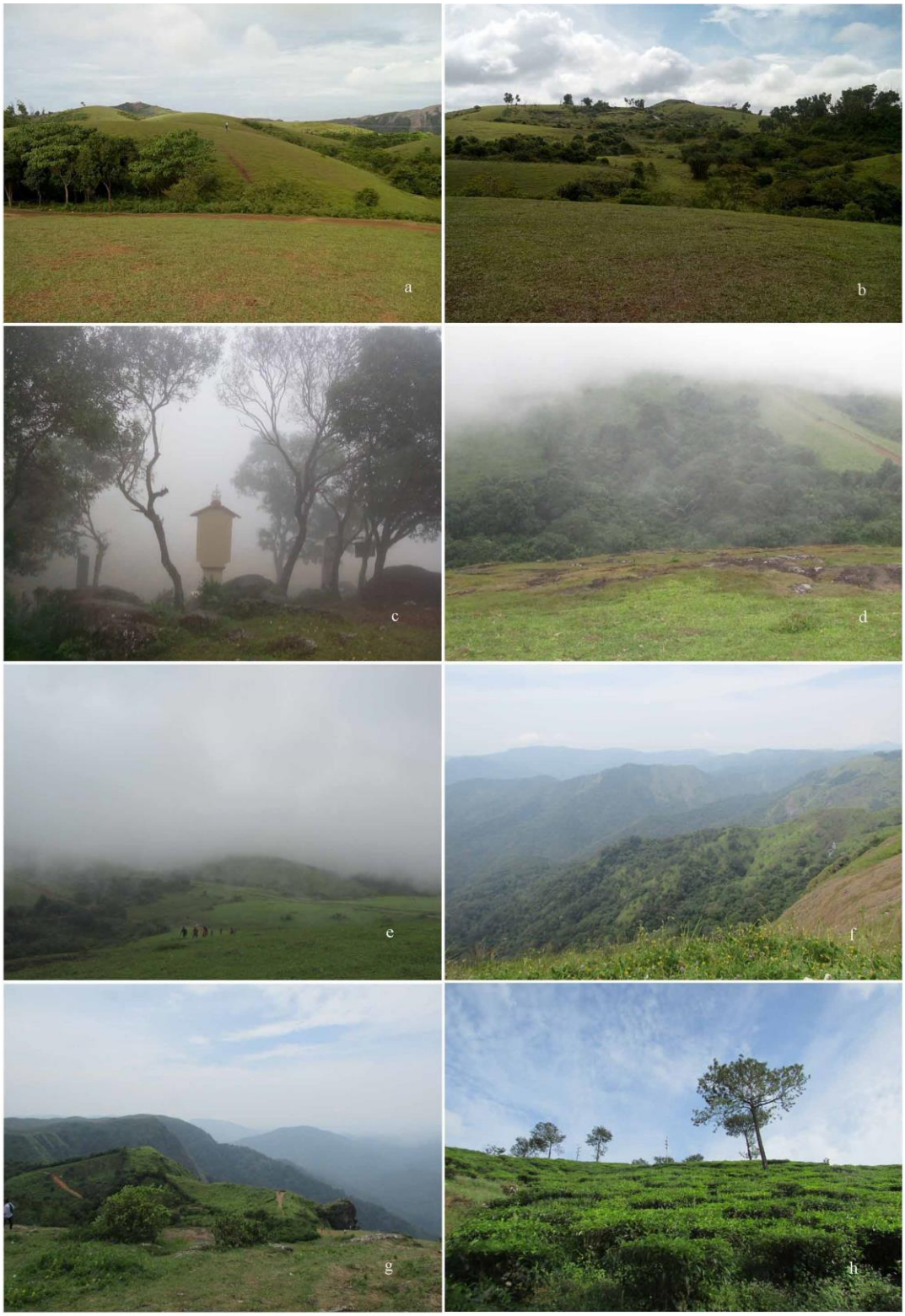


Plate 15. Macrohabitats in Western Ghats; a-e. Vagamon and Parunthan Para of Idukki district, a-g. grass land, h. tea plantation.

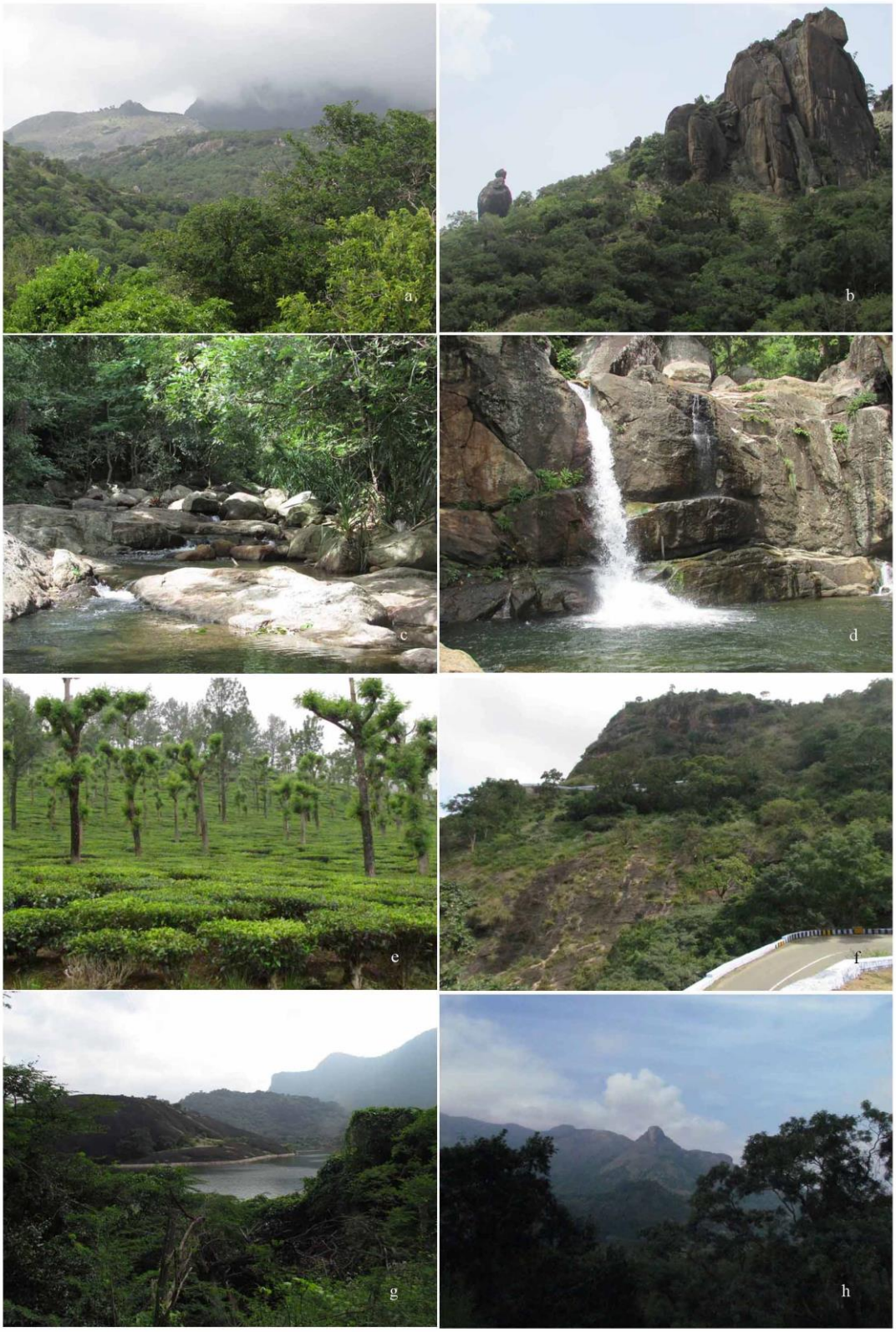


Plate 16. Macrohabitats inWestern Ghats; a-d. Courtalum, e-h. Valparai (Tamil Nadu)

Plate 17. Macrohabitats in Western Ghats; a. Dolphin's nose, Coonoor, b&c. Ooty, d. railway track in lovedale , e. plantation on the way to Ooty, f. Pine valley, g. Coakers walk, h. Pillar rock (Kodaikanal)

iii. Southern montane wet temperate forests (the Shola Forest)

The vegetation in the Nilgiris is very unique with rolling grasslands and stunted evergreen formations in the valleys, glens and folds locally called shola. The elevation ranges in between 1500-2600m. The shola forests which are evergreen in nature and the trees are stunted in nature and are comprised of both tropical and extra tropical elements (Meher-Homji, 1967). They reach a height of not more than 10-15 m high with umbrella-shaped canopy and luxuriant growth of mosses, lichens, epiphytes, orchids and climbers. The grasslands associated with high altitude shola forests are also very unique with specific assemblages of floral elements compared to the grasslands of lower elevations. The most conspicuous species of the sholas are *Gordonia obtusa* Wall. *ex* Wight & Arn., *Ilex wightiana* Wall. *ex* Wight, *I. denticulata* Wall. *ex* Wight, *Magnolia nilagirica* (Zenk.) Figlar, *Meliosma simplicifolia* (Roxb.) Walp., *Mahonia leschenaultii* (Wall. *ex* Wight & Arn.) Takeda *ex* Gamble, *Microtropis ramiflora* Wight, *Schefflera racemosa* (Wight) Harms, *Rhododendron arboreum* J. E. Smith *ssp. nilagiricum* (Zenk.) Tagg., etc. *Rhododendron arboreum* J. E. Smith *ssp. nilagiricum* (Zenk.) Tagg. an endemic element of Southern Western Ghats. The under growths are dominated by *Maesa indica* (Roxb.) DC., *Osbeckia cupularis* D. Don *ex* Wight & Arn., *Psychotria* sp., etc. Some of the common orchids found in the shola are *Aerides*, species of *Habenaria, Calanthe* etc. The grassland lying outside the shola forests are also characterised by certain species such as *Hypericum mysurense* Heyne *ex* Wight & Arn., *Rhodomyrtus tomentosa* (Sol. *ex* Ait.) Hassk., *Gaultheria fragrantissima* Wall, *Rubus* sp., *Hedyotis* sp., *Strobilanthes* spp. etc. The bryophyte flora of these forests are unique and share only very few species with evergreen and other forest types.

iv. Southern Tropical Moist Deciduous forests (**Moist Deciduous Forests)**

The moist deciduous forest is one of the most common type seen in a large extant of the Western Ghats. Generally it form at an altitudinal zone of 500-900 m above msl. Its rainfall is lower than the evergreen and semi-evergreen types, and varies 2,500-3,500mm. Based on the rainfall pattern and species composition, this type could be grouped into two, as primary and secondary. Due to the dry nature, the

bryophyte diversity is less compared to evergreen, semi evergreen and shola forests. Those bryophyte species which like high light and temperature thrive well here.

v. Dry Deciduous Forests

The dry deciduous forests are seen in the rainshadow parts of Western Ghats, which receives less amount of rainfall, ranging 900-2,000mm. The elevational range may vary 300-900 m. The soil is very shallow, with more thorny. The dry deciduous forests are contiguous with the moist deciduous forests that lie along the foothills of the southern extent of the Western Ghats, with less degree of endemism. Due to the occurrence of trees of decidous nature this vegetation type normally do not support the shade loving plants such as bryophytes. Hence the diversity is very less compared to other vegetation and open lands.

vi. Plantations

Over the period, large extant areas of the Western Ghats had been transformed into plantations of various cash crops such as tea, coffee, rubber, cardamom, etc. Plantations are of two types, pure stands and mixed vegetation. Teak, Eucalyptus, Cocoa, Tea and Coffee are the major plantation crops in Western Ghats. Most of these plantations have a belt of natural forests and good undergrowth of shrubs, herbs and grass species. The growth of bryophytes is minimum in these plantaions. However, members of some families such as Lejeuneaceae are common in this type. The plantations which lies near the forest areas, support some of the species from the surrounding areas. The homestead areas in the lowlands and midlands also support the growth of bryophytes. Species richness is comparatively less in such areas. However, some light adapted and tolerant to species grow well in this type of habitat.

Chapter: III

REVIEW OF LITERATURE

REVIEW OF LITERATURE

The floristic study of mosses especially the family Fissidentaceae Schimp., so richly distributed in the Indian subcontinent has received less attention throughout the past probably on account of non-availability of literature and lack of direct economic importance.

The detailed studies on bryophytes started in the 18th century and "Reproduction of the ferns and mosses" is considered as the first ever documented research compiled by the German botanist Professor Johann Jacob Dillenius (1717). Further he dealt exclusively with taxonomy of bryophytes in his Historia Muscorum (1741) which also includes algae, lichen, lycopods, etc. Eventhough the studies on bryophytes started in 1717, Linnaeus (1753) does not mentioned this group in his *Species Plantarum* along with other mosses and the record of the genus Fissidentaceae started much later and very few studies were done on this group in earlier days.

International status

The genus *Fissidens* was established by Hedwig (1801) which includes four species of *Fissidens* that were already reported by him (1791-1792). Dillenius (1741) described and illustrated *F. semicompletus* Hedw. which is validly reported by Hedwig in his Species Muscorum in 1801. Hedwig reported a total of fourteen species of *Fissidens,* in which ten species are still valid. Bridel (1798) reported one more species, *F. acacioides* Schrad. from Patagonia in South America which is later validated by Schrader (1803). This species was also first published by Dillenius (1741), included in Jaeger (1869) but disregarded by Hedwig (1801) and Mitten (1869). Bridel (1806) transferred the species *F. semicompletus* Hedw. as *Octodiceras fissidentoides* Brid., he also reported two more species, *Fissidens longifolius* Hook. f. & Wilson and *F. elegans* Brid. to the existing genus. Bridel (1819) reported *F. dominicensis* Brid. which is already reported as *Hypnum* [=*Calyptothecium duplicatum* (Schwär.) Broth.]. Hence *F. dominicensis* is an invalid species. Pylaie (1814-1815) coined the genus *Skitophyllum* Bach. Pyl. and

recognised all the species that are listed by Bridel during 1806 and 1819. Schwaegrichen (1816) synonymised *F. acacioides* Schrader under *F. osmundoides* Hedw.

Montagne (1837) introduced a new genus *Conomitrium* with one species *C. berteri* [=*F. berteroi*] including aquatic members of *Fissidens* with mitrate calyptra which is accepted by Schwaegrichen (1842). Mueller (1848-1849) reported 20 species of *Fissidens* from Neotropics and Temperate South America with many additional species from Brazil, Chile, Colombia, Peru and Suriname. Again Mueller (1850-1851) reported 29 species of *Conomitrium* and *Fissidens* from same area with many new findings. Mitten (1869) recorded 68 species of *Fissidens* in his 'Musci Austro-Americani' from Neotropics and South America. Jaeger (1869) catalogued 68 species of *Fissidens* from Neotropics including 11 species reported by Spruce (1867).

Britton (1900a) reported aquatic species, *F.grandifrons* Brid. with its distributional range as Himalaya mountains, Europe, Switzerland, Pyrenees, America, New York, Virginia, Michigan, Ohio and Missouri. Britton (1900b) discussed about the origin of specialised leaf structure in *Fissidens.* He explained three theories regarding the morphology of leaf. According to first theory accepted up to 1819, the leaf is corresponds to other mosses and the vaginant laminae is formed by splitting in the thickness of the leaves. According to second theory proposed by Brown (1819) vaginant laminae are the true leaves and the remaining dorsal lamina and apical lamina are additional wings. This view is supported by greatly reduced dorsal lamina and apical lamina of lower leaves in most o f the species. Third theory was proposed by Lindberg which states that the whole leaf is the part of true leaf except one flap of vaginant laminae which is considered as a stipule. Hill (1902) reported on the habits and propagation of *F. grandifrons* Brid. According to his observation, the sexual reproduction of this species is not common eventhough it bears archegonia. This plant possesses many asexual methods for propagation such as axillary nodules with rhizoids at base, older leaves with rhizoids at axils etc. Wolfe (1924) listed 76 mosses from Nebraska of United States with 42

new records. The family Fissidentaceae are represented by two species *F. minutulus* Sull. and *F. taxifolius* Hedw. which are new record to Nebraska.

Noguchi (1934) catalogued 17 taxa of mosses belonging to 13 families including *Fissidens planicaulis* Besch. of Fissidentaceae from Formosa. Noguchi (1939) listed one species *viz., F. japonicus* Dozy & Molk. along with 12 other mosses from Botel Tobago Island. Patterson (1940) reported 145 species of mosses collected during 1934 to 1940 from Virginia including six species of *Fissidens viz. ,F. minutulus* Sull., *F. taxifolius* Hedw., *F. osmundoides* Hedw., *F. subbasilaris* Hedw., *F. cristatus* Wilson *ex* Mitt. and *F. grandifrons* Brid.

Grout (1941) studied around 200 *Fissidens* specimens from Puerto Rico collected by Dr. William C. Steere during 1939 to 1940 and included in nine sections such as *Retieularia* Broth., *Limbatus* Grout, *Pycnothallia* Muell. Hal., *Semilimbatus* Grout, *Aloma* Muell. Hal., *Crenularia* Muell. Hal., *Amblyothallia* Muell. Hal., *Serridium* Muell. Hal. and *Pachyfissidens* Muell. Hal.

Bartram (1947) catalogued 127 species of mosses from South-eastern Mexico including three species of *Fissidens viz., F. kegelianus* C. M., *F. leptopodus* Cord., *F. debilis* Schwaegr. Bartram (1949) studied the moss flora of Guatemala with 24 species of *Fissidens* with two endemic species *viz*., *F. svihlae* Bartr. and *F. steyermarkii* Bartr.

Noguchi (1949) reported two species of *Fissidens* new to science *viz. F. saxatilis* Tuzibe & Noguchi and *F. capitulates* Noguchi from Japan.

Steere (1950) described one new species *Fissidens clebschii* Steere and one new record *F. exilis* Hedw. from North America. Later *F. clebschii* Steere has been synonymised under *F. taxifolius* Hedw. Koch (1951) reported one new species *F. milobakeri* L.F. Koch from California. This species also synonymised under *F. curvatus* Hornsch. by Pursell (1994). Lohammar (1954) studied the distribution and ecology of *F. julianus* (Sav.) Schimp., a rare moss in Northern Europe. This species is a hydrobiont prefers shaded lakes, rivers and rivulets and the growth is negatively influenced by accumulation of pesticides and sewage in water bodies, oligotrophic

conditions, etc. He also noticed *Amblystegium riparium* (Hedw.) Schimp. as a very common companion of this species in the study area.

Bartram (1961), reported 400 species of mosses including 20 new species and 13 new records from Eastern New Guinea. Among these, Fissidentaceae is represented by four species, *viz., Fissidens zollingeri* Mont.*, F. crispulus* Brid. (as *F. sylvaticus* Griff.*), F. oblongifolius* Hook. f. & Wilson and *F. dubius* P. Beauv. (as *F. cristatus* Wils.). Among these, *F. oblongifolius* Hook. f. and wilson and *F. dubius* P. Beauv. are reported as new record to Eastern New Guinea. McCleary (1962) studied the distribution of mosses in different altitudinal ranges in Arizona of United states. He reported two species of *Fissidens, F. fontanus* (Bach. Pyl.) Steud. (as *F. julianus* (Savi *ex* DC.) Schimp.) at an altitudinal range of 150-5000 feet and *F. sublimbatus* Grout from an altitudinal range of 1100-10000 feet.

Miller *et al.* (1963) reported a new species of *Fissidens via., F. micronesicus* H. Whittier from Macronesia along with 62 species of bryophytes. Bartram (1964-1965) described 29 species from Northern Argentina and the family Fissidentaceae is represented with *F. asplenioides* Hedw. and *F. repandus* Wils.

Whittier and Miller (1967) studied the genus *Fissidens* in the Society Islands of the tropical pacific which is the largest, most elevated land masses in the South-central Pacific. A total of thirteen species were reported. Among these, five are new species reported from the Island such as *F. jaiorum* Whitt. & Mill., *F. fautauae* Whitt. & Mill., *F. taiarapuensis* Whitt. & Mill., *F. mooreae* Whitt. & Mill. and *F. aoraiensis* Whitt. & Mill. *F. clarkia* Bartr. is a new record to Society Island and *F. jaiorum* Whitt. & Mill. is the first described new species under the subgenus *Pachyfissidens* from Pacific Island. Eddy (1988) in his Handbook of Malaysian mosses reported 39 species of *Fissidens* occurring in Malaysia, with detailed description, illustration and keys.

Zander (1969) reported a new species of *Fissidens viz., F. appalachensis* R. H. Zander from Southern Appalachin mountains of North Carolina. It is the only representative of the section *Pachylomidium* in *Fissidens* from the area. Iwatsuki and Sharp (1970) described 17 species of *Fissidens* with 18 other mosses from

Formosa, Taiwan. Among these, 13 species of *Fissidens* are new distributional records to the study area such as *F. adelphinus* Besch., *F. ceylonensis* Dozy & Molk., *F. garberi* Lesq. & Jam., *F. geppii* Fleisch., *F. hollianus* Dozy & Molk., *F. hyalinus* Hook. & Wils., *F. javanicus* Dozy & Molk., *F. micro-serratus* Sak., *F. papillosus* Sande Lac., *F. ryukyuensis* Bartr., *F. saxatilis* Tuzibe. & Nog., *F. wichurae* Broth. & Fleisch. and *F. yamamotoi* Sam.

Breen and Reese (1971) studied the mosses of Panama and reported 78 species with 21 new records. The genus *Fissidens* is represented by eight species such as *F. angustifolius* Sull., *F. pallidinervis* Mitt. (as *F. garberi* Lesq. & James.), *F. zollingeri* Mont. (as *F. kegelianus* Muell. Hal.), *F. elegans* Brid. (as *F. leptopodus* Card.), *F. flaccidus* Mitt. (as *F. mollis* Mitt.), *F. palmatus* Hedw. (as *F. reticulosus* (Muell. Hal.) Mitt.), *F. prionodes* Mont. and *F. steerei* Grout. Among these, *F. prionodes* Mont. and *F. steerei* Grout. are recorded as new distributional records to Panama. Robinson *et al.* (1971) catalogued 83 species of mosses from Ecuador with 20 new records to Ecuador including *Fissidens kegelianus* Muell. Hal. from the family Fissidentaceae.

Noguchi (1973) recorded 90 species of mosses with 20 new records and one new species from Ceylon based on Dr. Hiroshi Inoue. Among these four species are from Fissidentaceae *via., F. anomalus* Mont., *F. ceylonensis* Dozy & Molk., *F. fuscoviridis* Thwaites & Mitt. and *F. sylvaticus* Griff. *F. sylvaticus* Griff. is new record to Ceylon.

Robinson (1973) enumerated 34 species of mosses from Costa Rica and Mexico with 19 new records from Mexico and 11 from Costa Rica. The family Fissidentaceae is represented by five species *viz., F. diplodus* Mitt., *F. vardei* Thér., *F. veracruzensis* Pursell, *F. weirii* Mitt. and *F. weirii* var. *insertus* Grout. from Costa Rica. *F. diplodus* Mitt., *F. veracruzensis* Pursell, *F. weirii* Mitt. and *F. weirii* var. *insertus* Grout. were new records to Costa Rica.

Crum (1976) reported eight species of *Fissidens viz., F. grandifrons* Brid., *F. adiantoides* Hedw., *F. cristatus* Wils. *ex* Mitt., *F. osmundoides* Hedw., *F. taxifolius* Hedw., *F. bushii* (Card. & Thér.)., *F. obtusifolius* Wils. and *F. bryoides* Hedw. from

great lakes forest in America & Canada. Wallace (1976) reported one new species *viz., Fissidens taxifolius* Hedw. subsp. *pallidicaulis* (Mitt.) Moenkm. from West Scotland and South-West Ireland.

Ward *et al.* (1977) studied the heavy metal accumulation in eight selected bryophytes from two different mining areas in New Zealand. They found that both the habitat and the locality of collection partly influence the degree of element uptake for each species. Among these *F. rigidulus* Hook. f. & Wilson, aquatic bryophyte showed accumulation of cadmium, lead and zinc but less amount of copper compared to its environment. The variability in accumulation is probably due to difference in ion exchange capacity of the species (Whitehead & Brooks, 1969).

Bruggeman-Nannenga (1978) made notes (Notes I and II) on *Fissidens* based on the communication of Prof. Stafleu at the meeting in 1978. She united sections *Bryoidium* Muelll. Hal., *Pachylomidium* Muelll. Hal., *Aloma* (Kindb.) Muelll. Hal. and *Semilimbidium* Muelll. Hal. subsect. *Bryolimbidium* Nork. in Gangulee and named as section *Fissidens.* In note II five species of *Fissidens* such as *F. bambergeri* Schimp. *ex* Milde, *F. firmus* Mitt., *F. herzogii* Ruth, *F. canariensis* Bryhn and *F. bilewskyi* P. de la Varde are synonymised under *F. minutulus* Sull. and *F. subimmarginatus* Phil. is synonymised under *F. exiguous* Sull.

Allen (1980) studied about the peristome variations in 19 species of the genus *Fissidens* including two subgenera by using scanning electron microscope and found seven types of peristome such as bryoides type, scariosus type, obtusifolius type, zippelianus type, similiretis type, taxifolius type and subbasilaris type based on trabeculae and lamellae of dorsal and ventral surface. Long *et al.* (1981) enumerated the bryophytes from Islands of Gran Canaria, Tenerife and La Palma collected by different authors in 1978 and 1979 which includs two species of *Fissidens viz., F. ovatifolius* Ruthe. and *F. dubius* P. Beauv. (as *F. cristatus* Wils.).

Iwatsuki and Suzuki (1982) have done a complete illustrated revisionary work on the Japanese species of *Fissidens* with description, distribution and illustration of 43 taxa with 5 varieties and one subspecies. Tixier (1983) reported seven species of *Fissidens viz., F. anomalus* Mont., *F. ceylonensis* Dozy & Molk., *F.*

fuscoviridis Thwaites & Mitt., *F. intramarginatulus* Bart., *F. mittenii* Par., *F. nobilis* Griff. and *F. sylvaticus* Griff., from Sri Lanka.

Iwatsuki and Inoue (1984) conducted cytotaxonomic studies on 28 species of *Fissidens* included in four subgenera such as *Aneuron, Fissidens, Serridium* and *Pachyfissidens* by meiotic chromosome counting of 16 species and mitotic chromosome counting of 12 species. They concluded that the genus *Fissidens* is polyphyletic in origin and subgenera *Aneuron* (n=10) and *Fissidens* (n=5 to 15) are more advanced groups, while subgenera *Serridium* (n=6 to 24) and *Pachyfissidens* (n=12 to 16) are more primitive or they have a different ancestor.

Keizer *et al.* (1985) studied the effect of bryophytes on seedling emergence in the Chalk grassland of Netherland and they reported that *F. cristatus* Wilson *ex* Mitt. and *F. taxifolius* Hedw. are found abundant in the grassland which is correlated to the mortality rate of seedlings. Peñuelas (1985) investigated the HCO_3^- and CO_2 utilization ability of two aquatic mosses *Fontinalis antipyretica* Hedw. and *Fissidens grandifrons* Brid. during photosynthesis. They concluded that net photosynthetic rate was decreased at high pH for both the species and *Fontinalis antipyretica* Hedw. has the capacity to utilize HCO_3^- as exogenous carbon source while *Fissidens grandifrons* Brid. does not have the ability.

Norris and Koponen (1987) described the bryophyte flora of the Huon Peninsula of New Guinea including 25 species of Fissidentaceae, one species of Mitteniaceae, one species of Phyllodrepaniaceae, three species of Phyllogoniaceae and one species of Sorapillaceae. *F. adelphinus* Berch. is new record to Indonesia. Lectotypes are selected for *F. ceylonensis* var. *simplex* Műll. Hal., *F. incurvescens* Broth., *F. kurandae* Broth., *F. robinsonii* Broth. and *F. wichurae* Broth. & Fleisch.

Chiang and Kuo (1989) documented Bryophytes belonging to 36 genera from 62 different localities around Taiwan Island and Orchid Island, with eleven genera new to the Thaiwan bryoflora and three taxa new to science. Fissidentaceae are represented by 14 species including three varieties. Among these, *F. crenulatus* var. *pursellii* (S.H. Lin) T.Y. Ching & C.M. Kuo is new to science. *F. crenulatus* Mitt., *F. crenulatus* var. *elmeri* (Broth.) Z. Iwats. & Tad. Suzuki, *F. rupicola* Paris &

Broth., *F. kinabaluensis* Z. Iwats., *F. crassinervis* Sande Lac., *F. flabellulus* Thwaites & Mitt., *F. ganguleei* Nork., *F. subangustus* Fleisch.(as *F. leptopelma* Dixon)and *F. oblongifolius* Hook. f. & Wilson (as *F. mangarevensis* Mont.) are new records to the bryoflora of Taiwan.

Pursell (1989) discussed about the relationship of *F. leptophyllus* Mont., *F. obtusissimus* (Florsch.) Pursell and identity of *F. hornschuchii* Mont. He retaind *F. leptophyllus* Mont. and *F. obtusissimus* Mont. in *Aloma* of genus *Fissidens* on the basis of guttulae present in the laminal cells and a scariosus type peristome. *F. obtusissimus* Mont. is elevated to specific rank. The neotype of *F. hornschuchii* (Florsch.) Pursell selected by Florschuetz is rejected and replaced by original material. *F. legalloi* Crum is reduced to the synonymy of *F. hornschuchii* Mont.

Rincon and Grime (1989) experimentally studied the plasticity and light interception in relation to growth rate of six bryophytes including *Fissidens cristatus* Wilson *ex* Mitt. This species appeared to be relatively unresponsive in irradiance and showed low potential relative growth rate along with *Thamnobryum alopecurum* (Hedw.) Nieuwl. *ex* Gangulee which is correlated to the slow growing and deeply shaded habitat of these species leading to narrowing of its niche. Other species have apparent difference in growth rate, phenotypic plasticity and morphological variation during irradiance which permits the gametophyte to adjust to different habitats particularly related to water availability.

Robinson *et al.* (1989) studied the patterns and morphology of bryophytes and lichens of 95 different stands in the subarctic forest-tundra region of the Northwest territories of Canada including 150 mosses, 67 hepatics and 104 lichens. The family Fissidentaceae is represented by *F. adianthoides* Hedw. and *F. osmundoides* Hedw. They also reported a positive correlation for the diversity of mosses with increased pH, moisture and finer soil texture. The papillosity had no direct significant correlation to pH and soil texture but decreased from dry to wet along the moisture gradient and reached a high value only in 32% of moisture content.

Bruggeman-Nannenga and Berendsen (1990) recognised five basic types of peristomes based on the study of about 200 species of all the subgenera and sections of the family Fissidentaceae *viz.,* the bryoides type, the scariosus type, the zippelianus type, the similiretis type and the taxifolius type. They also correlated the importance of peristome type in the subgeneric classification of the family such as *Aloma, Fissidens, Crispidium, Sarawakia, Serridium, Amblyothallia* and *Aerofissidens.*

Redfearn (1990) done a review on moss flora in the Tropical regions of China and it contains 27 species and 3 varieties of *Fissidens.* Pursell (1990), reviewed all the classifications on the family Fissidentaceae and given a synopsis on the family in Neotropics.

Deguchi and Kariyasaki (1991), in the preliminary study of mosses in Tanegashima Island of Southern Japan revealed 74 species including eight members of *Fissidens viz., F. teysmannianus* Dozy & Molk. (as *F. adelphinus* Besch.), *F. bryoides* Hedw. var. *esquilorii* (Thér.) Z. Iwats. & Tad. Suzuki, *F. geminiflorus* Dozy & Molk. var. *nagasakinus* (Besch.) Z. Iwats., *F. gymnogynus* Besch., *F. nobilis* Griff., *F. obscurirete* Broth. & Par., *F. protonemaecola* Sak. and *F. crispulus* Brid. (as *F. zippelianus* Dozy & Molk.). Among these, *F. adelphinus* Besch. and *F. zippelianus* Dozy & Molk. were previously reported from Southern Japan and others are new distributional records.

Guerra *et al.* (1992) analysed the degree of adaptations in bryophytes in gypsiferous zones of South-East Spain characterised by extreme dryness and high temperature. They considered nine xerophytic adaptations reported in early studies. Among the total 67 species of mosses, the genus *Fissidens* includes two species *F. incurvus* Starke *ex* Röhl. and *F. viridulus* (Sw.) Wahlenb. *F. incurvus* shows leaf border with specialised cells which helps to prevent the dryness of rest of the foliar cells (Watson, 1914) and incrassate cells which offers resistance to desiccation. *F. viridulus* also have specialised cells bordering the leaves. Pursell *et al.* (1993) gave a detailed description and illustration about the identity of *F. gardneri* Mitt. and *F.*

pallidinervis Mitt. (as *F. minutus* Thwaites & Mitt.), the species with with broad distribution in the Neotropics-Asia and Africa.

Bruggeman-Nannenga and Pursell (1995) studied the status of the genus *Fissidens,* including nomenclatural changes and range extension of some species. Twenty names are placed in synonymy, neotype was designanted for *F. serratus* Muelll. Hal. and lectotypes were designanted for six species *viz. Conomitrium wilsoni* Muell. Hal., *C. pseudo-serratum* Muell. Hal., *Fissidens aberrans* Broth. & Dixon, *F. dasyphus* Welw. & Duby, *F. ischyro-bryoides* Muell. Hal. and *F. intermedius* Muell. Hal. They reinstated *F. flabellulus* Thwaites & Mitt. to the status of species from the synonymy of *F. serratus* Muell. Hal. and *F. cryptoneuron* P. de la Varde. is a new record to Kenya. Privitera and Puglisi (1996) added three new species to the moss flora of South Italian Peninsule including *F. rivularis* (Spruce) Schimp. a rare species in southern Italy and *F. viridulus* (Sw.) Wahlenb. along other bryophytes new to Calabria.

Vohra and Kar (1996) described mosses of Great Nicobar Island describing 37 species including one new record to India, one species is endemic to Nicobar Island and 17 species new to the flora of Island. Among these, the family Fissidentaceae is represented by two species *viz., F. crispulus* Brid. (as *F. sylvaticus* Griff.) and *F. javanicus* Dozy & Molk. The later species is reported as new record to the Nicobar Island. Pursell and Allen (1996) made a comparison of *F. appalachensis* Zander, an endemic species of Eastern North America with *F. bryoides* var. *pusillus* (Wilson) Pursell with detailed description and illustration. Both the species belonging to same complex and shares similar characters such as laminal cell shape and size, vaginant laminae forms, sexuality, sporophyte characters and orientation etc., but *F. appalachensis* Zander has a strong limbidium usually confluent with the costa at the mucronate apex, larger plants with greater number of leaves and the limbidium ends just above the leaf insertion where as *F. bryoides* var. *pusillus* (Wilson) Pursell is short plant with less number of leaves, relatively weak limbidium ending conspicuously below the leaf apex and well above the insertion of the dorsal lamina.

Bruggeman-Nannenga (1997) studied 400 African species of *Fissidens* including subgenera *Conomitrium, Moenkemeyera* and *Fissidentella.* She has synonymised nearly 133 species described from Africa along with 100 species which were previously synonymised by various authors such as Bizot (1968); Bizot and Pocs (1979); Bizot *et al.* (1990); Bruggeman-Nannenga (1993); Bruggeman-Nannenga *et al.* (1994); Bruggeman-Nannenga and Berendsen (1990); Bruggeman-Nannenga and Pursell (1990, 1995); Dirkse *et al.* (1991); Dixon (1910); Magill (1981); Magill and Schelpe (1979); Potier de la Varde (1929); Pursell (1987, 1994) and Pursell *et al.* (1992, 1993). She also done four new combinations *viz., F. pachyloma* Muell. Hal. is made as a variety of *F. curvatus* Hornsch., *F. helictocaulos* Muell. Hal. to subspecies of *F. megalotis* Schimp. *ex* Muelll. Hal., *F. ulna* (Muell. Hal.) Paris as a form of *F. sciophyllus* Mitt. and *Moenkemeyera macroglossa* Broth. is transferred to *Fissidens macroglossa* (Broth.) Brugg.-Nann. She designated a neotype for *F. lacouturei* Thér. and validated four species of *Fissidens* such as, *F. jeffreyi* Bizot *ex* Brugg.-Nann., *F. negerianus, F. pseudoplumosus* Bizot & Onr. *ex* Brugg.-Nann. and *F. subplanifrons* Bizot & Onr. *ex* Brugg.-Nann. which are invalidly published by Bizot (1968).

Pursell (1997) synonimised about twenty species of *Fissidens* Hedw. including *Conomitrium* Mont. and one species of *Eustichia* (Brid.) Brid. Under eleven accepted name of *Fissidens* and lectotypes were designated for four species of *Fissidens*. He extended the work and in 1997 synonymised ten more species and one new combination is made *viz., F. lagenarius* var. *muriculatus* (Mitt.) Pursell. Sérgio *et al.* (1997) rediscovered *F. luisierii* P. de la Varde from Macaronesia. They also compared this species with *F. adianthoides* Hedw., *F. nobilis* Griff., *F. polyphyllus* Wils *ex* B.S.G. and *F. serrulatus* Brid. along with revised description and illustration.

Beever and Stone (1998) revised the section *Amblyothallia* of *Fissidens* with six species and three varieties including two new combinations, *F. asplenioides* Hedw., *F. pallidus* Hook. f. & Wilson, *F. oblongifolius* Hook. f. & Wilson var. *oblongifolius, F. oblongifolius* var. *capitatus* (Hook. f. & Wilson) Hook. f. &

Wilson, *F. oblongifolius* var. *hyophilus* (Mitt.) J.E. Beever & I.G. Stone and *F. oblongifolius* var. *palmerstonensis* (I.G. Stone) J.E. Beever & I.G. Stone. *F. oblongifolius* var. *palmerstonensis* is reported only from Australia and others from New Zealand. Nikora *et al.* (1998) studied the effect of the moss *F. rigidulus* Hook. f. & Wilson on near bed flow structure in an experimental setup and it is found that the presence of this species causes reduction in an average longitudinal velocity, Reynolds stress and total turbulence energy.

Beever (1999) studied the genus *Fissidens* in the New Zealand with 24 species and nine varieties along with key to the species. Beever and Stone (1999) recorded two new taxa and one new distributional record from New Zealand. *Fissidens waiensis* Beever and *F. rigidulus* var. *pseudostrictus* Beever, are new to science. *F. perangustus* Broth. is new to New Zealand and lectoytpe is also designated for this species. *F. variolimbatus* Allison and *F. leptocladus* Muelll. Hal. *ex* Rodway var. *cheesemanii* are synonimised under *F. leptocladus* var. *leptocladus* Dixon. They reduced *F. australiensis* A. Jaeger to variety *F. tenellus* var. *leptochaete* (Dusen) J.E. Beever & I.G. Stone.

Een and Thingsgaard (1999) catalogued 15 taxa of mosses from the Island of Rodrigues with three new records to the Mascarenes including *Fissidens ramuloses* Mitt. and three species new to Rodrigues including *F. sciophyllus* Mitt. The authors were also mentioned the early reports from this area by Mitten (1879) such as *F. procumbens* Mitt. and *F. brevifrons* Mitt. Furthermore he recorded two species such as *F. flaccidus* Mitt. and *F. vogelianus* Mitt. *F. procumbens* Mitt. now synonymised as *F. crispulus* Brid. (Bruggeman Nannenga, 1997) and *F. vogelianus* Mitt. as *F. zollingeri* Mont. (Bruggeman-Nannenga, 1997). Czernyadjeva (2000) described and illustrated *F. arcticus* Bryhn. from three localities of Russia and also differentiated it from *F.bryoides* Hedw. Bruggeman-Nannenga (1999) revised the Seychelles Mosses with special reference to the family Fissidentaceae.

Reese and Pursell (2002) reported 18 species of *Fissidens* with a few hepatics and other mosses growing on forest floor termite structures which are an attractive substrate for certain taxa of this genus. Four of them appear preferentially

on termite structures such as *F. gymnostomus* Brugg.-Nann., *F. hornschucii* Mont., *F. scariosus* Mitt. and *F. subulatus* Mitt., *F. gymnostomus* is present exclusively on termite structures. Since this substrate provide an organically enriched naked soil like substrate for these plants, a degree of co-evolution is suggested and the overlapping growth pattern may function to prevent the erosion of termite structures.

O'Shea (2002) provided a checklist of mosses from Sri Lanka with 568 mosses including two new combinations based on previously published literature. Family Fissidentaceae is represented by 42 species with four varieties. O'Shea (2003) also revised the moss checklist of Bangladesh with an objective of comparing it with bryoflora of neighbouring geographic zones like India, Indochina and Malaysia. He reported 92% of similarity in the bryophyte flora with india among the total 183 mosses including 29 members of Fissidentaceae. Three species are endemic to Bangladesh. Among these, two members are from Fissidentaceae *viz.*, *F. crispulus* Brid. (as *F. sylvaticus* var. *ramosus* Banu-Fattah) a common species in India and *F. hadii* Banu-Fattah.

Vanderpoorten and Barker (2004) done a comprehensive field study in the Eastern Cape province of South Africa and recorded 143 species of mosses including eight members of *Fissidens viz., F. androgynous* Bruch, *F. asplenioides* Hedw., *F. curvatus* Hornsch., *F. fasciculatus* Hornsch., *F. ovatus* Brid., *F. palmifolius* (P. Beauv.) Broth., *F. plumosus* Hornsch. and *F. serratus* Muelll. Hal. Pursell and Bruggeman-Nannenga (2004), done a revisionary study on the infrageneric taxa of *Fissidens* based on their peristome type, costa type and number of files of exothecial cells and divided the single genus into four subgenera. Among these subgenera *Aloma* and *Octodiceras* are not sub divided, subgenus *Pachyfissidens* is divided into three sections such as, *Amblyothallia, Crispidium* and *Pachyfissidens*. Subgenus *Fissidens* is divided into two such as, *Fissidens* and *Sarawakia*. Section *Amblyothallia* contains most primitive members while sections *Aloma* and *Octodiceras* includes most advanced members. Bruggeman-Nannenga (2004) reported two new *Fissidens* taxa from Uganda, *viz. Fissidens unipapillosus* Brugg.-Nann. and *F. palmifolius* (P.Beauv.) Broth, var. *semilimbatus* Brugg.-Nann.

Fissidens ellipticoides Brugg.-Nann. & Keurschner is described and illustrated by Bruggeman-Nannenga and Krschner (2004). It is compared with the gametophytically similar species *F. macrosporus* Dixon and *F. ellipticus* Besch. Three species, *F. bogosicus* Muelll. Hal., *F. flaccidus* Mitt. and *F. taxifolius* Hedw. are reported for the first time from the mainland of the Arabian Peninsula.

Bruggeman-Nannenga (2005) described two new species of *Fissidens viz., F. harringtonii* Brugg.-Nann. and *F. artsii* Brugg.-Nann. from Sierra Leone and Réunion of Africa respectively. Yan *et al.* (2005) listed the mosses from most diverse Zhejiang province in the Eastern coast of China which consists of 1039 taxa including previous works. Among these 694 species, eight subspecies and 27 varieties belonging to 222 genera and 45 families are accepted as valid taxa with 22 species of *Fissidens.*

Colacino and Sabovljević (2006) prepared a preliminary checklist of Albanian bryoflora based on literature reports from the year 1888, including 327 taxa belonging to 141 genera and 62 families including three species and two varities of *Fissidens viz., F. bryoides* Hedw. *F. dubius* P. Beauv., *F. dubius* var. *mucronatus* (Breidl. *ex.* Limpr.) Karti., Hedenaes & Soederstr. and *F. taxifolius* Hedw. Frey *et al.* (2006) reported 100 families of bryophytes along with 31 familes of pteridophytes from Europe. The family Fissidentaceae are represented by 32 taxa including 28 species, five varieties and 2 subspecies. They provides key to all the taxonomic ranks starting from order. Hill *et al.* (2006) listed the moss flora of Europe and Mecaronesia, which consists of 278 genera, 1292 species, 46 subspecies and 118 varieties including 34 species of *Fissidens*.

Pradhan and Joshi (2006) prepared a checklist of *Fissidens* of Nepal with 42 species and 7 varieties from an altitude range of 100 to 3400m. Among these, *F. taxifolius* var. *calcuttense* (Gangulee) Daniels & Daniel (as *F. sylvaticus* var. *calcuttensis* Gangulee), *F. taxifolius* var. *auriculatus* (Muelll. Hal.) Daniels & Daniel (as *F. sylvaticus* var. *auriculatus* (Muelll. Hal.) Gangulee) and *F. strictus* Hook. & Wilson are new records to Nepal.

Pursell (2007) described the family Fissidentaceae of Neotropics including 93 species with complete description, illustration, distribution and keys. Among these 58 species are endemic and one species *F. ecuadorensis*Pursell is new to science. Lectotypes were designated for 23 species.

Bruggeman-Nannenga (2009a), described the family Fissidentaceae with 2 new taxa, fifteen synonyms and fifty five new country records and state records from Africa, Australia and Costa Rica. *F. ah-pengae* Brugg.-Nann. and *F. aristifer* Brugg.-Nann. are new species reported from La Réunion and Madagascar respectively. Fifteen species are subsumed under twelve taxa viz., *F. crassipes* Wilson ex Bruch & Schimp., *F. crispulus* Brid., *F. erosulus* (Muelll. Hal.) Paris, *F. flaccidus* Mitt., *F. lagenarius* Mitt. var. *lagenarius*, *F. madecassus* Schimp. *ex* Muell. Hal., *F. metzgeria* (Muell. Hal.) Broth., *F. pallidinervis* Mitt., *F. ramulosus* Mitt., *F. reflexus* Hampe, *F. usambaricus* Broth. and *F. weirii* Mitt. She reported *F. pocsii* Bizot & Dury ex Pócs as an epiphyllous *Fissidens* which is earlier reported as epiphyte on tree trunks, roots, twigs and vines. Bruggeman-Nannenga (2009b) reported two new African *Fissidens viz*., *F. costivelatus* Brugg.-Nann. and *F. curticostatus* Brugg.-Nann. *F. costivelatus* was described based on a corticolous specimen from Kenya collected at 1650 msl. A new species of the section Amblyothallia, viz., *Fissidens cagoui* Frank Muell., Pursell & Brugg.-Nann., is described and illustrated by Mueller *et al*. (2009). *F. pseudopallidus* I.G. Stone, and *F. rigidulus* Hook. f. & Wilson are reported as new to the moss flora of New Caledonia and recorded five other species of *Fissidens*.

Gradstein and Culmsee (2010) explored the bryophyte diversity on tree trunks in relation to elevation and tree characteristics in montane forests of Central Sulawesi, Indonesia including more than 150 species occurring in eight canopy trees. Two species of *Fissidens* are reported from lower montane forest and the species richness of mosses is decreasing towards high elevation and most of the species prefer to grow on trees with rough bark. Vanderpoorten and Shaw (2010) synonymised *F. luisieri* P. de la Varde under *F. serrulatus* Brid. based on

polyphyletic and morphological studies done by Werner *et al.* (2009) in which they conducted molecular studies in the ITS and choloplast regions.

Bruggeman-Nannenga and Arts (2010) revised the Fissidentaceae of La Réunion with keys, descriptions and illustrations of 35 species. Eighteen species are reported as new record from La Réunion and three species are reported as new for Mauritius. *Fissidens pseudoplumosus* subsp. *subplanifrons* (Bizot & Onr. ex Brugg.-Nann.) Brugg.-Nann. & Arts, is recorded as new to La Réunion. *F. tenellus* is recorded for the first time from Africa. *F. subplanifrons* Bizot & Onr. ex Brugg.-Nann. is made as a subspecies of *F. pseudoplumosus* Bizot & Onr. ex Brugg.-Nann. A new species is proposed as *Fissidens cyatheicola* Brugg.-Nann. *F. boivinianus* var. *longifolius* Besch. is synonimised under *F. asplenioides* Hedw., *F. cremersii* Bizot & Onr. and *F. grandiretis* Renauld & Cardot are synonimised under *F. pellucidus* Hornsch. and *F. ellipticus* Besch. and *F. ligulinus* Muell. Hal. under *F. punctulatus* Sande Lac.

Hradílek *et al.* (2011) recorded 17 bryophyte species and one variety new to Kazakhistan including *F. bryoides* Hedw. var. *gymnandrus* (Buese) Ruthe. Martínez-Torres *et al.* (2011) discovered a close association between Diplopoda and Bryophyta in a transitional Andean-Pacific forest in Colombia. They observed a millipede population of *Psammodesmus bryophorus* Hoffman, Martínez & Flórez with 10 epizoic bryophyte species from 5 families: Fissidentaceae (2 species), Lejeuneaceae (5 species), Metzgeriaceae (one species), Leucomiaceae (one species) and Pilotrichaceae (one species). Among these the family Fissidentaceae includes *F. weirii* Mitt. and *F. steerei* Grout. Zhang and Hong (2011) reported an interesting new species from Macao, China *viz.*, *Fissidens macaoensis* Zang with rhizoidal tubers and fusiform gemmae developed on rhizoids. According to the authors this is the first moss where an individual plant produces two types of vegetative diaspores simultaneously such as rhizoidal gemmae and rhizoidal tubers.

Bruggeman-Nannenga and Wigginton (2012) described 12 species of *Fissidens* with detailed illustration and key from St. Helena, South Atlantic Ocean

including one new species and one subspecies *viz. F. translucens* Brugg.-Nann. & Wigginton and *F. curvatus* subsp. *sanctae-helenae* Brugg.-Nann. & Wigginton

Bruggeman-Nannenga (2013a) reported two new species of *Fissidens* such as *F. acrophilus* Brugg.-Nann. and *F. obscurifrons* Brugg.-Nann. from Tropical Eastern Africa along with *F. bessouensis* Corb. a species with fimbriate leaves and multicellular spores. This character is observed only in this species. She also reported two new species in the same year (2013b) *viz., F. tamaspocsii* Brugg.-Nann. and *F. magnicellulatus* Brugg.-Nann. from Eastern Africa and validated the species *F. cyatheicola* Brugg.-Nann. by designanting a type. Bruggeman-Nannenga (2013c) revised the subgenus *Fissidens* in tropical Eastern Africa mainly based on the collections by Tamás Pócs. Among these, *F. artsii* Brugg.-Nann. was new for Kennya, Tanzania and Uganda, *F. gomae* P. de la Varde & Leroy was new for Uganda, *F. leucocinctus* Hampe was new to Angola. The species such as *F. magnicellulatus* Brugg.-Nann., *F. pachylomadelphus* Demaret. & P. de la Varde, *F. robynsianus* P. de la Varde, *F. rotereaui* P. de la Varde and *F. taylorii* Muell Hal. were reported for the first time from Tanzania. *F. rotereaui* P. de la Varde and *F. taylorii* Muell Hal. were reported for the first time from Africa. *F. simensis* Schimp. ex Muell. Hal., *F. longipes* Welw. & Duby, *F. subremotifolius* Muell. Hal., *F.gueinzii* Muell. Hal., *F. malco-bryoides* Muell. Hal., *F. obsoletidens* var. *schistophila* Broth., *F. platybryoides* var. *subimmarginatus* Dixon, *F. crateris* Dixon and *F. crateris* var. *sererekae* Dixon were synonymised under *F. androgynous* Bruch. *F. hoeegii* P. de la Varde, *F. cataractarum* Demaret & P. de la Varde were reduced to synonym of *F. crispus* Mont.

Porley (2013) conducted a study on rare liverworts and mosses of England with emphasis on their history, ecology and conservation. Fissidentaceae Schimp. is represented by two species such as *F. curvatus* Hornsch. (endangered, EN) and *F. serrulatus* Brid. (Vulnarable, VU). Shevock *et al.* (2013) studied and described several species of *Fissidens* from the Republic of Sao Tome and Príncipe. Among the 24 species, 21 are new for the Republic of Sao Tome and Príncipe and among the 21 species two are the first records for Africa.

Bruggeman-Nannenga and Pursell (2014) reported a pantropical species *F. brevinervis* Broth. from Ascension Island, Ethiopia, India and El Salvador and *F. cryptoneuron* P. de la Varde is reduced to the synonymy of *F. brevinervis.* Beever (2014) prepared a complete guide for Fissidentaceae Schimp. in the New Zealand including 41 taxa with 13 varieties and one subspecies. The auther reported a new variety *F. taylorii* var. *sainsburyanus* Beever. Schwarz (2014a) catalogued bryophytes from Shinagawa in Japan with 94 species belonging to 62 genera including seven species of *Fissidens viz., F. adalphinus* Besch., *F. bryoides* Hedw., *F. dubius* P.Beauv., *F. laxus* Sull. & Lesq., *F. obscurirete* Broth. & Par., *F. taxifolius* Hedw. and *F. tosaensis* Broth. Bruggeman-Nannenga and Verwimp in reported *Fissidens parkii* Mitt. as new record for Thailand. Printarakul *et al.* (2014) revealed the Indian connection of the Thailand moss flora with one new species, *F. elizbrowniae* B.C.Tan & K.Wong. They recorded 20 species of mosses from Northern Thailand as new to the Bryoflora of the country including *F. elizbrowniae* T.C. Tan & K. Wong., new to science. A number of species showed a continuous range or disjunctive distribution with that of India (Indichina) and Indian subcontinent among the new records.

Ho *et al.* (2015) reported 23 mosses from Vietnam and Laos. Fissidentaceae includes *F. guangdongensis* Z. Iwats. & Li and *F. hollianus* Dozy & Molk. *F. hollianus* Dozy & Molk. is a new record to Lâm Đông Province in Southern Vietnam. Yoon *et al.* (2015) recorded ten new bryophyte records from South Korea including one new variety of *Fissidens involutus viz., F. involutus* var. *jejuensis* Y.-J. Yoon, B.C. Tan & B.-Y. Sun. They combared this variety with *F. bushii* (Cardot & Thér.) Cardot & Thér. reported from Japan, *F. gedehensis* M. Fleisch. from Malesia and *F. teysmannianus* Dozy & Molk. from Hainan.

Erzberger (2016) conducted a detailed study on the genus *Fissidens* Hedw. from Hungary. He collected more than 1500 specimens and reported 16 species including two new records to Hungary such as *F. crispus* Mont. and *F. bambergeri* Schimp. ex Milde.

Bruggeman-Nannenga (2016) Synonymised *F. angustifolius* Sull. under *F. biformis* Mitt., since it is published prior to *F. angustifolius* Sull. She also commented that, *F. coorgensis* Broth. is a synonym of *F. zollingeri* Mont. which is earlier considered as a synonym of *F. biformis* Mitt. by Gangulee (1971) and Eddy (1988), based on the smooth cells of *F. coorgensis* Broth. and *F. zollingeri* Mont. but in *F. biformis* Mitt. and *F. angustifolius* Sull. have mamillose laminal cells. Búcaro *et al.* (2016) catalogued 28 species of *Fissidens* from Salvador including five new records *viz.*, *F. costivelatus* Brugg.-Nann., *F. gardneri* Mitt., *F. goyazensis* Broth., *F. santa-clarensis* Thér. and *F. subulatus* Mitt. Among these, *F. costivelatus* Brugg.-Nann., were also reported as new record to neotropics.

Bruggeman-Nannenga (2017) revised the *Fissidens* subgenus *Aloma* Kindb. having large-celled costate and ecostate species from tropical Africa. She reported a new variety *F. flaccidus* var. *mammillosus* Brugg.-Nann. and *F. mollis* Mitt., a doubtful taxa was reinstated in this study.

Anđić *et al*. (2018) described *Fissidens fontanus* (Bach.) Steud as new record to Montenegro. Its conservation status varies in European distribution range. NT (Near threatened) in Czech Republic and Finland, VU (Vulnerable) in Estonia, Ireland, Luxemburg, Poland and Switzerland, EN (endangered) in Latvia and CR (Critically endangered) in Bulgaria and Romania. This species is also recomanded for new European Red List (Hodgetts., 2015). Outside Europe this species is also distributed in Africa, North and Central America, West Indies, Australia and Asia (Israel, Iran and Turkey).

Bordin *et al.* (2018) selected a lectotype for the species *Fissidens minutipes* (Muell. Hal.) Broth. from herbarium of the National Museum of Rio de Janeiro (R) since its holotype is destroyed from Mueller's herbarium during second world war. They also synonymised *F. termitarum* (Herzog) Pursell. Diop *et al.* (2018) recorded 22 species of bryophytes of Senegal with key to the species of *Fissidens* in the Senegal. Among these 17 species are new record to Senegal. The family Fissidentaceae are represented by eight species *viz.*, *F. crispulus* Brid., *F. dasyphus* Welw. & Duby in Duby, *F. gardneri* Mitt., *F. intramarginatus* (Hampe) A. Jaeger,

F. marthae Cardot., *F. parkii* Mitt., *F. ramulosus* Mitt. and *F. submarginatus* Bruch. ex C. Krauss. Among these, *F. crispulus* and *F. ramulosus* are new records to Senegal.

National status

The first record on the bryophytes of Kerala is that appeared in Rheede's (1678-1703) monumental work on South Indian plants, *Hortus Malabaricus.* He described and illustrated one moss from Kerala as '*Poovam-peda*' (vol.12, t.37, p.71, 1693). It was later interpreted by Nicolson *et al.* (1988) as *Bryum bicolor* Dickson. After more than 200 years later, the studies on the bryophytes of South India were started and all the studies were mostly concentrated on random collections by foreign bryologists or nature lovers. The studies also shows that the first record of *Fissidens* started during these period and the first record on the *Fissidens* Hedw. from the Southern India is from Nilgheri hills in Tamil Nadu by Montagne (1842). He described three species of *Fissidens viz.*, *F. anomalus* Mont., *F. bryoides* Hedw. and *F. crispulus* Brid. (as *F. tamarandifolius* var. *crispulus* Brid.).

Brotherus (1899) collected seven species and one variety of *Fissidens* from Karnataka such as *F. anomalus* Mont., *F. biformis* Mitt., (as *F. coorgensis* Broth.), *F. carnosus* Broth., *F. excedens* Broth., *F. fuscoviridis* Thwaites & Mitt., *F. lutescens* Broth., *F. walkeri* Broth. and *F. walkeri* var. *elimbatus* (Broth.) Dixon.

The main contribution of recording *Fissidens* and other mosses from South India during the early 20th century is by Dixon. Dixon (1914) studied 58 species of mosses collected by C.E.C. Fischer and others from different parts of South India and Ceylon including two *Fissidens* species *viz.*, *F. diversifolius* Mitt. and *F. bryoides* Hedw.

Dixon (1921) also mentioned about eight species of *Fissidens* including three new species, in his collections from various habitats of South India such as *F. walkeri* Broth., *F. zollingeri* Mont., *F. crispulus* Brid. (as *F. zippelianus* Dozy & Molk.), *F. sedgwickii* Broth. & Dixon, *F. firmus* Mitt. (as *F. subfirmus* Dixon) *F.*

crassinervis var. *laxus* (Sull. & Lesq.) A. Eddy. (as *F. immutatus* Dixon) and *F. macrosporus* Dixon.

Bruehl (1931) reported 51 species of *Fissidens* from India in the records of the Botanical survey of India. Among these 14 species are reported from Western Ghats.

Dixon (1937) described mosses of Assam based on the collections of Dr. N.L. Bor during 1933-1936. A total of 108 species were reported including seven species of *Fissidens viz.*, *F. semperfalcatus* Dixon, *F. rubricaulis* Dixon, *F. bryoides* Hedw., *F. leptopelma* Dixon, *F. nobilis* Griff., *F. anomalus* Mont. and *F. areolatus* Griff. Among these, *F. rubricaulis* Dixon and *F. leptopelma* Dixon are new species.

Bruehl and Sarkar (1929) reported mosses of Bengal based on the report of Prof. Brotherus in the second edition of Engler's "Pflanzenfamilien". Among these, five species are *Fissidens.*

Chopra (1960) made a preliminary list of mosses from Nainital and adjacent regions represented by 25 families including seven terrestrial species of *Fissidens* such as *F. bryoides* Hedw., *F. dubius* P. Beauv. (as *F. cristatus* Wilson & Mitt.), *F. excendens* Broth., *F. grandifrons* Brid., *F. crispus* Mont. (as *F. schmidii* Muell. Hal.), *F. taxifolius* Hedw. and *F. crispulus* Brid. (as *F. sylvaticus* Griff.).

Gangulee and Chatterjee (1962) conducted cytological studies on the sporophytes of 37 populations of 33 moss species in the Gangetic Bengal plains and the mountainous regions of Eastern Himalayas. Fissidentaceae Schimp. are represented by two species *viz.*, *F. ceylonensis* var. *jhargramii* Gangulee and *F. incognitus* Gangulee.

Noguchi (1964) documented mosses collected by Schimidi in 1953-1954 from Kashmir and Pakistan. It includes a total of 35 species and two varieties with two members of Fissidentaceae, *F. dubius* P. Beauv. (as *F. cristatus* Wils.) and *F. grandifrons* Brid. Chopra and Kanta (1966) reported 17 species of mosses from Delhi including two species of *Fissidens viz., F. bryoides* Hedw. and *F. taxifolius*

Hedw. Kaul and Dhar (1968) reported 35 bryophytes from Kashmir Valley including *Fissidens grandifrons* Brid. and one unidentified species of *Fissidens.*

Gangulee (1969-1971) studied the moss flora of Eastern India and adjacent regions in details. He reported a total of 990 species belonging to 274 genera and 52 families. The genus *Fissidens* is represented by 51 species with four subgenus *viz., Aneuron* Kindb., *Fissidens, Pachyfissidens* (Muell. Hal.) Kindb. and *Octodiceras* (Brid.) Broth. Among the 51 species *F. rambii* Gangulee, *F. allanii* Gangulee and *F. subpulchellus* Nork. were new species, 21 species viz., *F. elongates* Mitt., *F. obscurus* Mitt., *F. jungermannioides* Griff., *F. leptopelma* Dixon, *F. laxitextus* Broth. ex Gangulee, *F. polysetulus* Muell. Hal. ex Gangulee, *F. pulchellus* Mitt., *F. subpulchellus* Nork., *F. griffithii* Gangulee, *F. kalimpongensis* Gangulee, *F. incognitus* Gangulee, *F. orishae* Gangulee, *F. ranchiensis* Gangulee, *F. bilaspurense* Gangulee, *F. ranuii* Gangulee, *F. allanii* Gangulee, *F. rigidiusculus* Broth., *F. rambii* Gangulee, *F. longisetus* Griff., *F. subbryoides* Gangulee and *F. subpalmatus* Muell. Hal. are reported as endemic to India. Among the 51 species 18 are synonimised under different species.

The first report of *Fissidens* from Kerala is that of Srinivasan (1974), reported 64 mosses from South India including *Fissidens crispus* Mont. as *F. schimidii* Muell. Hal. from Shembaganur in Tamil Nadu and Trivandrum in Kerala. He recorded the occurance of this species at an altitude of 2000m in Karnataka and 300m in Kerala.

Chopra (1975) studied about Indian mosses and given key to the genera and subgenera. He considered two genera in the family Fissidentaceae Schimp. such as, *Moenkemeyera* Muell. Hal. and *Fissidens* Hedw. and *Fissidens* is divided tofour subgenera *viz., Aneuron* Kindb., *Fissidens* Mitt., *Pachyfissidens* (Muell. Hal.) Kindb. and *Octodiceras* (Brid.) Broth. According to him, only genus *Fissidens* is reported from India. Subgenus *Fissidens* Mitt. is divided in to 14 sections.

Vohra *et al.* (1982) reported 83 species of mosses from Silent valley National Park in Palakkad district of Kerala. Among these, two collections were *Fissidens,* but not yet identified the species. The collected specimens were deposited

at Central National Herbarium, Kolkata (CAL) and we could not locate the specimen during the present study (The specimens were misplaced or lost). Gangulee (1985) reported *Fissidens ceylonensis* Dozy & Molk. from West Bengal along with 100 genera from eastern India and adjuscent regions. He considered the family under the order Dicranales. Mohamed *et al.* (1986) contributed 45 species of mosses belonging to 17 families including 17 species new to the Bryoflora of Western Ghats from Mahabaleshwar, Poona and Khandala of North Western Ghats. Among these, eight species were *Fissidens* with four new records such as *F. diversifolius* var. *rubricaulis* (Dixon) Nork., *F. polysetulus* Muell. Hal. ex Gangulee & Nork., *F. pulchellus* Mitt. and *F. zollingeri* Mont. are the newly reported species along with already reported species such as, *F. ceylonensis* Dozy & Molk., *F. pellucidus* Hornsch. (as *F. mittenii* Par.), *F. ranchiensis* Gangulee and *F. crispulus* Brid. (as *F. sylvaticus* Griff.).

Kumar and Arora (1988) studied cytological features of some West Himalayan species of *Fissidens* such as *F. bryoides* Hedw. var. *bryoides* with n=12, *F. bryoides* var. *schmidii* (Muell. Hal.) Chopra & Kumar With n=13, *F. zollingeri* Mont. (as *F. xiphioides* Fleisch.) with n=12, *F. crenulatus* Mitt. (as *F. virens* Thwaites & Mitt.) with n=12, *F. dubius* P. Beauv. (as *F. cristatus* Wils. & Mitt.) with n=12 and *F. taxifolius* Hedw. with n=12. *F. bryoides* Hedw. var. *bryoides, F. dubius* P.Beauv. and *F. taxifolius* Hedw. are polyploids with varying chromosome numbers. Srivastava and Norkett (1988) reported *Fissidens arunii* J.P. Srivast. & Nork. as new to science from Mahabaleshwar, India. Since then this specimen has not been collected by anybody and the protologue suggest that the species needs further study to fix its identity. We could not locate this species during our present collection and the description is given based on the protologue.

Ellis (1992a), while studying the moss flora of South India reported *Fissidens ceylonensis* Dozy & Molk. from Kallar in Thiruvananthapuram district, a widely distributed species in Kerala and *F. ceylonensis* var. *acutifolius* Dixon & P. Varde from Kumali in Idukki district. Chaudhary and Deora (1993) reported five species of *Fissidens* including one variety from Rajasthan *viz., F. bryoides* Hedw.,

F. diversifolius Mitt., *F. geminiflorus* var. *nagasakinus* (Besch.) Doxy & Molk., *F. involutus* ssp. *curvato-involutus* (as *F. curvato-involutus* Dixon) and *F. sylvaticus* Griff.

Negi and Gadgil (1997) studied the diversity and community ecology of 177 mosses by using 50m x 10m transects between 1500m and 3700m in the Garwal Himalaya. They recorded 56 species as terricolous, 31 as lignicolous and corticolous and six saxicolous species. Remaining 84 species were found on more than two major types of substrates. One unidentified epiphytic *Fissidens* species is also reported from an altitude of 2600m.

Nath *et al.* (2000) reported the role of bryophytes in soil management and rock binding based on earlier works and recorded that some liverworts and mosses including *F. taxifolius* Hedw. were flourishing well in a highly calcareous stream water in reference to the work of Pant (1987). Negi (2000a) studied the species richness and turnover of moss communities along a disturbance gradient in the western parts of Nanda Devi Biosphere Reserve in the Western Himalayam Mountain range of India. He reported one unidentified species of the genus *Fissidens* on soil at an altitude of 3300m from the area with less species richness along with a total of 42 species. He also commented that habitat transformation, deforestation etc. adversely affect the diversity but the traditional livestock and collection of fuel wood and fodder seems to have no serious impact on moss diversity.

Pant (2001) reported three species of *Fissidens* along with 29 liverworts and 58 mosses from Kumaon Himalaya. *F. ceylonensis* Dozy & Molk., *F. grandifrons* Brid. and *F. taxifolius* Hedw. are the species of *Fissidens.* Chaudhary and Deora (2001) revealed the moss diversity of MT. Abu in India with 25 species. The family Fissidentaceae is represented by four species such as, *F. involutus* subsp. *curvatoinvolutus* (Dixon) Gangulee (as *F. curvato-involutus* Dixon), *F. diversifolius* Mitt., *F. Gaminiflorus* var. *nagaskinus* (Besch.) Dozy & Molk. (may be misspelled *F. geminiflorus* Dozy & Molk.) and *F. taxifolius* Hedw. (as *F. sylvaticus* Griff.)

Dabhade and Patil (2001) studied the spore characters of nine species of mosses from Western Ghats using SEM. Among these, six species belongs to genus *Fissidens viz., F. bryoides* Hedw., *F. zollingeri* Mont. (as *F. zollingeri* Mont. and *F. xiphoides* Fleisch.), *F. teniolatus* Dixon & P. de la Varde, *F. sedgwickii* Broth. & Dixon, *F. crenulatus* Mitt. and *F. walkeri* Broth.

Easa (2003) in the biodiversity documentation of Kerala enumerated the species of Bryophytes occurring in Kerala till date and these report includes only the published data, not going into the details of the species. This report includes 232 species of bryophytes and includes 12 species and one variety of *Fissidens* in Kerala.

Daniels and Daniel (2003a) added three mosses and three liverworts new to the Peninsular India from Tamil Nadu including *F. kalimpongenesis* Gangulee and *F. subangustus* M. Fleisch. (as *F. leptopelma* Dixon). Daniels and Daniel (2003b) reported *Fissidens griffithii* Gangulee from Tamil Nadu as new record for the bryoflora of India.

Nair and Madhusoodanan (2002 & 2004) reviewed the history of the bryophyte studies and distributional pattern of bryophytes in Southern India, with particular reference to the state of Kerala which also discussed the occurrence of the genus *Fissidens*.

Nair *et al.* (2005) published a book, Bryophytes of Wayanad in Western Ghats, the first comprehensive taxonomic treatment of South Indian bryophytes which includes 171 species with two varieties belonging to 47 families. The genus *Fissidens* represented by nine species including one unidentified *viz., F. asperisetus* Sande-Lac., *F. ceylonensis* Dozy & Molk., *F. crenulatus* Mitt., *F. crispulus* Brid. var. *crispulus, F. crispulus* var. *robinsonii* (Broth.) B.C. Tan & Choy, *F. flaccidus* Mitt., *F. subbryoides* Gangulee, *F. zollingeri* Mont. and *Fissidens sp. F. crispulus* var. *robinsonii* (Broth.) B.C. Tan & Choy was a new record to Peninsular India. The unidentified species is identified as *F. bryoides* Hedw. during the present study. A new species of *Fissidens, viz., F. longtonianus* Z. Iwats. & Tad. Suzuki was described by Iwatzuki and Suzuki (2005) based on the collection by Rajeevan

(1990) from Idukki district. This was recorded as *F. choprai* Nork. by Rajeevan in his thesis and Iwatzuki and Suzuki later named and described the same as new species *viz*., *F. longtonianus* Z. Iwats. & Tad. Suzuki.

Daniels and Daniel (2005) reported four species new to the moss flora of Indian mainland including *F. crispulus* var. *robinsonii* (Broth.) Z. Iwats. & Z.-H. Li *(*as *Fissidens robinsonnii* Broth.) from Thirunelveli district of Tamil Nadu. Chaudhary *et al.* (2006) conducted study on bryophyte flora of Gujarat with seven species including two subspecies and one variety such as *F. bryoides* Hedw., *F. bryoides* ssp. *Schimidii* (Muell. Hal.) Nork., *F. flaccidus* Mitt. (as *F. splachnobryoides* Broth.), *F. zollingeri* Mont., *F. xiphoides* Fleisch., *F. macrosporoides* Dixon, *F. involutus* ssp. *curvato-involutus* (Dixon) Gangulee and *F. geminiflorus* var. *nagasakinus* (Besch.) Doxy & Molk. He considered *F. xiphoides* Fleisch. as a separate species which is considered as a synonym of *F. zollingeri* Mont.

Manju *et al.* (2006) enumerated the bryophytes of Chinnar Wildlife Sanctuary in the Eastern parts of the high ranges in the Southern Western Ghats with an altitudinal range of 450m – 2372m with a total of 40 mosses, 19 liverworts and one hornwort. The family Fissidentaceae are represented by two species, *viz., F. crenulatus* Mitt. (as *F. virens* Thwaites & Mitt.) and *F. hollianus* Dozy & Molk. (as *F. asperisetus* var. *andamanensis* Gangulee). *F. asperisetus* var. *andamanensis* Gangulee was reported as new record to the mainland of India.

Nair and Madhusoodanan (2006) catalogued the bryophytes of Vellarimala which is a mountainous area in the Western Ghats of Kozhikode district of Kerala with a variety of habitats suitable for the colonization and diversified growth of Bryophytes. They reported 53 species including 34 mosses and 19 leafy liverworts, the family Fissidentaceae are represented by one common high altitude epiphytic species *viz*., *Fissidens anomalus* Mont.

Phatak *et al.* (2007) studied bryophyte diversity and distribution in Goa with a total of 50 species including two unidentified species of *Fissidens.* Vashistha (2007) reported seven species of *Fissidens viz., F. bryoides* Hedw., *F. taxifolius* Hedw., *F.*

involutus Wilson & Mitt., *F. diversifolius* Mitt., *F. flaccidus* Mitt. (as *F. splachnobryoides* Broth.), *F. ceylonensis* Dozy & Molk. (as *F. intramarginatulus* Bartr.) and *F. crenulatus* Mitt. (as *F. semperfalcatus* Dixon) along with 57 species of mosses from plains of Northern India and adjacent regions. Vijayan *et al.* (2007) assessed the ecological and conservation strategies of bryophytes in Goa and reported 35species. The family Fissidentaceae are represented by two unidentified species of which one species is aquatic and other one is present as terrestrial and aquatic. Chaudhary and Sharma (2007) reported two species of *Fissidens viz., F. bryoides* and *F. macrosporoides* along with 21 epiphytic species of mosses from Gujarat which is the first consolidated report of bryophytes from Gujarat in Western Ghats.

Daniels and Daniel (2007) reported 74 species of mosses from Southern Western Ghats including 19 species with four varieties of *Fissidens.* Daniels and Kariyappa (2007) sampled 135 bryophytes including list of 22 species and two subspecies of *Fissidens* from various parts of evergreen forests, degraded evergreen forests, clove and rubber plantations in the Southern Western Ghats to study the diversity along the gradient of human disturbance and reported that evergreen forest had the highest diversity followed by degraded evergreen forests, clove and rubber plantations. Besides, the highest number of exclusive species found in the evergreen forest whereas degraded evergreen forest, clove and rubber plantations have more generalised and light tolerant species including *F. ceylonensis* Dozy & Molk. and *F. zollingeri* Mont. While some species such as *F. polysetulus* Muell. Hal. ex Nork. & Gangulee and *F. diversifolius* Mitt. are exclusively evergreen forest species.

Madhusoodanan *et al.* (2007) explored the bryophyte diversity of Eravikulam National Park including 86 species of mosses with four members of *Fissidens* and 29 species of liverworts. Genus *Fissidens* includes four species *viz.*,*F. anomalus* Mont. *F. ceylonensis* Dozy & Molk., *F. curvato - involutus* Dixon and one unidentified species.

Manju *et al.* (2008a) reported a new species of *Fissidens viz., F. kammadensis* Manju, K.P. Rajesh & Madhus. from a sacred grove, the

Kammadakavu of Kasaragod district in Kerala. This species is growing in the low altitudinal evergreen forest mostly along with the *Myristica* roots, on small rocks and cuttings where water flows regularly. Later Jyothilakshmi *et al.* (2016) also collected the same species from Vallikkattu kavu of Kozhikode district in a similar microhabitat. This report shows that this species is found in the low altitudinal evergreen forests of northern Kerala and is endemic to Kerala.

After Easa (2003), Manju *et al*. (2008b) prepared a checklist of bryophytes occurring in Kerala with upto date nomenclature details; this list includes a total of 465 valid species of bryophytes from Western Ghats of Kerala with 148 liverworts, 10 hornworts and 307 mosses. The family Fissidentaceae are represented by 25 species which includes the species occurring in Easa (2003) and the species reported after 2003 to 2008.

Chaudhary *et al.* (2008) studied the bryophyte flora of North Konkan in Maharashtra state of India and reported 100 species belonging to 24 families. Fissidentaceae are represented by eight species with one variety *viz., F. bryoides* Hedw., *F. bryides* subsp. *schmidii* (Muell. Hal.) Nork., *F. flaccidus* Mitt. (as *F. splachnobryoides* Broth.), *F. crenulatus* Mitt., *F. involutus* subsp. *curvato-involutus* (as *F. curvato involutus* Dixon), *F. zollingeri* (as *F. zollingeri* and *F. xiphoides* Fleisch.) *F. macrosporoides* Dixon & P. de la Varde and *F. geminiflorus* Dozy & Molk. (wrongly spelled as *F. gaminiflorus* Dozy & Molk.).

Dash *et al.* (2009) reported 31 bryophytes from Baphlamali hill in the Orissa including *F. serratus* Muell. Hal. Choyal and Sharma (2011) conducted study on moss flora and the growth forms of mosses in Dharmshala tehsil of Kangra district in Himachal Pradesh during 2008 to 2010. They reported different habitats of mosses in the study area such as humus rich soil, calcareous soil, laterite soil, peaty soil, forest floor, aquatic, moist soil and epiphyte. *F. walkeri* Broth., *F. bryoides* Hedw., *F. zollingeri, F. flaccidus* Mitt. (as *F. splachnobryoides* Broth.) are reported as growing on humus rich soil. *F. sedgwickii* Broth. & Dixon and *F. grandifrons* Brid. are as aquatic, growing on large and small rocks under the water.

Manju *et al.* (2009a) studied the bryophyte flora of Aralam wildlife Sanctuary in the Western Ghats and catalogued 116 taxa, of which eight species were *Fissidens viz., F. anomalus* Mont., *F. asperisetus* Sande-Lac., *F. ceylonensis* Dozy & Molk., *F. crenulatus* Mitt. (as *F. virens* Thwaites & Mitt.), *F. pellucidus* Hornsch., *F. pulchellus* Mitt., *F. serratus* Muell. Hal. var. *Serratus* and *F. crispulus* Brid. var. *crispulus* (as *F. sylvaticus* var. *zippelianus* (Dozy & Molk.) Gangulee). *F. pellucidus* Hornsch. is recorded as new distributional record to Kerala. Manju *et al.* (2009b) listed 90 taxa including 58 mosses and 32 liverworts from Agasthyamalai Biosphere Reserve, of which 16 species are new to Peninsular India and six species are new record to Kerala State. The family Fissidentaceae is represented by *Fissidens anomalus* Mont. only.

Daniels (2010) prepared a checklist of bryophytes with up to date nomenclature of the species from Tamil Nadu. This checklist includes 712 taxa reported from the state. Among these, 41 species were validly published species of *Fissidens.*

Hile and Dhabhade (2011) studied and given detailed description with keys of five species of the genus *Fissidens viz., F. flaccidus* Mitt. (as *F. splachnobryoides* Broth.), *F. bryoides* Hedw., *F. zollingeri* Mont. (as *F. curvato-xiphoides* Dixon &. P. de laVarde), *F. crenulatus* Mitt. and *F. pallidinervis* Mitt. (as *F. minutes* Thwaites & Mitt.) from Thal Ghat (Maharashtra) of Western Ghats. Among these, *F. bryoides* Hedw., *F. zollingeri* Mont. and *F. pallidinervis* Mitt. were newly reported from the area.

Manju and Rajesh (2011) studied the bryophyte diversity of Parambikulam Tiger Reserve and reported 58 taxa including three species of *Fissidens* such as *F. anomalus* Mont., *F. crispulus* Brid. and *F. kurzii* Muell. Hal. Manju *et al.* (2011) reported the bryophyte diversity of Kakkavayal Reserve Forest in the Western Ghats of Kozhikode district with a total of 24 mosses and 16 liverworts and recorded five species of *Fissidens viz., F. diversifolius* Mitt., *F. ceylonensis* Dozy & Molk. (as *intromarginatulus* Bartr.), *F. pulchellus* Mitt., *F. crispulus* (misidentified as *F. polysetulus* Muell. Hal. ex Nork. & Gangulee) and *F. serratus* Muell. Hal.

Dandotiya *et al.* (2011) provided a checklist of bryophytes of India, accounting 2489 taxa, including 88 species of *Fissidens* but eight of them are misspelled or invalid species. Most of the species followed without author citation. Hence the validity of the above number is doubtful.

The economic utility of the species is not studied due to the small size of the plant and non availability of available quantity in pure form. Still Srivastava *et al.* (2011) conducted plant mediated synthesis of silver nanoparticles using *F. minutus* Thwaites & Mitt. and studied its anti-microbial properties and found that aqueous extract of *F. minutus* treated with 0.5mM silver nitrate solution produced silver nanoparticles at room temperature rapidly and the nanosilver produced has a potent antibacterial activity against both gram positive and gram negative bacteria. This is the only study conducted on *Fissidens* for the antimicrobial studies.

Nath *et al.* (2011) studied the genus *Fissidens* at Pachmarhi Biosphere Reserve and reported six species such as, *Fissidens asperisetus* var. *andamanensis* Gangulee, *F. ceylonensis* Dozy & Molk., *F. crispulus* Brid. var. *crispulus*, *F. involutus* Wils. ex Mitt., *F. pulchellus* Mitt. and *F. taxifolius* Hedw. Verma *et al.* (2011) stated the status of mosses from Nilgiri hills based on all earlier reports including 157 taxa in which 22 are new to Nilgiri hills. The genus *Fissidens* is represented by nine species with two varieties *viz.*, *F. anomalus* Mont. (based on Montagne, 1842), *F. bryoides* Hedw. (based on Gangulee, 1971; Muellller, 1853), *F. ceylonicus* Dozy *et al.* (based on Bruhel, 1931), *F. ceylonensis* Dozy & Molk. var. *ceylonensis* (based on Bruhel, 1931), *F. diversifolius* Mitt. (based on Gangulee, 1971), *F. grandiformis* Brid. (based on Gangulee, 1971), *F. hyalinus* Hook. & Wilson (as *F. nymanii* Fleish. (based on Gangulee, 1971), *F. sylvaticus* var. *acericulatus* (based on Bruhel, 1931) and *F. wilsoni* Mont. (based on Bruhel, 1931).

In Karnataka, the genus *Fissidens* is represented by 16 species (Frahm *et al*., 2013; Schwarz, 2013). Schwarz & Frahm (2013) also enumerated the Bryoflora of Coorg, Karnataka with 94 species including nine new records. The genus *Fissidens* is represented by only one species viz., *F. sedgwickii* Broth. & Dixon.

Deora and Rathore (2013) studied the antimicrobial properties of some bryophytes from Mt. Abu against certain bacterial strains. They found that the crude extract of *F. bryoides* Hedw. has the capacity to work against *Xanthomonas citri* and no bacterial growth was observed in more than 50% concentration. The growth of *Agrobacterium tumifaciens* and *Streptomyces scabies* are also negatively affected by the concentration gradient of *F. bryoides* Hedw.

Mufeed *et al.* (2014) reported 32 species of bryophytes from Thusharagiri hills of Western Ghats in Kozhikode district of Kerala. The genus *Fissidens* is represented by an unidentified species which is now confirmed as *F. crispulus* Brid.

Schwarz (2014b) reported *F. brevinervis* Broth. from Bangalore in Karnataka state which is an addition to Indian bryoflora and previously known from China and Indonesia. They also provided a brief summary of bryophyte flora of Bangalore and a checklist of genus *Fissidens* with 76 species including six varieties and one subspecies from India.

Aruna and Krishnappa (2014) explored the Bryoflora of malanad regions of Chikmangalur District in Karnataka state and recorded a total of 62 species belonging to 44 genera and 30 families. Fissidentaceae are represented by four species, *F. asperisetus* Sande-Lac., *F. ceylonensis* Dozy & Molk., *F. crenulatus* Mitt. and *F. zollingeri* Mont. Mishra *et al.* (2014) studied the therapeutic properties of bryophytes and reported that *F. nobilis* Griff. has diuretic and hair growth stimulation properties.

Rajesh and Manju (2014) listed the diversity of bryophytes of the lowlands and midlands of Kozhikode district mainly from thickly populated areas with 57 taxa including six species of *Fissidens viz.*, *F. bryoides* Hedw., *F. ceylonensis* Dozy & Molk., *F. crispulus* Brid., *F. flaccidus* Mitt., *F. kurzii* Muell. Hal. and *F. pulchellus* Mitt. Manju *et al*. (2014) studied the bryophyte diversity of Silent valley National park of Western Ghats in Kerala with 109 mosses, 36 liverworts and 3 hornworts. *Fissidens* is represented by *F. asperisetus* Sande-Lac., *F. firmus* Mitt. and *F. virens* Thwaites & Mitt. Among these, the report of *F. firmus* Mitt. is based on the collection of Vohra *et al.* (1982).

Alam *et al.* (2015) described the moss flora of Central India including Gujarat, Madhya Pradesh, Jharkhand, Chhattisgarh and Southern Rajasthan with 210 species in 94 genera and 30 families. *Fissidens* is the largest genus with 26 taxa. Rawat *et al.* (2015) listed 51 species of bryophytes from Rajasthan and Punjab Plains, *Fissidens* had the maximum diversity with seven species *viz., F. bryoides* Hedw., *F. ceylonensis* Dozy & Molk., *F. crispulus* Brid., *F. diversifolius* Mitt., *F. gemminiflorus* Dozy & Molk., *F. involutus* ssp. *curvato-involutus* (Dixon) Gangulee and *F. taxifolius* Hedw.

Bruggeman-Nannenga *et al.* (2015) described a little known species *F. firmus* Mitt. from Western Ghats with illustration and distribution. It is a new record for India. They provided the comparison of *F. firmus* Mitt. with *F. hollianus* Dozy & Molk. which is reported as *F. firmus* Mitt. from the Silent valley National Park in Kerala by Vohra *et al.*, 1982. Lalhriatpuia and Laha (2015) assessed the bryophyte diversity of Mamit district in Mizoram for first time. A total of 65 taxa are described including two species of *Fissidens viz., F. nobilis* Griff. and *F. polypodioides* Hedw.

Manjula *et al.* (2015a) reported *F. macrosporus* Dixon from Kuruva dweep of Wayanad district in Kerala. It is a rediscovery of this endemic species after more than ninety years from the Western Ghats. Dixon (1921) reported this species from Canara district of Karnataka for first time but there is no any other report about its occurence till 2015. It is an epiphytic species on twigs and small branches of small shrubs in evergreen forests of Western Ghats with immersed to slightly emergent sporophyte.

Manjula *et al.* (2015b) described *F. linearis* var. o*bscurirete* as new distributional record to India from Thiruvananthapuram and Idukki districts of Kerala. It is earlier reported from China, Japan, Korea, Taiwan and New Caledonia. But after carefull examination with type specimen and consulting with experts it is confirmed that the species *F. linearis* var. o*bscurirete* is *F. speluncae* Broth. Earlier this species is collected during 1910 from Sri Lanka by Brotherus and Viktor Ferdinand which is the type locality of this species and hence this collection is also a rediscovery after more than a century.

Jyothilakshmi *et al.* (2016) studied the bryophyte diversity of a sacred Grove, Vallikkattukavu of Kozhikode district in Kerala. They described a total of 29

bryophytes including 10 liverworts and 19 mosses. Family Fissidentaceae are represented by eight species *viz., F. ceylonensis* Dozy & Molk., *F. crispulus* var. *crispulus* Brid., *F. crispulus* var. *robinsonii* (Broth.) B.C. Tan & Choy., *F. flaccidus* Mitt., *F. ganguleei* Nork., *F. hollianus* Dozy & Molk., *F. kammadensis* Manju, K.P.Rajesh & Madhus. and *F. pellucidus* Hornsch. Among these, *F. kammadensis* is reported only from the sacred grove in Kasaragod district of Kerala. It is observed that this species inhabits only in sacred groves.

Srivastava *et al.* (2015b) reported *Fissidens ceylonensis* Dozy & Molk. from Gupt-Godavari cave in Chitrakoot of Central India, a common species of India. Normally *F. ceylonensis* shows submarginal limbidium, excurrent costa, etc. But this collection showed some interesting variations in the morphology of limbidium which is never submarginal and costa always percurrent.

Mehta *et al.* (2016) studied the status of the family Fissidentaceae in Gujarat in India including eight species *viz., F. zollingeri* Mont., *F. flaccidus* Mitt. (as *F. splachnobryoides* Broth.), *F. curvato-involutus* Dixon and five unidentified species. Among the unidentified species, species1 is F*issidens flaccidus* Mitt. and the only difference they mentioned is the curved lower margin of leaf in species1 which is not strong enough to separate it from original *F. flaccidus* Mitt. The key provided is not clear to distinguish other unidentified species and description is not provided for each species.

Bruggeman-Nannenga *et al.* (2016) reported an African species *F. enervis* Sim as new distributional record to Asia. It is reported from a highly disturbed habitat in the Nelliampathy hills of Western Ghats in Kerala which is earlier reported from South Africa. This species was collected by Manjula from the area and it is confirmed by Bruggeman-Nannenga of Netherlands. Manjula *et al.* (2016) revealed the distribution pattern of the genus *Fissidens* in the Eastern Ghats of Andhra Pradesh with eight species *viz., F. flaccidus* Mitt., *F. zollingeri* Mont., *F. diversifolius* Mitt., *F. crenulatus* Mitt., *F. crispulus* Brid., *F. taxifolius* Hedw., *F. ceylonensis* Dozy & Molk. and *F. pallidinervis* Mitt. Of which, *F. taxifolius* Hedw. and *F. pallidinervis* Mitt. were new for Eastern Ghats; *F. crispulus* Brid. and *F. ceylonensis* Dozy & Molk. were new for the state of Andhra Pradesh.

Sreebha *et al*. (2016) reported long-lost *F. serratus* var. s*erratus* Műll. Hal. from Indira Gandhi National park in Anamalai hills of the Western Ghats after two centuries. Mishra *et al.* (2016) studied the current status of moss diversity and distribution of bryophytes in Odisha in India. They reported a total of 149 species. The family Fissidentaceae are one of the largest families in Odisha and is represented by 15 species with two varieties.

Gupta *et al.* (2017) reported two species of *Fissidens* from Pachmarhi BR; *F. oblongifolius* Hook. f. & Wilson and *F. formosanus* Noguchi which are new distributional records from India.

Subramanian (2016) reported two species of *Fissidens* from South India *viz., F. grandifolia* D.S. and *F. barbuloides* D.S. Among these, he recorded *F. grandifolia* D.S. as a new species from Coonoor in Tamil Nadu. The illustration given in the protologue is very poor without any characters to support his findings. He described that the isotypes were kept in his custody at home and holotype is deposited in BSI (CBE, TN). But the abbreviation for herbarium of BSI, Coimbatore is MH and during our present survey we could not locate the species from BSI, Coimbatore. The second species listed by him in the paper is authored by himself (Subramanian, 2011). But this species also we could not locate from BSI, Coimbatore.

Venugopal and Manju (2017) reported 37 species of bryophytes including four species of *Fissidens viz., F. bryoides* Hedw., *F. crispulus* Brid., *F. flaccidus* Mitt. and *F. zollingeri* Mont. from the Wayanad pass, a very important historical area in Kerala. Manjula *et al.* (2017) reported a new species *viz., F. manilalia* Manjula, Manju & K.P. Rajesh from a semi-urban area of Kozhikode district in Kerala. It is a tiny species growing along with *F. pallidinervis* Mitt., *Calymperes erosum* Muell. Hal. and *Cyathodium cavernarum* Kunze in avenue trees such as *Samanea saman* (Jacq.) Merr. and *Terminalia catappa* L. in highly disturbed areas.

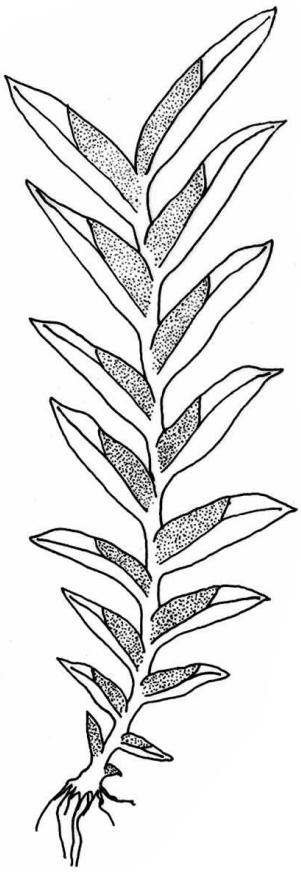
Palani *et al.* (2017) recorded a list of 52 species of mosses belongs to 21 family from Bodamalai Hills in Eastern Ghats of Tamil Nadu. The family

Fissidentaceae are represented by two species, *F. ceylonensis* Dozy & Molk. var. Ceylonensis and *F. subangustus* M. Fleisch.

Magdum *et al*. (2017) given a detailed checklist of the bryophytes of Maharashtra. In this paper they have listed 12 species of Fissidens viz., *F. bryoides* Hedw., *F. crenulatus* Mitt., *F. curvatoxiphoides* Dixon & P. de la Varde, *F. gaminiflorus* Dozy & Molk., (it is *F. geminiflorus*; wrongly spelled as *F. gaminiflorus* Dozy & Molk.). *F. macrosporoides* Dixon and P. de la Varde, *F. minutus* Thwaites & Mitt., *F. sedgwickii* Broth. & Dixon, *F. splacnobryoides* Broth., *F. teniolatus* Dixon & P. de la Varde, *F. walkeri* Broth., *F. xiphioides* Fleisch. and *F. zollingeri* Mont. Among these, *F. curvatoxiphoides* and *F. xiphioides* are synonimised under *F. zollingeri* Mont. and *F. minutus* Thwaites & Mitt. under *F. pallidinervis* Mitt..

Daniels *et al.* (2017) reported *Fissidens neomagofukui* Z. Iwats. & Tad. Suzuki from Valparai in Tamil Nadu which is earlier reported from Japan only. It is an epiphytic plant growing on *Ginko biloba* L. in Japan and *Terminalia paniculata* Roth. in semi-evergreen forest of Western Ghats. They commented that the Indian plants show some variations from that of the Japanese plants may be due to the different climatic conditions and also commented the curious disjunct distribution of this species in a temperate country and in tropical region. Daniels *et al.* (2018) published a new book entitiled 'Bryoflora of Indhira Gandhi National Park in Anamalai Hills, India' with a total of 217 species and six intraspecific taxa belonging to 109 genera and 50 families. Among these 135 species with 4 intraspecific taxa are mosses, one species is hornwort and 81 species with two intraspecific taxa are liverworts. The family Fissidentaceae are represented by 20 species. Among these, *F. neomagofukui* Z. Iwats. & Tad. Suzuki is already reported by Daniels *et al.* (2017). All other species were earlier reported from Western Ghats. The species *F. titalyanus* Muell. Hal. is earlier considered as a variety of *F. crenulatus* Mitt. But in the present study they have considered it as a separate species based on difference in peristome characters.

From the above review it is clear that the International status of the studies on this family is comparatively stronger compared to the studies in India. In this scenario, a detailed taxonomic treatment of the family Fissidentaceae in the Western Ghats is of atmost significance.



Chapter: IV

MATERIALS AND METHODS

MATERIALS AND METHODS

The members of the genus *Fissidens* thrive well in all habitats except in marine water. They inhabit as epiphytes, on rocks, terrestrial forms and in submerged condition. The specimens for the present study were collected from different microhabitats of the Western Ghats from 2013 to 2018. The important steps in the taxonomy of *Fissidens* are collection, preservation and herbarium preparation, identification, giving taxonomic description, photodocumentation and illustration, naming with up to date nomenclature system and finely deposition of voucher specimens in recognised herbaria.

Collection:

The important step in the study of *Fissidens* taxonomy is the collection from different microhabitats. Field trips were undertaken with all necessary items required in the field such as field book, sharp edged knife, scalpel, newspaper, pen or pencil, slip pad, collection bag and GPS reader. The plants were collected randomly from the field by observing the morphology of *Fissidens*. Plants were scraped out from the substratum with the help of a sharp edged knife. Terrestrial species were collected with along the substratum and the bulk of the soil particles were removed leaving a thin film. Because some species shows profuse growth of protonema. Corticolous and lithophytic species when strongly attached to the substratum were collected with a portion of the bark and rock respectively. The field data were recorded in the field book, such as the locality, date, altitude, latitude, longitude, microhabitat, substratum, associated species, etc. The collected specimens were rapped in newspaper packets and the materials were brought to the lab and each specimens were sorted under the microscope. The specimens collected from one area may contain more than one species; hence sub numbers were given by separating the species like, 720a, 720b, etc. In some cases, the vegetative and reproductive plants are dissimilar, these species were sorted out after careful examination and given same number.

Preservation and herbarium preparation

The methods adopted for preserving *Fissidens* is very simple. The freshly collected specimens were first air dried in room temperature. If the collection is bulky, a portion of the specimens were kept as fresh by keeping in refrigerator. So that, it can be examined them alive, which later may be dried and stored in the Herbarium packets. The sporophyte, if present is preserved in 70% alcohol for future studies.

After proper drying, the *Fissidens* specimens were transferred to brown paper packets of standard size 12.7 cm x 10.16 cm (5" x 4"). The packets were correctly labelled. The properly labelled packets were deposited in the Zamorin's Guruvayurappan College Herbarium (ZGC) and also in the Calicut University Herbarium (CALI) based on Pursell & Bruggeman- Nannenga (2004) classification system. Holotype was deposited in CALI and isotypes were in Central National Herbarium (CAL) in Kolkata and ZGC.

Identification

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.

Identification of the specimens was done by referring authentic literatures (Eddy, 1988; Bruggemann-Nannenga, 1997 & 2013; Bruggeman-Nannenga and Pursell, 1995; Daniels, 2013; Gangulee, 1971; Iwatsuki and Suzuki, 1982; Li and Iwatsuki, 2001; Nair *et al*., 2005; Pursell, 2007; Pursell & Bruggeman- Nannenga, 2004). Confirmation of identified taxa were done by referring types, protologues, authentically identified herbarium specimens from various herbaria and also by consulting with experts from various national and international institutions.

Institutions visited for literature survey, herbarium consultation

Calicut University Herbarium (CALI), Malappuram, Kerala; Malabar Botanical Garden & Institute for Plant Sciences (MBG), Kozhikode; Botanical Survey of India, Southern Circle (MH), Coimbatore; Central National Herbarium (CAL), Kolkata; Scott Christian College, Nagercoil (SCCN), Tamil Nadu; National Botanical Research Institute (NBRI- LWG), Lucknow; Botanical Survey of India, (BSI), Pune; Blatter Herbarium (BLAT), Mumbai.

Loan specimens procured from:

Natural History Museum (BM)

Calicut University Herbarium (CALI)

Taxonomic description

Detailed descriptions were given for family, genus, key to subgenera and description on subgenera, key to sections and description on section, key to species and species description. Each species is described with up-to-date nomenclature including basiyonym and synonyms if any, pertaining to India and other parts of the world as far as possible with the protologues and type details. The detailed description of species including the morphology and anatomy of gametophyte and sporophyte, diagnostic characters, habitat and general ecology, distribution, specimens examined, etymology of available species and a note on discussion on each species are also provided. Authors of plant names are abbreviated based on Brummit and Powell (1992) and the titles of journals are based on Taxonomic

literature (Stafleu & Cowan, 1976-1986). The family is arranged according to the classification of Goffinet *et al.* (2008) and the subgeneric classification is based on Pursell & Bruggemann-Nannenga (2004). All the species under each subgenera are arranged alphabetically.

Photodocumentation and illustration

The macroscopic photographs of the species and their microhabitat were taken using Canon Powershot & Nikon Coolpix P520 camera. The photographs of external features of the specimens were taken by using camera attached Stereo dissection microscopes (Labomed Luxeo 4z and Olympus SZ) and photographs of anatomical features by camera attached compound microscopes (Labomed LX-400, LX-500 & Olympus CX21iLED). Each species is followed by a world map and Western Ghats map showing the distribution. Each species is described with illustration and photoplate of habit together with details of available characters such as plant morphology, leaves, capsule, spores, etc. Photos of types and authentic specimens are also provided for some species. Each species is provided with microhabit and habitat plate (for available one).

Measurements used in the Description of species

Terminology and definitions used in this thesis related to the family Fissidentaceae Schimp. are based on Iwatsuki and Suzuki (1982); Pursell (2007) and Pursell and Bruggeman-Nannenga (2004).

Photographs and illustrations of taxa are based on specimens collected, type and authentically identified specimens from various herbaria which are cited in the specimens examined part of result.

A minimum of four or five individual plants from each collection are considered for measurements based on the availability of specimens. The details of these collections are added in the ‘specimens examined’ part of description.

Length and width of plant is measured including leaves. The length of smaller once and the larger among the matured plants are noted to get the range of variation in length.

Normally the leaves towards apex are larger and the basal once are reduced. So always tried to measure the size of leaves which are midway above to the stem.

Laminal cells are measured from different areas in a single leaf in wet condition. 90% ethyl alcohol and 1.5-3.0% KOH were used for better clarity of leaves and laminal cells (Koponen, 1970). Only sterile leaves are considered for general cellular measurements.

Capsule length is measured from neck of sporophyte to mouth. Spores are measured from one sporophyte in a collection.

Characters used in the study and Terminology

The development of an individual plant of *Fissidens* Hedw. starts from a single celled spore which develops into an elongated multicellular structure known as '*protonema*'. Protonema of the genus *Fissidens* are mostly ephemeral except some species like *F. firmus* Mitt., *F. serrratus* Muell. Hal., *F. manilalia* Manjula, Manju & K.P. Rajesh, where the protonema is persistent. The general characters of family Fissidentaceae Schimp. used for identification are summarised below with emphasis to the present study.

Plant size and growth pattern

Among the species of *Fissidens* Hedw. the plant size varies from minute or stemless plant such as *F. manilalia* Manjula, Manju & K. P. Rajesh and fertile plant of *F. curvatus* Hornsch., having size of 1-2 mm to large species *F. anomalus* Mont. having 2-7cm long. Some authors like Iwatsuki and Suzuki (1982) used the term '*gigantic*' to describe the large species and '*micro'* or '*mini Fissidens'* for smaller species like *F. protonemaecola* Sak. and *F. manilalia* Manjula, Manju & K.P. Rajesh. These minute species are very difficult to locate in the field without sporophytes and always immersed with other species of bryophytes.

The members of the family are acrocarpic. Most of the species are unbranched with simple stem like *F. pallidinervis* Mitt., *F. enervis* Sim etc. While some often possess branches with rhizoids at the base as in *F. crispulus* Brid. They are easily detachable from the main stem and grow as new plant. In some species like *F. longtonianus* Z. Iwats. & Tad. Suzuki, certain innovations may be developed from just below the terminal inflorescence.

Stem anatomy and Axillary hyaline nodule

The degree of differentiation of central strand is an important character in the identification of *Fissidens* Hedw. In many large *Fissidens,* such as *F. anomalus* Mont., *F. javanicus* Dozy & Molk., etc. the stem central strand is '*differentiated'* with small, thick walled cortical cells and large, thin walled central cells. In other species central strand of stem is '*weakly differentiated'* or '*completely lacking'* like in *F. crenulatus* Mitt. and *F. beckettii* Mitt.

'*Axillary hyaline nodule'* on stem of gametophyte in *Fissidens* Hedw. is discussed in detail by Iwatsuki & Pursell (1980). It is a branch primordium which is variously known as '*Blasenartige Auftreibung*' (Mueller, 1901), '*axillary glandular structure'* (Norkett, 1969; Gangulee, 1971), '*group of inflated cells'* (Iwatsuki, 1969), '*clusters of enlarged cells'* (Robinson, 1970), *'clusters of hyaline cells'* (Iwatsuki & Suzuki, 1977). Axillry hyaline nodule of some species like *F. crispulus* Brid., *F. bryoides* Hedw., etc., is prominent while in some others it is indistinctly swollen, thin walled and slightly differentiated from stem cortical cells or not as in *F. subbryoides* Gangulee.

Leaf

The unique structure of leaf of *Fissidens* composed of three types of laminae;

1. Lamina

The leaves are distichously arranged and vertically oriented in the same plane on the stem which is a unique and distinguishing gametophytic character of this family. Leaves are equitant which clasps the stem. The stem is often elongated and

the distichous leaves have a pinnate arrangement, but if the stem is very short the leaves have a palmate arrangement. This leaf arrangement in two ranks is by the activity of an apical cell with two cutting surfaces (Pursell, 2007).

In some members the perichaetial and perigonial leaves, the leaves enclosing the archegonia and antheridia respectively differs from cauline leaves.

1.1. **Vaginant Laminae**

'*Vaginant laminae'* forms the clasping proximal portion of the leaf as two flaps. It is also known as '*sheathing laminae'*, '*duplicate laminae',* etc. Salmon (1899) and Robinson (1970) considered this as the true leaf. According to Salmon other two laminae are outgrowths, while Robinson thought that the other two laminae as the parts of true leaf which are vertically reoriented. In some older literatures these were often referred to as the *'lamina vera'*. Tip of vaginant laminae can be '*equal'* or '*unequal'*. When equal, the distal end of each vaginant lamina ends at the margin of leaf (*F. bryoides* Hedw., *F. flaccidus* Mitt., etc.). If one vaginant lamina is smaller than the other the distal end of smaller one ends either on costa or in between costa and leaf margin are said to be unequal. In some extreme cases, like *F. asplenioides* Hedw., one vaginant lamina is essentially continuous with the apical lamina, while the other one is fused with the apical lamina at short distance from the costa and the rest of apex is open.

Robinson (1970) called this smaller vaginant lamina as the '*lesser lamina'* and Pursell (2007) as '*minor lamina'.* The larger lamina is known as *'major lamina'* (Pursell, 2007) or *'greater lamina'* (Norris & Koponen, 1987).

1.2. **Apical Lamina**

'*Apical lamina'* seen above the vaginant laminae on the same side of costa (midrib). It is also known as '*ventral lamina'* or '*anterior lamina'.*

1.3. Dorsal Lamina

'*Dorsal lamina'* occupies the entire length of the leaf on one side of costa as the opposite side of vaginant laminae and apical lamina. Usually the dorsal lamina

ends at or very near the leaf insertion like *F. crispulus* Brid. and *F. bryoides* Hedw. Rarely it ends well above the insertion like *F. curvatus* Hornsch. or decurrent on the stem like *F. taxifolius* Hedw.

In lower leaves of plants and some perichaetial and perigonial leaves poorly developed or vestigial dorsal and apical lamina.

2. Costa

The leaf of *Fissidens* Hedw. contains a single '*costa'* at the middle of leaf. It separates dorsal lamina from vaginant and apical laminae. Costa is generally well developed in all the members of Fissidentaceae Schimp. except some species like *F. enervis* Sim and *F. hyalinus* Hook. f. & Wilson., in which costa is greatly reduced or nearly absent represented only by a basal vestige (Salmon, 1899). The length of costa can be '*excurrent', 'percurrent'* or'*subpercurrent'*.

Kawai (1968) was the first to consider the costa of *Fissidens* systematically. Bruggeman-Nannenga (1990) and Stone (1990) considered structural variation in the anatomy of costa in the intrageneric classification of *Fissidens* Hedw. significantly. Bruggeman-Nannenga (1990) recognised three basic types of costa such as, the '*oblongifolius type'* in which the proximal part of leaf have two lateral and one ventral bands of stereid cells with as many as 16 peripheral guide cells arranged in the form of a 'U' or 'V' and as many as five large central cells. The '*taxifolius type'* having two peripheral guide cells and two lateral bands of steried cells separated usually by 1-5 large central cells in the proximal part of the leaf. The '*bryoides type'* costa is characterised in the proximal region of the leaf by two peripheral guide cells and two lateral bands of steried cells separated by one large central cell. There are anomalies in the costa in some Asiatic and American species. Bruggeman-Nannenga (1990) and Stone (1990) proposed that these variations in the structure of costa correlate well with variations in the peristome but to determine the type of costa the section should be taken from cauline leaves and not the perichaetial leaves in which the character of costa may vary.

3. Leaf margin

'*Limbidium'* is a band of elongated, hyaline to yellowish, smooth prosenchymatous cells at the leaf margin. It can be unistratose or pluristratose. In '*strong limbidium'* the cells are with thick walls and sharp ends. In '*weak limbidium*' the walls are usually thin with more or less truncate ends which is difficult to distinguish.

The limbidium can be restricted to vaginant laminae only like *F. crenulatus* Mitt., *F. walkeri* Broth., etc. or it can be well developed on all the three laminae like *F. bryoides* Hedw., *F. flaccidus* Mitt., *F. zollingeri* Mont., etc. In some species such as *F. pallidinervis* Mitt. and *F. kurzii* Muell. Hal., limbidium confined to the perichaetial leaves or one or two leaves below apex. In some other species like *F. ceylonensis* Dozy & Molk., the limbidium is intramarginal. Limbidium completely absent in species such as *F. crispulus* Brid., *F. involutus* Wilson ex Mitt., *F. taxifolius* Hedw., etc. In *F. anomalus* Mont. and *F. javanicus* Dozy & Molk. the marginal cells are well differentiated with thick walls than inner laminal cells but not elongated.

4. Laminal Cells

The photosynthetic laminal cells of the leaf vary considerably in size among the members of *Fissidens.* Smaller cells are more or less firm walled and the larger ones are often thin walled and shrink drastically upon drying. During investigation cold water or KOH is best to rehydrate the cells for better result. Laminal cells are mostly '*unistratose'* except for some species like *F. sedgwickii* Broth. & Dixon, which is '*bistratose'*.

Laminal cells are also '*smooth'* to '*pluripapillose'* or '*mamillose'*. A mamilla is a hollow protuberance of a cells wall like *F. crispulus* Brid. and *F. walkeri* Broth. Papilla is a localised thickening of the cell wall. Papillosity may ranges from '*unipapillose'* like in *F. macrosporus* Dixon to pluripapillose like in *F. ceylonensis* Dozy & Molk. and *F. hollianus* Dozy & Molk. In some species like *F. asplenioides* Hedw. cells appear to be mamillose but are '*lenticularly thickened'*. In some other

species like *F. pellucidus* Mitt. small, colourless '*guttulae'* are present which can be mistaken as unipapilla. Guttulae are also known as '*nucleus-like hyaline spots'* (Iwatsuki & Suzuki, 1982), as '*hyaline dots'* (Stone, 1987) and '*thin spots'* (Norris & Koponen, 1987).

Gemmae

'*Gemmae'* are the multicellular structures that contribute in vegetative multiplication. Many of the members of *Fissidens* Hedw. in Western Ghats have branched filaments of chlorophyllose structures at the base of leaves or clavate as in *F. angustifolius* Sull. and *F. zollingeri* Mont. Epiphyllous gemmae have been observed in one African species in the subgenus *Aloma* (Pursell & Bruggeman-Nannenga, 2004). However these structures do not have any systematic importance for the classification of species.

Sexual Condition

The gametophyte is often '*monomorphic*' in which sterile and fertile plants are more or less same length as in *F. crispulus* Brid., *F. ceylonensia* Dozy & Molk. and *F. walkeri* Broth. In some species such as *F. curvatus* Hornsch. the fertile plants are much shorter than the sterile plants and they are morphologically different also. They are termed as '*dimorphic*'. Fissidentaceae Schimp. are '*acrocarpous*' where '*perigonia'* and '*perichaetia'* occurs at the tip of fertile plant and branches. Some perigonial branches are axillary or basal to large stem and gemmiform. Many larger species are '*dioicous*' in which perigonial and perichaetial plants are separate and they are more or less equal in size or perigonial plants are shorter. In most of the dioicous plants perigonial plants are rare and difficult to find. In plants such as *F. curvatus* Hornsch. and *F. cristatus* Wils. ex Mitt. the small perigonial branches were developed in between vaginant laminae as epiphyllous termed as '*pseudautoicous'*.

In *monoicous condition* '*antheridia'* and '*archegonia'* are produced on same plant. Most of the *micro-Fissidens* are example. It can be '*autoicous*' in which perigonia and perichaetia are on the same plant or the perigonial and perichaetial branches are attached by rhizoids or perigonial branches are gemmiform and

clusterd around the perichaetial stem known as '*rhizautoicous'* or antheridia and archegonia are produced in the same perichaetium known as '*synoicous'*.

In *F. bryoides* Hedw. and related species, sexual condition varies within monoicous condition, however sexuality of *F. bryoides* Hedw. var. *bryoides* is autoicous.

Calyptra

'*Calyptra'* is the enlarged archegonial remains which is '*cucullate*' and smooth in most of the species. '*Prorate*'or '*papillose*' in some species such as *F. serratus* Muell. Hal. or '*mitrate*' like *F. ganguleei* Nork. ex Gangulee. In *F. crenulatus* var. *elmeri* (Broth.) Z. Iwats. & Tad. Suzuki calyptra is more or less '*scabrous*' due to small papillae on surface and companulate like in *F. crispulus* Brid.

Sporophyte

The sporophyte consists of *'foot',* '*seta'* and '*capsule'*. Usually single sporophyte is developed from one perichaetium even though two sporophytes per perichaetium are not rare.

Foot

Foot of the sporophyte is similar to all other mosses and it does not have any significance in the subgeneric classification of this genus. The role of foot is anchoring and absorption as in all other mosses.

Seta

Seta is the stalk of capsule which is '*smooth*' in most of the species except some species like *F. hollianus* Dozy & Molk. in which seta is more or less '*scabrous*' in the upper part.

Normally the seta of *Fissidens* is elongated and capsule is '*exserted*' while in some species such as, *F. macrosporus* Dixon and *F. longtonianus* Z. Iwats. & Tad.

Suzuki the seta is typically short and the capsule is '*immersed'* to '*slightly emergent*'.

Capsule

Theca

'*Theca'* is the capsule case which contains spores. It is '*erect*' or '*inclined*' and radially symmetric or bilaterally symmetric. The cells on theca wall is known as '*exothecial cells'* which are mostly quadrate to oblong, often collenchymatous and/or with vertical walls somewhat thicker than the horizontal walls. Bruggeman-Nannenga (1990) recommended the correlation of number of exothecial cells with the peristome type and costa type. According to Pursell and Bruggeman-Nannenga (2004) theca with more than 40 files of exothecial cells are the characteristic of subgenus *Aloma* Kindb. and theca with less than 40 files of exothecial cells is the characteristic of subgenera *Fissidens* Hedw., *Pachyfissidens* (Muell. Hal.) Kindb. and *Octodiceras* (Brid.) Broth.

'*Stomata'* is not occasional in the theca of *Fissidens.* It is'*pheneroporous*', few in number and restricted to the proximal part of the theca. Most of the '*micro-Fissidens'* have stomata with thin walled guard cells while large species have thick walled guard cells.

Operculum

Operculum is the conical shaped lid of capsule in *Fissidens* Hedw. which is '*short-rostrate'* or '*long rostrate'* as long as theca.

A differentiated '*annulus'*, opening for spore dispersal is absent rather spore dehisces by the dissolution of the walls of an abscission layer.

Peristome

Peristome filaments of Fissidentaceae Schimp. are '*endostomes'* of 16 '*haplolepideous'* teeth in eight pairs usually divides into two by 1/2-1/3 of its length which are more or less equal in size. Some species have anomalous peristome in

which the teeth are undivided or imperfectly divided or divided the entire length of peristome. In one African species and one Neotropical species the peristome is absent but it is not reported from India. The peristome variation is an important character in the intrageneric identification of these members.

Fleischer (1904) and Brotherus (1901, 1924a) proposed two types of peristome filaments *viz.,* '*peristome schenkel knotig verdickt*' and '*spiralig verdickt'*. The '*bryoides type'* and '*scariosus type'* peristomes have spirally thickened filaments and the '*taxifolius type'* peristome is associated to knotty or articulated thickness. Bruggeman-Nannenga and Berendsen (1990) had done a meticulous study on peristome structure which is an important tool for the intrageneric classification of *Fissidens* Hedw. and identified six basic peristome types based on '*trabeculae*' and '*lamellae*',

Bryoides type- Trabeculae on dorsal face of the undivided proximal part is distinct, usually higher than lamellae. Upper ends of filaments spirally thickened.

Scariosus type- Trabeculae on dorsal surface of the undivided proximal parts is indistinct, equally high to lamellae. Fimbriae, the figure like projections are often found along the outer edges of trabeculae ventral surface.

Taxifolius type- Trabeculae on dorsal face of the undivided proximal part is distinct, higher than lamellae and filaments articulated (nodose).

Similiretis type- Trabeculae on dorsal surface of the undivided proximal parts is indistinct from the equally high lamellae, upper ends of filaments squamose.

Zippelianus type- Trabeculae on the outer (dorsal) surface of the undivided proximal (basal) parts that are clearly distinct from and usually higher than the lamellae

There are a number of species in which the peristome shows high variations from the above described peristome types mostly found in section *Pachyfissidens* (Muell. Hal.) Kindb. and *Amblyothallia* (Muell. Hal.) of subgenus *Pachyfissidens*,

subgenus *Octodeceras* (Brid.) Broth. and section *Fissidens* and *Sarawakia* (Muell. Hal.) Pursell & Brugg-Nann. of subgenus *Fissidens* Hedw.

Spores

Size of '*spore'* has relevance in the identification of some species like *F. diversifolius* Mitt., *F. longtonianus* Z. Iwats. & Tad. Suzuki etc., from its related species while most of the other members of *Fissidens* Hedw. have smaller spores of size 8.0 – 15.0 µm.

Ecology of Fissidentaceae in Western Ghats

In order to analyse the pattern of distribution, data matrices of *Fissidens* species in the Western Ghats were prepared for three major categories, such as macrohabitat (major vegetation types), microhabitat and altitudianal zones (0-2600, with intervel of 100 m). Cluster analysis in PAST 3.20 software (http://folk.uio.no/ohammer/past) (Hammer, 2018) was performed using Sorensen Similarity Index. Linkage or Similarity dendrograms were prepared using Unweighted Pair-Group Method with Arithmetic mean (UPGMA), with bootstrap of 1000.

Chapter: V

RESULTS & DISCUSSION

RESULTS AND DISCUSSION

Phylogeny and Intrageneric classification of genus *Fissidens* Hedw.

This acrocarpous family Fissidentaceae Schimp. has copious resemblance to the family Dicranaceae Schimp. and both the family may be derived from a common ancestor. Most of the authors including Iwatsuki and Suzuki (1982) and Pursell (2007) considered Fissidentaceae Schimp. and Dicranaceae Schimp. in the order Dicranales M. Fleisch. because of the haplolepideous peristome of 16 teeth in which the ventral trabeculae are thicker than the dorsal trabeculae while differs in specialised leaf structure of Fissidentaceae. Bruggeman-Nannenga and Berendsen (1990) found that the variation of taxifolius type of peristome was also evident in such dicranaceous species such as *Cynodontium strumiferum* (Hedw.) Lindb., *C. alpestre* (Wahlenb.) Milde, *Dichodontium pellucidum* (Hedw.) Schimp., *Dicranella heteromalla* (Hedw.) Schimp., *Dicranum scoparium* Hedw. and *Oncophorus virens* (Hedw.) Brid. Even though molecular phylogenetic studies are really limited in this group La Farge *et al.* (2000) and Goffinet and Cox (2000) further support the relationship of the Fissidentaceae Schimp. with members of the Dicranaceae Schimp.

In Indian context Gangulee (1971) considered this family under the order Fissidentales but most of the authors were placed this family under the order Dicranales. Goffinet *et al.* (2008) also classified this family under the order Dicranales. In the present study, I also following the classification of Goffinet *et al.* (2008) upto family and for subgeneric classification Pursell and Bruggemann-Nannenga (2004) is followed.

After establishing this genus by Hedwig (1801) and addition of *F. acacioides* by Schrader (1803), Bridel (1806) described two more species *F. longifolius* Brid. and *F. elegans* Brid. from Islands of Hispaniola in the Caribbean Islands. Bridel (1819) added one species *F. dominicensis* Brid. to the genus *Fissidens* which is invalid since the same was published as *Hypnum* [=*Calyptothecium duplicatum* (Schwägr.) Broth.].

Eventhough the genus *Fissidens* is unique in its leaf character, a number of segregate genera have been proposed by different workers and among these, *Octodiceras* Brid. is the pineer one proposed by Bridel (1806). He also transferred *F. semicomplatus* to the genus *Octodiceras* as *O. fissidentoides* Brid. This segregation is based on a misinterpretation in the peristome illustration of Hedwig. Montagne (1837) corrected this by replacing this genus by *Conomitrium* with one species *C. berteri* Mont. [=*F. berteroi* (Mont.) Muell. Hal.] from South America to include aquatic species with mitrate calyptra. He transferred *Fissidens semicomplatus* to *Conomitrium hedwigii* Mont. and *Octodiceras dillenii* (Bach. Pyl.) Brid. to *Conomitrium dillenii* (Bach. Pyl.) Mont. Authors like Schwaegrichen (1842) accepted these changes. But Mitten (1859) commented that a single character is not enough to segregate a taxa. Mueller (1901) expanded *Conomitrium* with a number of sections. Authors like Bruggeman-Nannenga & Nyholm (1986), Deull and Meinunger (1989), Frahm and Frey (2004), Hill *et al.* (1992), Heuber (1998), Pilous and Duda (1960) and Smith (2004) recognised *Octodiceras* as a separate genus based on the aquatic habitat, feather-like gametophyte, short seta and absence of stomata on theca.

The group introduced by Pylaie in 1814-1815 as *Skitophyllum* to replace *Fissidens* but it is invalid and later Bridel (1827) changed it as *Schistophyllum* which more truthful in its etymology.

Mueller (1886) proposed another segregate genus *Moenkemeyera* based on its undivided peristome, while Grout rejected this since it cannot be distinguished from *Fissidens* in the absence of sporophyte and undivided peristome is also found in different subgenera of *Fissidens*.

Cardot (1909) introduced *Fissidentella* Cardot to include plants having thin, fugacious, papillose peristome teeth. Later Bruggeman-Nannenga (1997) synonymised this under *Fissidens.* Herzog (1909) proposed *Simplicidens* to include plants with gametophyte similar to that of section *Fissidens* having characters such as very large cylindrical theca, long undivided peristome teeth with delicate papillae

which is later synonymised under *Fissidens* by Bruggeman-Nannenga and Berendsen (1990).

During this course of time in the development of research in this group many small genera and sections are introduced to accommodate one or two species like, transfer of *F. semicomplatus* Hedw. to *Cecalyphum semicomplatus* by Palisot de la Beauvois (1805), *Fissidens bryoides* to *Heterodon bryoides* by Rafinesque-Schmaltz (1808) and *Fissidens osmundoides* Hedw. to *Osmundula osmundioides* by Rabenhorst (1863).

Dixon (1941) introduced the name *Sainsburia* to separate plants with undivided peristome with median splits which is synonymised under *F. taylorii* Muell. Hal. by Allison (1960). Dixon (1922) introduced the genus *Nanobryum* to include plants having dicranaceous gametophyte and *Fissidens* type sporophyte. Later Dixon and Brotherus placed this genus to the family Dicranaceae which is changed by Schultze-Motel (1969) as Nanobraceae. This genus is studied in details by many researchers like Potier de la Varde (1928, 1936), Bizot (1963), Stone (1982), Bruggeman-Nannenga and Berendsen (1990). Later Pursell and Reese subsumed this genus *Nanobryum* under genus *Fissidens* and family Nanobryaceae under Fissidentaceae. The detailed discussion of important schemes in the intrageneric classification of *Fissidens* is also done in the present study.

Some members of *Fissidens* Hedw. such as *F. bryoides* Hedw. var. *bryoides*, *F. dubius* P. Beauv., *F. taxifolius* Hedw. etc. shows polyploidy and generally the chromosome numbers reported for this genus are, n= 4, 5, 6, 8, 9, 10, 12, 13, 14, 15, 16, 19, 21, 24 (Fritsch, 1991; Kumar & Arora, 1988). According to Smith (1978) n= 6 is the basic chromosome number which is derived from the 'ancestral stock' with n= 7 and the chromosome number n= 5 have been derived from n= 6. According to Iwatsuki and Inoue (1984) species with n= 10 and n= 12 are derived from n=5 and n=6 respectively by the duplication of chromosomes. They also concluded that the large plants with the higher chromosome number are more primitive than the small autoicous plants with the small chromosome number. But, Chopra and Kumar (1981) argued it by stating that the members of *Fissidens* Hedw. with smaller

chromosome number were more primitive than those with higher chromosome number.

Iwatsuki and Suzuki (1982) suggested that the *micro-Fissidens* with diverse sexual condition and spirally thickened peristome filament are derived from comparatively large species having dioicous gametophyte and narrow ecological requirements with articulate peristome filaments. Robinson (1970) believed unequal vaginant laminae and dorsal lamina ending before leaf insertion as the primitive characters while dorsal lamina reaching leaf insertion or decurrent and equal vaginant laminae as advanced. According to Iwatsuki (1985) this large and diversified genus is polyphyletic while the similarity in basic structure of leaf and peristome substantiate the monophyletic origin of this genus.

Important schemes of intrageneric classification of *Fissidens* Hedw.

Most of the recent subgeneric classifications of the genus *Fissidens* based on Mueller (1848-1849; 1901). He introduced different schemes of classification during the cource of time by modifying his own classificatins based on available characters in each survey. Many other authors also modified these schemes based on different characters that are incorporated to the system. Most vital schemes includes Brotherus (1924a), Norkett (1969), Bruggeman-Nannenga (1978), Iwatsuki and Inoue (1984), Pursell (1988), Bruggeman-Nannenga *et al.* (1994) and Pursell and Allen (1994). Some authors made modification based on SEM studies of peristome (Mueller, 1973; Allen, 1980; Bruggeman-Nannenga & Berendsen, 1990 and Ishihara & Iwatsuki, 1992) while some others carried out cladistics analysis on peristome types (Bruggeman-Nannenga & Roos, 1990). Cytogenetic characters are also considered for classification of this genus as in Iwatsuki and Inoue (1984). Difference in the anatomy of leaf costa are also important in some schemes of subgeneric classification (Bruggeman-Nannenga, 1990; Stone, 1990). and this proposed one of the first schemes of classification in which he treated Fissidentaceae as a Tribus under the family Fissidentaceae Schimp.

Tribus Fissidenteae

Genus *Fissidens* Hedw.

Section 1. *Hydrofissidens* Muell. Hal.

Section 2. *Pachyfissidens* Muell. Hal.

Section 3. *Areofissidens* Muell. Hal.

Section 4. *Eufissidens* Muell. Hal.

Mueller (1850-1851) modified this scheme by including the genus *Conomitrium* Mont. also. The classification is partly based on peristome characters which is quite different from the classification that is widely used in many books.

Tribus Fissidentaceae

Genus1. *Conomitrium* Mont.

Section 1. *Octodiceras* (Brid.) Muell. Hal.

Section 2. *Reticularia* Muell. Hal.

Section 3. *Sciarodium* Muell. Hal.

Genus 2. *Fissidens* Hedw.

Section 1. *Pachyfissidens* Muell. Hal.

Section 2. *Eufissidens* Muell. Hal.

Classification proposed by Mueller (1901) in his '*Genera Muscorum Frondosorum'* with three genera and 24 'gruppen' based on the characteristics of gametophyte. He expanded genus *Conomitrium* with 12 sections.

Genus 1. Mönkemeyera (Sic) Muell. Hal.

Genus 2. Fissidens Hedw.

Gruppen: Heterocaulon Muell. Hal.

Bryoidium Muell. Hal.

Pyncothallia Muell. Hal.

Pachylomidium Muell. Hal.

Semilimbidium Muell. Hal.

Aloma Muell. Hal.

Crenularia Muell. Hal.

Amblyothallia Muell. Hal.

Crispidium Muell. Hal.

Orthothalia Muell. Hal.

Pachyfissidens Muell. Hal.

Serridium Muell. Hal.

Genus 3. Conomitrium Mont.

Gruppen: Octodiceras (Brid.) Muell. Hal.

Sarawakia Muell. Hal.

Limbidium Muell. Hal.

Polypodiopsis Muell. Hal.

Schistostegiopsis Muell. Hal.

Webriopsis Muell. Hal.

Bryoidiopsis Muell. Hal.

Alomidium Muell. Hal.

Pycnothallidium Muell. Hal.

Crispidiella Muell. Hal.

Crenulidium Muell. Hal.

Semilimbidiella Muell. Hal.

Fleischer (1904) divided *Fissidens* into two groups based on peristome. His second group consist of most of the species now classified in section *Serridium.* But he did not given any name to this group.

1.Schenkel der Peristomzähne spiralig verdickt, glatt oder papillös

Subgenus 1. *Polypodiopsis* Muell. Hal.

Subgenus 2. *Areofissidens* Muell. Hal.

Subgenus 3. *Eufissidens* Muell. Hal.

2.Schenkel der Peristomzähne ringförming (knotig) verdickt.

Kindberg (1897) classified the family Fissidentaceae Schimp. into four subgenera and three sections mostly based on European and North American species. He introduced the subgenera *Aloma* Kindb., and *Aneuron* Hedw.

Genus: *Fissidens* Hedw.

Subgenus 1. *Aneuron* Hedw.

Subgenus 2. *Pachyfissidens* (Muell. Hal.) Kindb.

Subgenus 3. *Aloma* Kindb.

Section 1. *Camptodontii* Kindb.

Section 2. *Obtusifolii* Kindb.

Section 3. *Adiantoidei* Kindb.

Subgenus 4. *Eufissidens* Muell. Hal.

Brotherus (1924a) proposed another modified classification of his own (Brotherus, 1901) for Fissidentaceae Schimp. based on peristome filaments. Most of the sections in this scheme are ill-defined and artificial (Crum & Steere, 1957; Iwatsuki, 1985; Pursell 1988; Bruggeman-Nannenga & Berendsen, 1990).

Genus 1. *Fissidens* Hedw.

Subgenus 1. *Polypodiopsis* Muell. Hal.

Subgenus 2. *Eufissidens* Muell. Hal. [=*Fissidens*]

Section 1. *Weberiopsis* Muell. Hal.

Section 2. *Reticularia* Broth.

Section 3. *Bryoidium* Muell. Hal. [=*Fissidens*]

Section 4. *Pachylomidium* Muell. Hal.

Section 5. *Pycnothallia* Muell. Hal.

Section 6. *Heterocaulon* Muell. Hal.

Section 7. *Semilimbidium* Muell. Hal.

Section 8. *Aloma* Muell. Hal.

Section 9. *Crenularia* Muell. Hal.

Section 10. *Crispidium* Muell. Hal.

Section 11. *Amblyothallia* Muell. Hal.

Section 12. *Serridium* Muell. Hal.

Subgenus 3. *Pachyfissidens* (Muell. Hal.) Kindb.

Subgenus 4. *Octodiceras* (Brid.) Broth.

Genus 2. *Simplicidens* Herzog.

Genus 3. *Moenkemeyera* (Muell. Hal.) Broth.

Genus 4. *Fissidentella* Cordot.

Grout (1936) proposed a new classification scheme for Fissidentaceae Schimp. with two genus *Fissidens* Hedw. and *Bryoxiphium* Mitt., *Bryoxiphium* Mitt. is not further divided.

Genus 1. *Fissidens* Hedw.

Subgenus 1. *Eufissidens* Muell. Hal.

Section 1. *Terminales* Grout.

Subsection 1. *Limbatus* Grout.

Subsection 2. *Semilimbatus* Grout

Subsection 3. *Aloma* (Muell. Hal.) Grout.

Section 2. *Laterals* Grout.

Subgenus 2. *Polypodiopsis* (Muell. Hal.) Broth.

Subgenus 3. *Pachyfissidens* (Muell. Hal.) Kindb.

Subgenus 4. *Octodiceras* (Brid.) Broth.

Genus 2. *Bryoxiphium* Mitt.

Grout (1941) revised his scheme of classification by modifying the sections.

Genus 1. *Fissidens* Hedw.

Section 1. *Schistostegiopsis* Muell. Hal.

Section 2. *Reticularia* Broth.

Section 3. *Limbatus* Grout.

Section 4. *Pycnothallia* Muell. Hal.

Section 5. *Semilimbatus* Grout.

Section 6. *Aloma* Muell. Hal.

Section 7. *Crenularia* Muell. Hal.

Section 8. *Amblyothallia* Muell. Hal.

Section 9. *Serridium* Muell. Hal.

Section 10. *Marginatus* Grout.

Section 11. *Pachyfissidens* Muell. Hal.

Section 12. *Octodiceras* (Brid.) Mitt.

Genus 2. *Bryoxiphium* Mitt.

He again modified the classification by considering Fissidentaceae as a monotypic family consists of genus *Fissidens* Hedw. only. He also adopted the taxa introduced by Mueller (1901) and used by Brotherus (Grout, 1943).

Genus 1. *Fissidens* Hedw.

Section 1. *Schistostegiopsis* Muell. Hal.

Section 2. *Reticularia* Broth.

Section 3. *Bryoidium* Muell. Hal.

Section 4. *Pycnothallia* Muell. Hal.

Section 5. *Semilimbidium* Muell. Hal.

Section 6. *Aloma* Muell. Hal.

Section 7. *Crenularia* Muell. Hal.

Section 8. *Amblyothallia* Muell. Hal.

Section 9. *Serridium* Muell. Hal.

Section 10. *Marginatus* Grout.

Section 11. *Pachyfissidens* Muell. Hal.

Section 12. *Octodiceras* (Brid.) Mitt.

Classification scheme proposed by Norkett in Gangulee (1971) is the elaborated and one of the important intrageneric classification in Indian context. Here he proposed a number of changes to improve the classification. He reduced the section *Pachylomidium* to a subsection of section *Fissidens* and section *Semilimbidium* was further divided. He also excluded sections *Amblyothallia* Muell. Hal. and *Heterocaulon* Muell. Hal.

Genus 1. *Fissidens* Hedw.

Subgenus 1. *Aneuron* Kindb.

Subgenus 2. *Fissidens*.

Section 1. *Aerofissidens* Muell. Hal.

Section 2. *Fissidens*.

Subsection 1. *Fissidens*

Subsection 2. *Pachylomidium* (Muell. Hal.) Nork.

Section 3. *Pycnothallia* Muell. Hal.

Section 4. *Semilimbidium* Muell. Hal.

Subsection 1. *Bryolimbidium* Nork.

Subsection 2. *Semilimbidium*.

Series 1. *Semilimbidium*.

Subseries 1. *Unipapillatae* Nork.

Subseries 2. *Multipapillatae* Nork.

Series 2. *Suberenularia* Nork.

Section 5. *Crenularia* Muell. Hal.

Section 6. *Aloma* Muell. Hal.

Section 7. *Crispidium* Muell. Hal.

Section 8. *Serridium* Muell. Hal.

Subgenus 3. *Pachyfissidens* (Muell. Hal.) Kindb.

Subgenus 4. *Octodiceras* (Brid.) Broth.

Iwatsuki (1985) proposed another classification by considering the chromosome number for first time in the intrageneric classification of *Fissidens* Hedw. but he did not addressed the status of sections proposed by Brotherus.

Genus 1. *Fissidens* Hedw.

Subgenus 1. *Aneuron* Kindb. (n=10)

Subgenus 2. *Fissidens* (n=10 or 12)

Subgenus 3. *Serridium* (Muell. Hal.) Z. Iwats. (n=12)

Subgenus 4. *Pachyfissidens* (Muell. Hal.) Kindb. (n=12)

Subgenus 5. *Octodiceras* (Brid) Broth. (n=?)

Subgenus 6. *Sarawakia* (Muell. Hal.) Z. Iwats. (n=?)

Classification proposed by Pursell and Bruggeman-Nannenga (2004) is one of the well-established scheme of classification among the recent ones. They considered some new relevant characters such as the peristome type, number of files of exothecial cells for their classification.

Genus 1. *Fissidens* Hedw.

Subgenus 1. *Pachyfissidens* (Muell. Hal.) Kindb.

Section 1. *Amblyothallia* Muell. Hal.

Section 2. *Crispidium* Muell. Hal.

Section 3. *Pachyfissidens*

Subgenus 2. *Octodiceras* (Brid.) Broth.

Subgenus 3. *Fissidens*

Section 1. *Fissidens*

Section 2. *Sarawakia* (Muell. Hal.) Pursell & Brugg-Nann.

Subgenus 4. *Aloma* Kindb.

The studies and reports on the phylogeny of this single genus authenticate that The subgenus *Pachyfissidens* is to be the most primitive with *F. asplenioides* Hedw., *F. fasciculatus* Hornsch. Iwatsuki (1985) and Iwatsuki and Inoue (1984) treated *F. grandifrons* Brid. as the most primitive member in this genus even though its streamlined aquatic gametophytic habitat, equal vaginant laminae, pluristratose laminal cells are in contradiction to it. Anyhow Pursell and Bruggeman-Nannenga (2004) agree with Iwatsuki that the acostate species in the subgenus *Aloma* Kindb. are the most advanced than costate species in *Aloma* and they also suggest that the members of subgenus *Octodiceras* (Brid.) Broth. are the advanced ones.

In the present study I have followed the classification proposed by Pursell and Bruggeman-Nannenga (2004). They originally proposed this scheme based on African species, and some of them are distributed in India also. The present study incorporated the species present in Western Ghats into this classification by considering the gametophytic and sporophytic characters proposed by Pursell and Bruggeman-Nannenga (2004) like peristome type and number of files of exothecial cells several vegetative characters which were not originally classified.

Systematic Treatment of the family Fissidentaceae in Western Ghats

FISSIDENTACEAE Schimp., Coroll. Bryol. Eur. 96. 1856.

Gangulee, Moss. E. India, 1(2): 447. f. 265. 1971; Iwatsuki & Suzuki, J. Hattori Bot. Lab. 51: 329. 1982; Eddy, Handb. Malay. Moss. 1: 77. 1988; Li & Iwatsuki, Moss Fl. China 2: 1. 2001; Nair *et al.,* Bryo. Wayanad W. Ghats.: 105. 2005*;* Pursell, Fissidentaceae Fl. Neo. Mono. 101: 16. 2007; Bruggeman-Nannenga & Arts, J. Bryology 32: 170. 2010; Daniels & Daniel, Bryo. South. W. Ghat. 35. 2013; Beever, Fl. New Zealand Moss. 8: 2. 2014; Erzberger, Studia. Bot. Hung. 47(1): 49. 2016.

Type. *Fissidens bryoides* Hedw.

Skitophyllaea Mitt., J. Linn. Soc. Bot. 12: 11.23. 580. 1869; *Schistophyllaceae* Lindb., Ut. Bladmoss. 16. 1878; *Archifissidentaceae* Dixon & P. de la Varde, in P. de la Varde, Arch. Bot. Mém. 1(3): 23. 1927.

Plants acrocarpous. Leaves distichous, equitant, vertically placed, each consisting of two vaginant laminae that clasp the stem, an apical lamina and a dorsal lamina; costa single, usually well developed, sometimes reduced or absent. Peristome single, haplolepideous, endostomate, rarely absent, consisting of 16 teeth, usually divided, 1/2-2/3 of peristome length, infrequently undivided or irregularly divided or reduced.

Fissidens Hedw., Sp. Musc. Frond. 152. 1801.

Type. *Fissidens bryoides* Hedw. (lectotype designated by E. Britten in Britton Fl. Bermuda 435. 1918).

The name *Fissidens* is derived from two Latin words (*fissus* = cleft + *dens* = tooth) in reference to the peristome teeth that are divided for much of their length.

Heterodon Raf., Med. Repose., ser. 2. 5: 350. 1801; *Octodiceras* Brid., Muscol. Recent. Suppl. 1: 162 1806; *Skitophyllum* Bach. Pyl. J. Bot. Agric. 4: 133. 1814; *Schistophyllum* Brid., Bryol. Univ. 2: 679. 1827; *Conomitrium* Mont. Ann. Sci. Nat. Bot., ser. 2, 8: 245. 1837; *Osmundula* Rabenh., Krypt.-Fl. Sachsen 1: 609. 1863;

Schistophyllum Lindb., Utkast Eur. Bladmoss. 16. 1878; *Orthodens* A. Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1877-78: 394. 1879; *Moenkemeyera* Muell. Hal., Flora 69: 506. 1886; *Pachyfissidens* (Muell. Hal.) Limpr., Laubm. Deutschl. 1: 454. 1887; *Simplicidens* Herzog, Beih. Bot. Centrabl. 26: 58. 1909 [1910]; *Nanobryum* Dixon, J. Bot. 60: 101. 1922; *Sainsburia* Dixon, Bryoiogist 44: 40. 1941.

Plant pale to dark green, infrequently brownish to blackish, terrestrial or aquatic, epilithic, corticolous, erect but most often becoming decumbent, infrequently floating or trailing, scattered, tufted or forming dense mats: protonemata usually ephemeral, infrequently persistent. Stem less than 1mm to several cm in length, unbranched to branched profusely: rhizoids basal and axillary, typically smooth, infrequently papillose, reddish, branches most often with basal rhizoids, axillary hyaline nodules present or absent; epidermis and outer cortical cells in transverse section usually small and pigmented but in some enlarged, hyaline and thin walled; inner cortical cells larger, thin-walled, hyaline, central strand present or absent; axilliary hairs uniseriate, filiform, all cells hyaline, axillary or epiphyllous, stalked, multicellular, filiform or clavate gemmae infrequent, subterranean, irregularly globose, multicellular, rhizoidal gemmae infrequent; leaves distichous, equitant, pinnately arranged on elongate stems or palmately arranged on short stems, firmly attached to stem, infrequently caducous; perichaetial leaves often differentiated from cauline leaves, often larger, vaginant laminae often distally rounded or narrowed to the costa; cauline leaves of infertile stems often smaller than those on perichaetial stems; proximal cauline leaves smaller, often lacking dorsal and/or apical lamina; costa usually well developed, ending far below leaf apex to excurrent, variable in structure, sometimes reduced; margin entire to serrate or dentate, marginal cells differing little or not at all from inner laminal cells, infrequently conspicuously smaller, often differentiated into a limbidium on vaginant laminae or to varying degrees on all laminae; limbidial cells uni to pluristratose, usually prosenchymatous, yellowish; laminal cells mostly unistratose, some-times regularly to irregularly bi to pluristratose, small, quadrate, rounded to irregularly hexagonal, firm-walled, outer walls smooth, plane, bulging, mamillose

(conical) unipapillose (sharply pointed) or pluripapillose, infrequently lenticularly (convexly) thickened, eguttulate or gutulate. Monoicous (rhizautoicous, gonioautoicous, cladautoicous, synoicous, polyoicous), infrequently dioicous, rarely pseudautoicous; naked antheridia and archegonia sometimes in leaf axils.

Sporophytes 1-2 per perichaetium, infrequently of greater number, yellow when young, darkening with age, orange or reddish; seta short to elongate, smooth or infrequently papillose; theca immersed to exserted, erect, radially symmetric to inclined, proximally stomatose; exothecial cells quadrate to oblong, vertical walls, often thicker than horizontal walls, often collenchymatous, peristome haplolepideous, endostomate; operculum conic-rostrate, rostrum short or as short as theca straight or oblique. Spores finely papillose to smooth, green. Calyptra cucullate or mitrate, smooth or sometimes prorate, naked, covering the entire operculum or only the rostrum.

Genus *Fissidens* Hedw. is divided into four subgenera *viz.*, *Pachyfissidens* (Muell. Hal.) Kindb., *Octodiceras* (Brid.) Broth., *Fissidens* and *Aloma* Kindb. Among these, *Pachyfissidens* (Muell. Hal.) Kindb. is divided into three sections such as, *Pachyfissidens*, *Amblyothallia* Muell. Hal. and *Crispidium* (Muell. Hal.) Pursell & Brugg.-Nann. Subgenus *Fissidens* is divided into two sections such as, *Fissidens* and *Sarawakia* (Muell. Hal.) Pursell & Brugg.-Nann. Subgenus *Aloma* Kindb. and section *Fissidens* of subgenus *Fissidens* contain the greatest number of species.Table 1 shows the subgeneric classification of species found in Western Ghats.

Table 1. Subgeneric classification of Fissidens species found in Western Ghats

Subgenus/Section	Species
Subgenus *Pachyfissidens* (Muell. Hal.) Kindb.	
Sect. *Amblyothallia* Muell. Hal.	1. *Fissidens asplenioides* Hedw.
Sect. *Pachyfissidens*	1. *Fissidens anomalus* Mont. 2. *Fissidens dubius* P. Beauv. 3. *Fissidens grandifrons* Brid. 4. *Fissidens involutus* Wilson *ex* Mitt. subsp. *involutus* Gangulee 5. *Fissidens involutus* subsp. *curvatoinvolutus* (Dixon) Gangulee 6. *Fissidens jungermannioides* Griff. 7. *Fissidens obscurus* Mitt. 8. *Fissidens taxifolius* Hedw. 9. *Fissidens taxifolius* var. *auriculatus* (Muell. Hal.) A.E.D. Daniels & P. Daniels 10. *Fissidens taxifolius* var. *calcuttense* (Gangulee) A.E.D. Daniels & P. Daniels 11. *Fissidens taxifolius* var. *teraicola* (Muell. Hal.) A.E.D. Daniels & P. Daniels
Sect. *Crispidium* Muell. Hal.	1. *Fissidens crispulus* Brid. var. *crispulus* 2. *Fissidens crispulus* var. *robinsonii* (Broth.) B.C.Tan & Choy 3. *Fissidens crispulus var. nov.* 4. *Fissidens excedens* Broth. 5. *Fissidens geminiflorus* Dozy & Molk. 6. *Fissidens javanicus* Dozy & Molk. 7. *Fissidens lutescens* Broth. 8. *Fissidens subangustus* Fleisch.
Subgenus O*ctodiceras* (Brid.) Broth.	No representation in Western Ghats
Subgenus *Fissidens*	
Sect. *Fissidens*	*1.* *Fissidens beckettii* Mitt. *2.* *Fissidens bryoides* Hedw. *3.* *Fissidens crispus* Mont. *4.* *Fissidens curvatus* Hornsch. *5.* *Fissidens viridulus* (Sw.) Wahlenb. *6.* *Fissidens diversifolius* Mitt. *7.* *Fissidens microdictyon* Dixon & P. de la Varde
Sect. *Sarawakia* Muell. Hal.	No representation in Western Ghats
Subgenus *Aloma* Kindb.	
	1. *Fissidens arunii* J.P. Srivast. & Nork. 2. *Fissidens biformis* Mitt.

	3. *Fissidens brevinervis* Broth. 4. *Fissidens ceylonensis* Dozy & Molk. 5. *Fissidens crenulatus* Mitt. 6. *Fissidens enervis* Sim 7. *Fissidens firmus* Mitt. 8. *Fissidens flaccidus* Mitt. 9. *Fissidens ganguleei* Nork. in Gangulee 10. *Fissidens gardneri* Mitt. 11. *Fissidens griffithii* Gangulee 12. *Fissidens hollianus* Dozy & Molk. 13. *Fissidens incognitus* Gangulee 14. *Fissidens kalimpongensis* Gangulee 15. *Fissidens kammadensis* Manju, K.P. Rajesh & Madhus. 16. *Fissidens kurzii* Muell.Hal. 17. *Fissidens laxitextus* Broth. ex Gangulee 18. *Fissidens longtonianus* Z. Iwats. & Tad. Suzuki 19. *Fissidens macrosporus* Dixon 20. *Fissidens macrosporoides* Dixon & P. de la Varde 21. *Fissidens manilalia* Manjula, Manju & K.P. Rajesh 22. *Fissidens neomagofukui* Z. Iwats. & Tad. Suzuki 23. *Fissidens orishae* Gangulee 24. *Fissidens pallidinervis* Mitt. 25. *Fissidens pellucidus* Hornsch. 26. *Fissidens pokhrensis* Nork. ex S.S. Kumar 27. *Fissidens polysetulus* Muell. Hal. ex Nork. 28. *Fissidens pulchellus* Mitt. 29. *Fissidens ranchiensis* Gangulee 30. *Fissidens sedgwickii* Broth & Dixon 31. *Fissidens serratus* Muell. Hal. 32. *Fissidens speluncae* Broth. 33. *Fissidens subbryoides* Gangulee 34. *Fissidens subpalmatus* Muell. Hal. 35. *Fissidens walkeri* Broth. 36. *Fissidens zollingeri* Mont. 37. *Fissidens sp.*1 38. *Fissidens sp*.2

Key to the subgenera of genus *Fissidens*

1a. Leaves with bryoides type costa; peristome bryoides type or scariosus type……2

1b. Leaves with oblongifolius type or taxifolius type costa; peristome not bryoides or scariosus type …….. subgenus *Pachyfissidens*

2a. Laminal cells smooth; peristome bryoides type, more than 40 files of exothecial cells ….....3

2b. Laminal cells smooth or papillose or mamillose; peristome scariosus type, less than 40 files of exothecial cells …. ..... subgenus *Aloma*

3a. Axillary hyaline nodules completely absent; peristome reduced bryoides type..... ..... subgenus *Octodiceras*

3b. Axillary hyaline nodule absent or weakly developed, peristome bryoides type ....…..subgenus *Fissidens*

1. *Fissidens* Hedw. subgenus *Pachyfissidens* (Muell. Hal.) Kindb.

Plants small to large, often robust erect to decumbent, 4mm to several centimeters long. Stem monomorphic, unbranched or branched; rhizoids basal and axillary, smooth, rarely papillose; branches with basal rhizoids; axillary hyaline nodules present or absent; leaves pinnately arranged, usually imbricate; elimbate or weakly limbate on proximal parts of vaginat laminae, margin sometimes with darker or lighter band of cells; costa oblongifolius or taxifolius type; laminal cells eguttulate, unistratose mostly, firm walled, smooth, plane, buging or lenticularly thickened or mamillose or pluripapillose, irregularly quadrate to irregularly hexagonal. Dioicous or monoicous. Sporophytes 1-2 per perichaetium, seta short or elongate; theca immersed or exserted, erect, radially symmetric, stomatose, exothecial cells more than 40 files; peristome taxifolius, similiretis or zippelianus type; operculum conic, long-rostrate, rostrum straight or oblique. Spores finely papillose or smooth. calyptra cucullate, smooth, covering only the rostrum.

This subgenus is divided into three sections: *Pachyfissidens*, *Amblyothallia* Muell. Hal. and *Crispidium* Muell. Hal. This subgenus includes the most primitive species.

Key to the sections of subgenus *Pachyfissidens*

1a. Axillary hyaline nodules rare; costa oblongifolius type, laminal cells smooth with frequently convexly thickened .....section *Amblyothalia*

1b. Axillary hyaline nodules present in some species or common, costa taxifolius type, laminal cells smooth, papillose or mamillose 2

2a. Axillary hyaline nodule in all species; peristome zippelianus type ……. ……. ..... section *Crispidium*

2b. Axillary hyaline nodule in some species, peristome taxifolius type … ……. .....section *Pachyfissidens*

a. Fissidens* subgenus *Pachyfissidens* section *Amblyothallia Muell. Hal., Gen. Musc. Frond. 63: 1901 [1900].

Plants light green to dark green, small to large. Stems monomorphic, usually branched; rhizoids basal and axillary, reddish; branches with basal rhizoids; axillary hyaline nodules present; epidermis and outer l-3 tiers of cells small, pigmented, central strand present Leaves usually imbricate pinnately arranged, mostly lanceolate; margin elimbate or with a weak limbidium on proximal parts of vaginant laminae; costa distinct, oblongifolius type; dorsal lamina variable; vaginant laminae mostly unequal; laminal cells eguttulate, mostly unistratose, firm walled, smooth, often lenticularly thickened or plane in dorsal and apical lamina. Dioicous or monoicous; perigonia terminal or axillary, perichaetia terminal on stems and branches; naked, axillary archegonia sometimes present. Sporophytes 1-2 per perichaetium reddish or yellowish green, darkening with age; theca erect, radially symmetric or more or less arcuate, stomatose. exothecial cells in more than 40 files, quadrate to oblong, vertical walls thicker than horizontal walls; peristome similiretis or taxifolius type rarely anomalous; operculum conic, long-rostrate. Spores finely papillose to smooth. Calyptra cucullate, smooth.

Section *Amblyothalia* of subgenus *Pachyfissidens* contain only one species in Western Ghats.

Fissidens asplenioides Hedw., Sp. Musc. Frond. 156. 1801; Bartram, Fieldiana: Botany 25: 20. 1949; Pursell, Fissidentaceae Fl. Neo. Mono. 101: 39. 2007; Daniels, Archive Bryol. 65: 54. 2010.

Type: Jamaica, Swartz s. n. (lectoyype G. designated by Pursell, 1986a)

Conomitrium ligulatum (Hook. f. & Wilson) Muell. Hal., Gen. Musc. Frond.75. 1900; *Fissidens amblyophyllus* Muell. Hal., Hedwigia 38: 57. 1899; *F. amboroicus* Herzog, Beih., Bot. Centralbl., Abt. 227(2): 349. 1910; *F. araucarieti* Muell. Hal., Bull. Herb. Boissier 6: 23. 1898; *F. asplenioides* var. *latifolius* Thér., Rev. Bryol. Lichénol. 7: 56. 1934; *F. atlanticus* Renauld & Cardot, Bull. Soc. Roy. Bot. Belgique 41(1): 48. 1905; *F. barbe-montis* Muell. Hal., Bull. Soc. Roy. Bot. Belgique 31(2): 152. 1893; *F. boivinianus* var. *longifolius* Besch., Ann. Sci. Nat., Bot., sér. 6, 9: 331. 1880; *F. costaricensis* Besch., Bull. Herb. Boissier 2: 390. 1894; *F. genunervis* Muell. Hal., Syn. Musc. Frond. 1: 70. 1848; *F. glossophylloides* Besch. & Geh., Rev. Bryol. 28: 64. 1901; *F. glossophyllus* Muell. Hal., Linnaea 42: 236. 1879; *F. gracilifrondeus* Muell. Hal., Bull. Herb. Boissier 5: 172. 1897; *F. guadelupensis* Schimp. ex Besch., Ann. Sci. Nat., Bot., sér. 6, 3: 193. 1876; *F. knightii* Reichardt, Verh. Zool.-Bot. Ges. Wien 18: 194. 1868; *F. laxobasis* Bizot & Thér., Mem. Soc. Cub. Hist. Nat. "Felipe Poey"13: 209. 31 f. 7. 1939; *F. ligulaefolius* Muell. Hal. ex M. Fleisch., Musci Buitenzorg 1: 48. 1904; *F. ligulatus* Hook. f. & Wilson, Fl. Nov.-Zel. 2: 63. 84 f. 1. 1854; *F. linguaefolius* Muell. Hal., Hedwigia 38 (Beibl. 1): 58. 1899; *F. lingulatus* Muell. Hal., Bull. Herb. Boissier 5: 172. 1897; *F. martinicae* Besch., Ann. Sci. Nat., Bot., sér. 6, 3: 192. 1876; *F. maschalanthus* var. *minor* Dusén *ex* Thér., Revista Chilena, Hist. Nat. 22: 83. 1918; *F. nigricans* Schimp. *ex* Besch., Ann. Sci. Nat., Bot., sér. 6, 3: 192. 1876; *F. obtusatus* Hampe, Vidensk. Meddel. Dansk Naturhist. Foren. Kjøbenhavn 4: 59. 1872; *F. obtusissimus* Muell. Hal. *ex* Broth., Nat. Pflanzenfam. I (3): 359. 1901; *F. pycnotylus* Broth., Nat. Hist. Juan Fernandez 2: 418. pl. 26: f. 9–12. 1924; *F. revolvens* Schimp. *ex* Muell. Hal., Nuovo Giorn. Bot. Ital., n.s.4: 164. 1897; *F. spectabilis* Muell. Hal., Hedwigia 38 (Beibl.): 59. 1899; *F. turbinatus* Taylor, London J. Bot. 7: 190. 1848.

Plants yellowish green, 8-10 x 1.5-3.5 mm, unbranched; rhizoids smooth, axillary and basal; axillary hyaline nodules normally absent; stem outer cortical cells 2-3 tiers, inner cortical cells large, thin walled; leaves imbricate to distatnt, crispate when dry, 10-15 pairs, lanceolate to lingulate, apex rounded or obtuse, apiculate, margin slightly serrulate; limbidium absent or very rarely weak limbidium in proximal part of vaginant laminae; vaginant laminae 1/2- 3/4 of leaf length, unequal, minor lamina slightly dom shaped at apex, uniseriate or biseriate; dorsal lamina base round, slightly decurrent or not, dorsal lamina and apical lamina uniseriate; costa prominent, oblongifolius type, ending 3-6 cells below apex; laminal cells distinct, eguttulate, firm walled, irregularly rounded hexagonal, 7.5-12.0 µm, juxta costal cells and inner proximal cells of vaginant laminae elongated, 9.2-14.95 µm; gemmae not found (Plate 18 & Fig.1).

Fertile parts not found.

Diagnostic characters: *F. asplenioides* Hedw. is characterised by large plants, leaves lanceolate to lingulate, dome shaped minor vaginant lamina apex and rounded to obtuse and apiculate apex. *F. asplenioides* Hedw. can be confused with other larger plants like *F. polypodioides* Hedw. in the dorsal laminal cells and leaf length, eventhough *F. asplenioides* has oblongifolius type costa, smaller dorsal and apical lamina.

Note: Pursell and Bruggeman-Nannenga (2004) reported that this species possess axillary hyaline nodules but the present collections do no bear axillary hyaline nodules. Beever (2014) also described this species without axillary hyaline nodules from New Zealand. *F. asplenioides* Hedw. is reported from Ponmudi of Thiruvananthapuram district of Kerala in the present study. Daniels (2010) reported the occurance of this species from some other localities in the Western Ghats based on previous data by Dixon and Potier de la Varde (1927) and Foreau (1930, 1961).

Habitat and General Ecology: This species is predominantly found in shaded areas on land cuttings at an altitude of 1100-1200 m in the evergreen forests. Associated species includes *Campylopus flexuosus* (Hedw.) Brid., *Philonotis hastata* (Duby) Wijk & Margad. and *Sematophyllum subhumile* (Muell. Hal.) M. Fleisch.

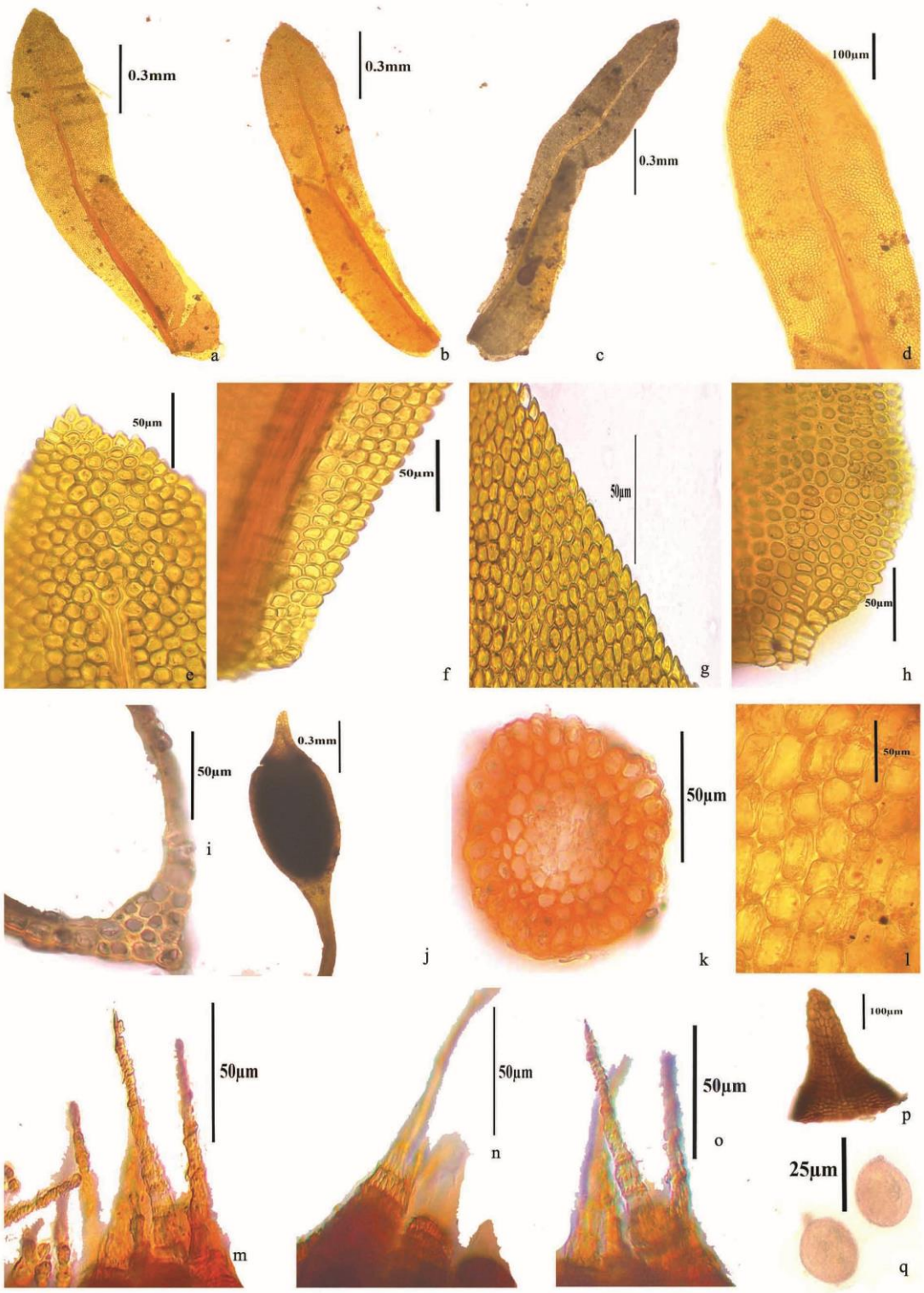


Plate 18. *Fissidens asplenioides* Hedw., a&b. vegetative leaf, c. perichaetial leaf, d&e. leaf apex, f. dorsal lamina base, g. leaf margin, h. vaginant laminae base, i. leaf T.S., j. capsule, k. seta T.S., l. exothecial cells, m-o. peristome, p. operculum, q. spores.

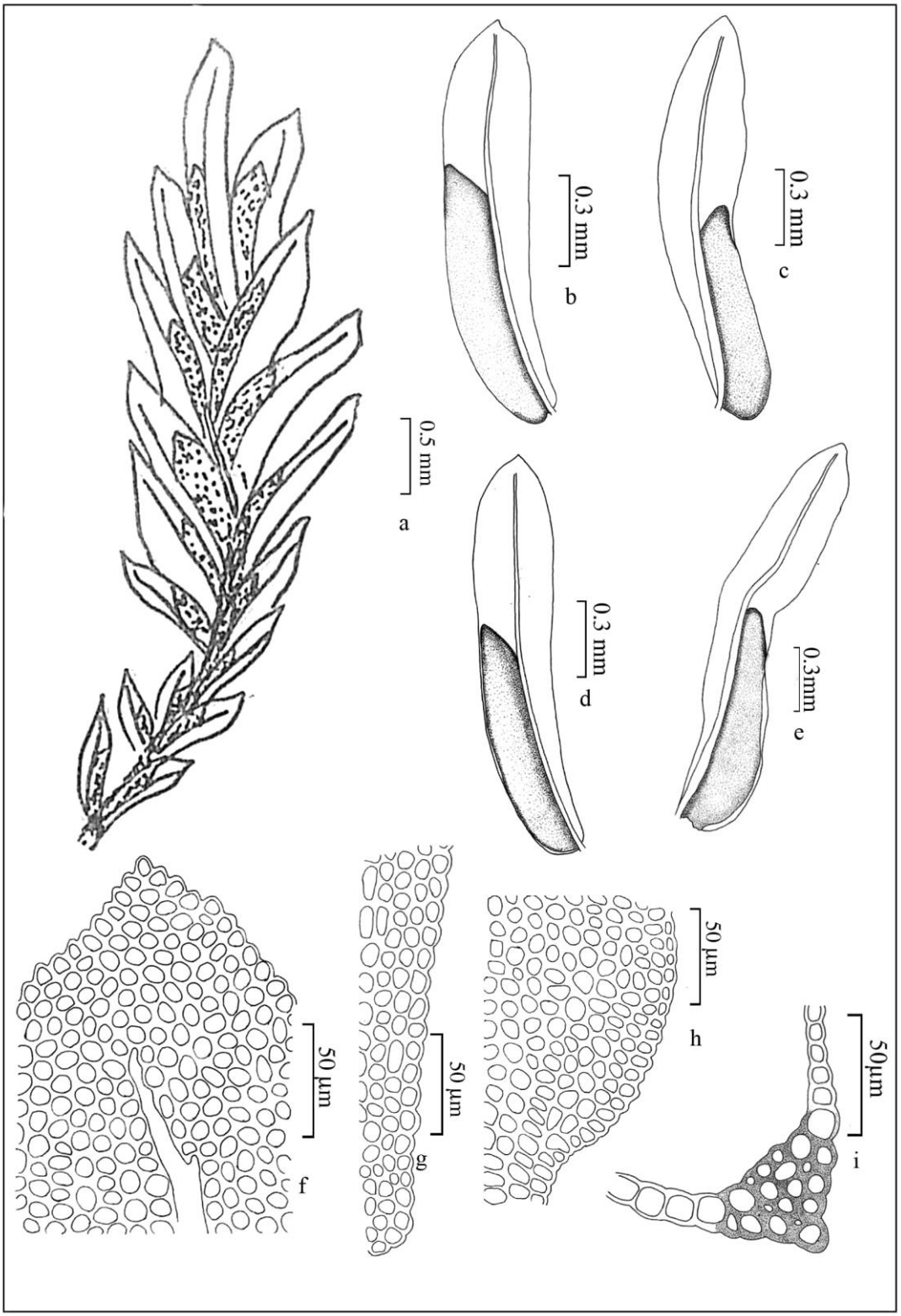


Fig. 1. *Fissidens asplenoides* Hedw., a. vegetative plant, b-e. vegetative leaves, f. leaf apex, g. dorsal lamina base near insertion, h. vaginant laminae base, i. leaf T.S.

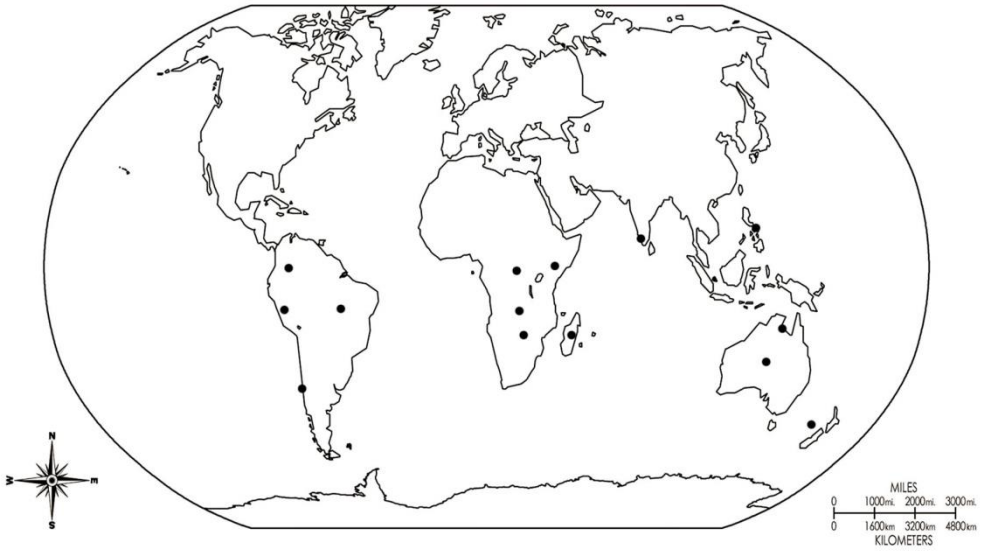
Distribution: India (Tamil Nadu (Dixon & Potier de la Varde, 1927; Daniels, 2010; Foreau 1930, 1961), Kerala (present collection); Australia, Bioko, Brazil, Cameroon, Caribbean, Chile, Colombia, Comoros, Costa Rica, Democratic republic of the Congo, El Salvador, Guatemala, Guinea, Honduras, Kenya, Madagascar, Malawi, Mexico, New Zealand, Panama, Peru, Philippines, Reunion, Rwanda, South Africa, Suriname, Tanzania, Uganda, United states (Alabama, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina), Zambia, Zimbabwe (Pursell, 2007; Tropicos.org). The present collection is a new record of the species to Kerala. (Map 2A&2B).

Specimens examined: India, Kerala, Thiruvananthapuram (Ponmudi, Attupara, 1100m), 08.11.2001, Saju, K.A. (ZGC 80303).

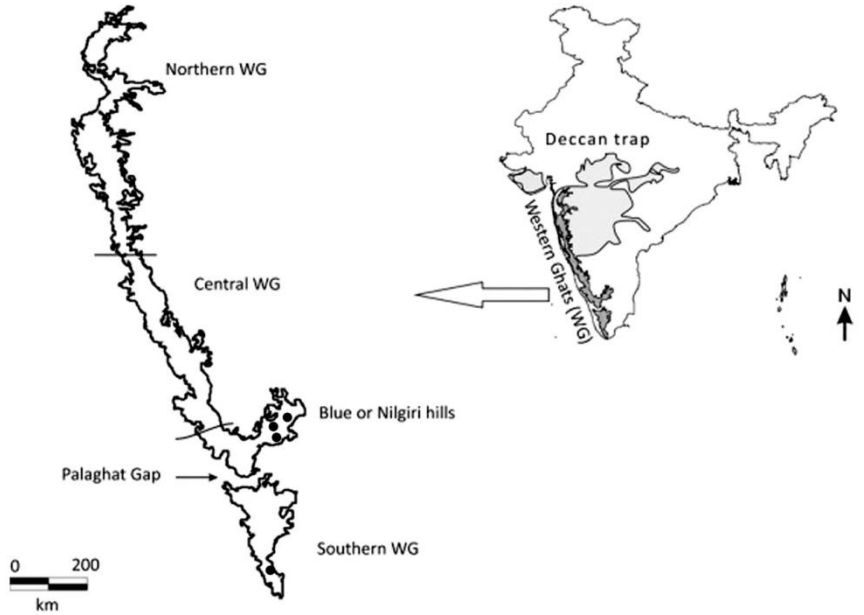
Etymology: The specific epithet *asplenioides* is derived from the similarity of this plant to the genus *Asplenium* of pteridophyte especially the long leaves. (*asplenium+oides* (resembling).

b. Fissidens* subgenus *Pachyfissidens (Muell. Hal.) Kindb. **section *Pachyfissidens*** Eur. N. Am. Bryin 2: 166. 1897.

Plants light to dark green, medium to large. Stems monomorphic usually branched; rhizoids basal and axillary, reddish, mostly smooth; branches with basal rhizoids; axillary hyaline nodules present or absent; epidermis and outer 1-3 tiers of cortical cells small, incrassate. pigmented; central strand present, infrequently absent. Leaves pinnately arranged, usually imbricate, oblong to lanceolate; margin often irregularly coarsely serrate distally, elimbate; costa distinct, rarely obscured by bulging overlying chlorophyllose cells, taxifolius type; dorsal lamina usually reaching insertion; vaginant laminae equal or nearly so; laminal cells eguttulate, uni-bi or rarely pluristratose, firm-walled, walls evenly thickened, smooth, more or less bulged, mamillose in the vaginant laminae of *F.taxifolius* Hedw. Monoicous or dioicous; perigonia gcmmiform, basal or axillary, infrequently terminal or longer stems, rarely as epiphyllous dwarf males (*F.dubius*, lwatsuki & Suzuki, 1982); perichaetia terminal on short axillary branches, rarely terminal on main stems. Sporophytes usually one per perichaetium, reddish; seta usually elongate; theca



Map. 2A. World distribution of ***Fissidens asplenioides*** *Hedw.*



Map. 2B. Distribution of ***Fissidens asplenioides*** *Hedw. in Western Ghats*

usually exserted, rarely immersed, erect, somewhat inclined, mostly stomatose, exothecial cells quadmte to oblong, vertical walls thicker than horizontal wall; peristome taxifolius type; operculum conic, Iong-rostrate. Spores finely papillose to smooth. Calyptra cuculate, smooth.

Section *Pachyfissidens* of subgenus *Pachyfissidens* contain seven species with two subspecies and four varieties in Western Ghats

Key to the species of the section *Pachyfissidens*

1a. Axillary hyaline nodule present ..... (2)

1b. Axillary hyaline nodule absent ..... (3)

2a. Plants large more than 20 mm long; leaf apex obtuse to rounded, inner laminal cells multistratose ..... *F. grandifrons*

2b. Plants less than 10 mm long; leaf apex acute to acuminate, laminal cells unistratose .....*F. involutus*

3a. Plants more than 10 mm long; costa excurrent or ending in short apiculus.... (4)

3b. Plants less than 10 mm long; costa percurrent to subpercurrent or ending 1or 2 cells .below apex …….....…(6)

4a. Leaf pairs more than 20; leaf margin entire, marginal cells not differentiated; stem central strand not differentiated, dorsal lamina base wedge shaped ..... ……. *F. obscurus*

4b. Leaf pairs less than 20; leaf margin not entire, marginal cells differentiated, stem central strand differentiated, dorsal lamina base not wedge shaped ……... ..... (5)

5a. Leaf apex irregularly serrate; costa percurrent; dorsal lamina base slightly decurrent .....……*F. dubius*

5b. Leaf apex not irregularly serrate, costa ending 1 or 2 cells below, dorsal lamina base not decurrent ……..…… *F. anomalus*

6a. Stem central strand differentiated, dorsal lamina base not wedge shaped, marginal cells not differentiated ……*F. taxifolius*

6b. Stem central strand not differentiated, dorsal lamina base wedge shaped, marginal cells slightly differentiated ……..... ...…. *F. jungermannioides*

Fissidens anomalus Mont., Ann. Sci. Nat., Bot., sér. 2 17: 252. 1842; Muell. Hal., Bot. Zeitung (Berlin) 11: 19. 1853: Broth., Rec. Bot. Surv. India 1(12): 314. 1899; Foreau, J. Madras Univ. 2: 242. 1930 & J. Bombay Nat. Hist. Soc. 58: 15. 1961; Bruehl, Rec. Bot. Surv. India 13(1): 18. 1931; Dixon, J. Bombay Nat. Hist. Soc. 39: 773. 1937; Wadhwa, Patrika 4: 90. 1969; Gangulee, Moss. E. India & Adj. 1(2): 555. f. 265. 1971; Bruggeman-Nannenga & Berendsen, Journ. Hattori Bot. Lab. 68: 213. 1990; Nair & Madhus., J. Econ. Taxon. Bot. 25: 571. 2001; Lal, Checklist Indi. Moss. 60. 2005; Madhus. e*t al.,* Curr. Trends Bryol. 261. 2007; Manju *et al.*, Tropical Bryol. Res. Rep. 7: 12. 2008b; Daniels & Daniel, Bryo. South. W. Ghat. 36. 2013.

Type: India, (Tamil Nadu) Nilgherris, Perrottet *s.n.* (PC)

Fissidens cryptotheca Dozy & Molk., Pl. Jungh. 314. 1854; *F. neckeroides* Griff., Calcutta J. Nat. Hist. 2: 504. 1842; *F. schiffneri* Baumgartner & Dixon Ann. Nat. Hist. Mus. Wien 59: 67. 1953.

Plants large, light green coloured, 20-40 x 3-4 mm, branched or unbranched; rhizoids brown, smooth; axillary hyaline nodules not differentiated; leaves 11-19 pairs, leaf tip curls in herbarium, densely arranged towards tip, lanceolate, apex acute or acuminate, 2.5-4.0 x 0.6-0.8 mm, 4 times long as wide, margin serrate; limbidium absent; vaginant laminae longer than wide, slightly unequal, reaching ½ or ¾ of leaf length, uniseriate, base broad; dorsal lamina base round, rarely short decurrent, dorsal lamina and apical lamina uniseriate; costa prominent, distinct, reaching 1 or 2 cells below apex; laminal cells round or irregularly polygonal, mamillose, leaf boarded by a lighter coloured band of 2-4 rows of smooth, pale coloured cells, vaginant laminal cells 9.74-12.18 x 7.31-9.74 µm, dorsal laminal cells 7.20-8.57 x 6.67-7.20 µm, juxta costal cells slightly elongated, 17.05-24.36 x 7.31-9.74 µm (Plate 19&20 & Fig.2).

Fertile parts, perigonium not found; perichaetial leaves ovate-lanceolate to subulate-lanceolate, ca. 0.9 mm long, setae short, 1.5–2.0 mm long, smooth, capsules erect, symmetric, exothecial cells oblong, with thickened vertical walls and thinner transverse walls, opercula long rostrate, 0.5–0.8 mm long, peristome teeth 0.3–0.5 long, 88–98 µm wide at the base, calyptra campanulate.

Diagnostic characters: *F. anomalus* Mont. is characterised by large sized plants compared to other *Fissidens* species with lanceolate leaves, a distinct margin of smooth cells, inner laminal cells mamillose and elongated juxta costal cells.

Note:It is similar to *F. dubius* P. Beauv. in plant morphology and leaf appearence but differs from *F. dubius* by narrow leaves and more sharp leaf apex. Gangulee (1971) reported *F. anomalus* Mont. and *F. cristatus* Mitt. as separate species. But Ignatov and Afonina (1992) synonimised *F. cristatus* under *F. dubius*. This plant shows variations in plant height. Li and Iwatzuki (2001) reported up to 53 pairs of leaves in the vegetative plant but the present plant shows only upto 19 pairs of leaves. *F. anomalus* Mont. is found only in the high altitude shola forests above 1000 m in the Western Ghats. Gangulee (1971) recorded that the habitat of this species ranges between 2300-3000m.

Habitat and General Ecology: This species is found only on shola forests at an altitude above 1000 m in Western Ghats. Found on bark and exposed roots of shola trees along with Lejeuneaceae members and lichen and saxicolous near riverine areas. On rocks it is associated with *Rhodobryum giganteum* (Schwägr.) Paris, *Plagiomnium rhynchophorum* (Hook.) T.J. Kop., *Hypopterygium aristatum* Bosch & Sande-Lac. and *Thuidium pristocalyx* (Muell. Hal.) A. Jaeger in wet areas.

Distribution: India (Karnataka, Kerala, Tamil Nadu, Western Himalaya (Simla) (Brotherus, 1899; Daniels & Daniel, 2013; Frahm *et al*., 2013; Foreau 1930, 1961; Schwarz, 2014b; Gangulee, 1971; Madhusoodanan *et al.*, 2007; Manju *et al.*, 2008b; Montagne 1842; Muller 1853), China, Indonesia, Java, Myanmar, Nepal, Philippines, South East Asia, Sri Lanka, Thailand, Vietnam, Yunnan (Li & Iwatsuki, 2001) (Map 3A&3B).

Specimens examined: India, Kerala, Idukki district, Eravikulam NP (Neerar, Kattumala, 2010m), 22.09.2001, Manju (80204) (CALI!), Way To Eravikulam Hut, 1975m, 09.01.2001, Manju (76013) (CALI!), Varayattu motta, 1950m, 11.01.2001, Manju (76032) (CALI!), Moonnar (Kattumala, 2100m), 27.09.2001, Manju (80254) (CALI!), (Mathikettan Shola NP, 1200 m), 20.03.2014, Rajilesh, V.K. (ZGC 1024); Malappuram district, (New Amarambalam RF, $11^{0}34^{'}34^{''}$ N, $76^{0}41^{'}$ E, 1050m), K.P. Rajesh (ZGC 111857 (B); Kannur district, Aralam WLS, (Ambalappara,

Plate 19. *Fissidens anomalus* Mont., a&c. habit (on bark), b&d. enlarged view

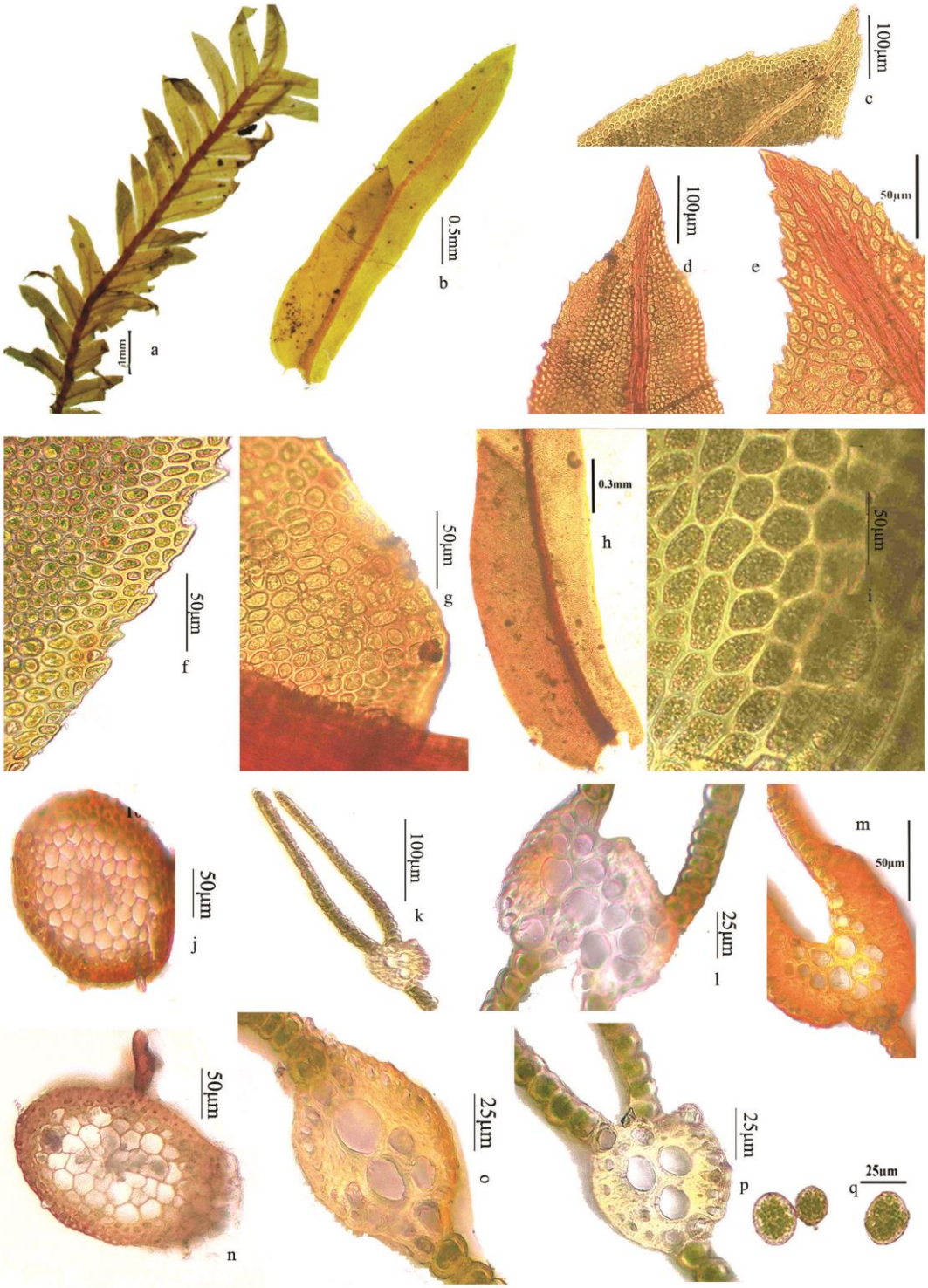


Plate 20. *Fissidens anomalus* Mont., a. habıt, b. leaf, c- e. leaf apex, f. leaf margin, g. dorsal lamina base, h. vaginant laminae, i. vaginant laminae base, j&n. stem T.S., k-m & o,p. leaf T.S., q. spores.

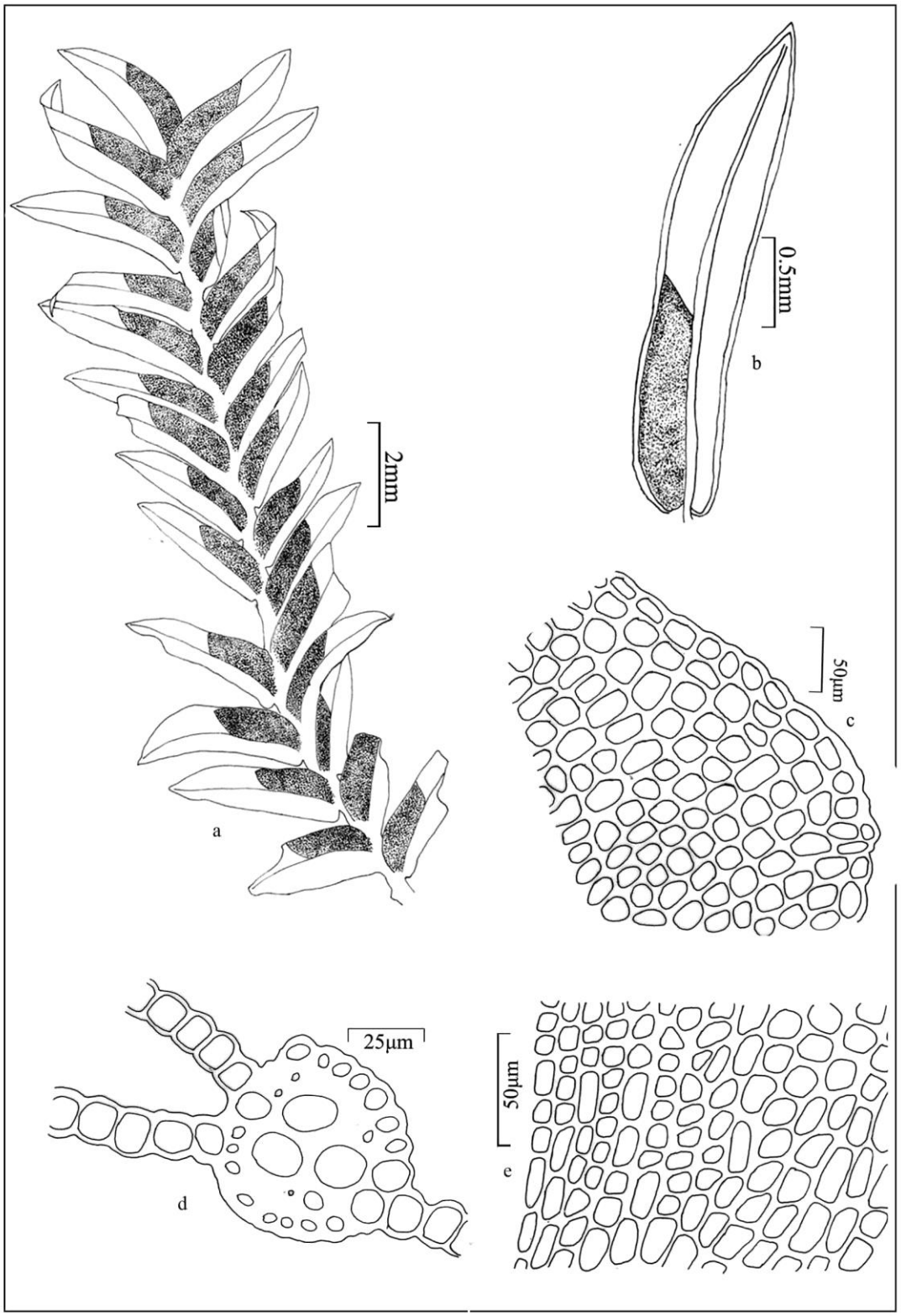
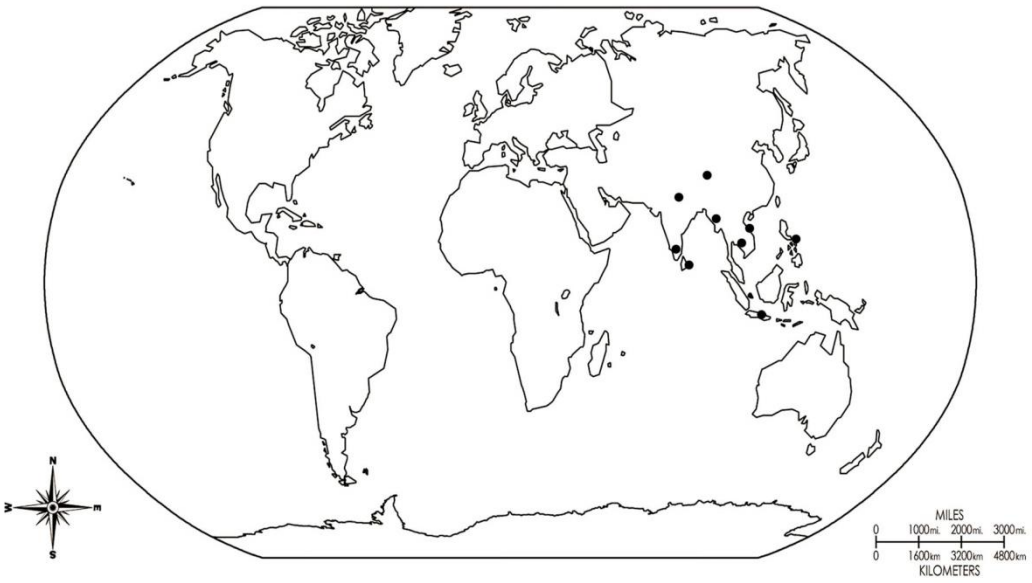
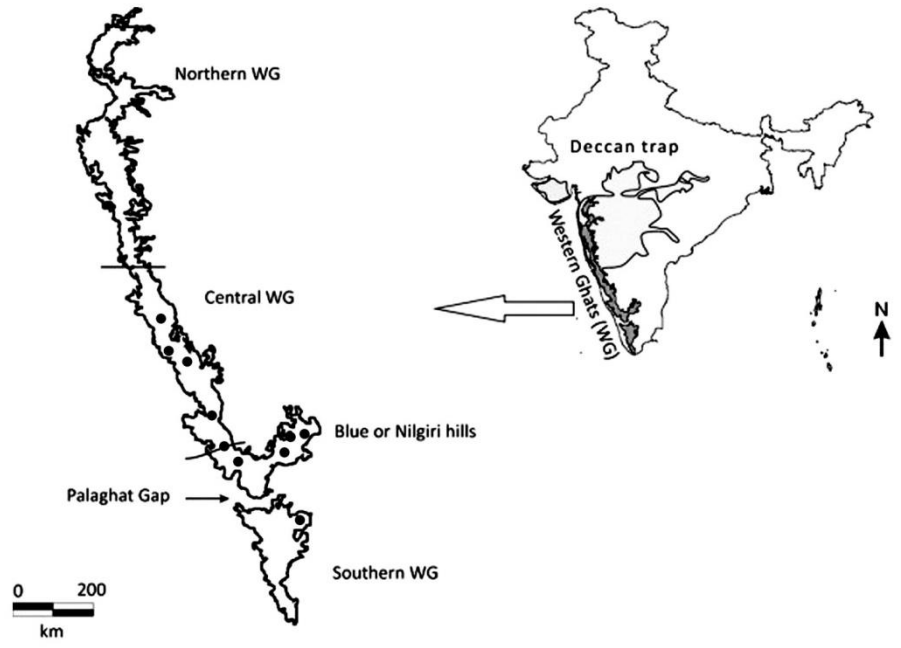


Fig. 2. *Fissidens anomalus* Mont., a. vegetative plant, b. vegetative leaf, c. dorsal lamina base near insertion, d. leaf T.S., e. vaginant laminae base



Map. 3A. World distribution of ***Fissiens anomalus*** *Mont.*



Map. 3B. Distribution of ***Fissiens anomalus*** *Mont. in Western Ghats*

$11^0$93’77.5” N, $65^0$93’86.1” E, 1400 m), K.P. Rajesh (106683) (CALI!); Kerala, Palakkad district, Parambikulam WLS (1250m), 12.10.2006, Manju C.N. (106822 CALI!); Kozhikode district, (Vellarimala, $11^0$49’64” N, $76^0$14’21” E, 998m), Satheesh *et al*. (87133) (CALI!), Satheesh Kumar (87180) (CALI!); Thiruvananthapuram, Agasthyamala, 1500m, 15.04.2008, Manju (106659) (CALI!); Sri Lanka, Thwaites, 133. (BM!)

Etymology: The specific epithet is based on the anomalus size of the plant compared to other *Fissidens* species.

Fissidens dubius P. Beauv., Prodr. Aethéogam. 57. 1805; Gangulee, Moss. E. India & Adj. 1: 553. f. 264. 1971 (as *F. cristatus*); Iwatsuki & Suzuki, J. Hattori Bot. Lab. 51: 418. 1982; Li & Iwatsuki, Moss Fl. China 2: 30. 2001; Pursell, Fissidentaceae Fl. Neo. Mono. 101; 29. 2007; Beever, Fl. New Zealand Moss. Fissidentaceae 8: 23. 2014.

Type. U.S.A. (without locality and collector) Lectotype, GL-Arnott. (Isolectotype H-SOL, FH-Taylor)

Fissidens cristatus Wils. *ex* Mitt., J. Proc. Linn. Soc., Bot., Suppl. 1: 137. 1859; Gangulee, Moss. E. India & Adj. 1: 553. f. 264. 1971. *F. circinans* Muell.Hal., Bot. Zeitung (Berlin) 22: 340. 1864; *F. decipiens* De Not., Atti R. Univ. Genova 1: 479. 1869; *F. rupestris* Wilson, Proc. Nat. Hist. Soc. Glasgow 1: 91. 1869; *F. floridanus* Lesq. & James, Proc. Amer. Acad. Arts 14: 137. 1879; *F. adianthoides* var. *savatieri* Besch., Ann. Sci. Nat., Bot., sér. 7, 17: 335. 1893; *F. decipiens* var. *winonensis* Renauld & Cardot., Bot. Gaz. 22: 50. 1896; *F. obsoleto-marginatus* Muell. Hal., Nuovo Giorn. Bot. Ital., n. ser. 3: 89. 1896; *F. savatieri* (Besch.) Paris, Index Bryol. 484. 1896; *F.micro-japonicus* Par., Rev. Bryol.35: 125. 1908; *F. erosodentatus* Card., Bull. Soc. Bot. Gen. sér. 2, 1: 121. 1909; *F. pseudo-gymnogynus* Toy., Acta. Phytotax. Geobot. 4: 216. F. 4. 1935; *F. adianthoides* var. *semicristatus* Grout., Moss Fl. of N. Amer. 1: 21. 1936; *F. koshikijimensis* Sak., Bryologist 39: 4, pl. II. 1936.

Plants green to brownish, leafy stems simple, rarely branched, 10–50 mm long, 3.5–5.0 mm wide; rhizoids smooth, basal; axillary hyaline nodules not

differentiated; central strand well differentiated; leaves in 13–58 pairs, rather densely arranged; the lowermost leaves small, upper leaves much larger; middle to upper leaves lanceolate, 3.2–3.5 mm × 0.7–0.8 mm, distinctly crisped when dry, acute to narrowly acute at apex, margins irregularly toothed near the apex, finely crenulate to serrulate below, bordered by a lighter coloured band of 3–5 rows of incrassate, smooth, paler cells, this lighter-coloured band is one cell to rarely two cells thick in cross section, much clear on apical and dorsal laminae than on vaginant laminae; costa stout, percurrent, taxifolius type; vaginant laminae 3/5 – 2/3 the leaf length, equal or slightly unequal; base of dorsal laminae rounded to shortly decurrent, dorsal lamina and apical lamina bistratose; cells of apical and dorsal laminae usually rounded-hexagonal, rarely elliptical-ovate, 10–11 µm long, distinctly mammillose, obscure, apical laminae one cell thick, but occasionally two cells thick; cells of vaginant laminae similar to those of apical and dorsal laminae, but less mamillose.

Fertile parts, male plants small, *ca*. 1 mm long, growing from vaginant laminae of female plants. perichaetium axillary, perichaetial leaves much smaller than stem leaves, ovate-lanceolate, 1.0–1.3 mm long, archegonia ca. 300 µm long; setae lateral, 5–8 mm long, smooth, capsules slightly inclined, asymmetrical, urns 0.8–1.4 mm long, exothecial cells quadrate to oblong with thickened vertical walls and thinner transverse walls, opercula long rostrate, *ca*. 1.6 mm long; peristome teeth 0.5–0.6 mm long, taxifolius type; calyptra campanulate, *ca*. 1.6 mm long (Plate 21 & Fig.3).

Diagnostic characters: *Fissidens dubius* P. Beauv. is characterised by moderately large plants, lanceolate leaves, irregularly crenulated margin and mammillose laminal cells. It is similar to *F. anomalus* Mont. in plant appearance and laminal cells but differs in the more broad leaves and leaf apex, percurrent costa of *F. dubius* P. Beauv.

Note: some authors cited *F. dubius* P. Beauv. as a synonym of *F. cristatus* Wils. *ex* Mitt. but considering the priority of publication *F. cristatus* should be considered as a synonym of *F. dubius* P. Beauv. Gangulee (1971) also considered F. dubius as a synonym of *F. cristatus*. But later Pursell (1994) synonimised this species under *F. dubius*.

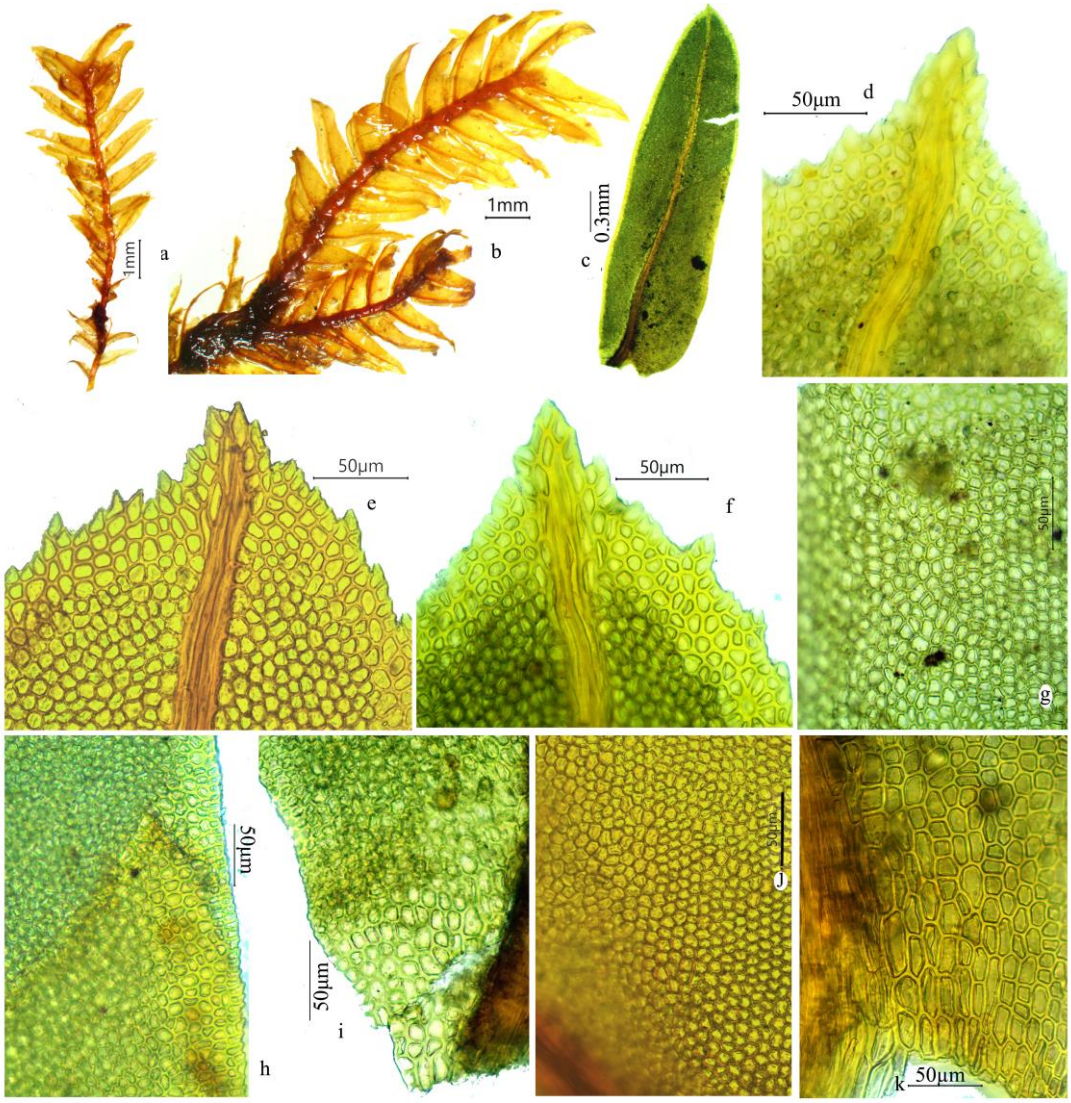


Plate 21. *Fissidens dubius* P.Beauv., a&b. habit, c. vgetative leaf, d-f. leaf apex, g. laminal cells, h. vaginant laminae apex, i. dorsal lamina base near insertion, j. apical laminal cells, k. vaginant laminae base (photos from Long (BM!).

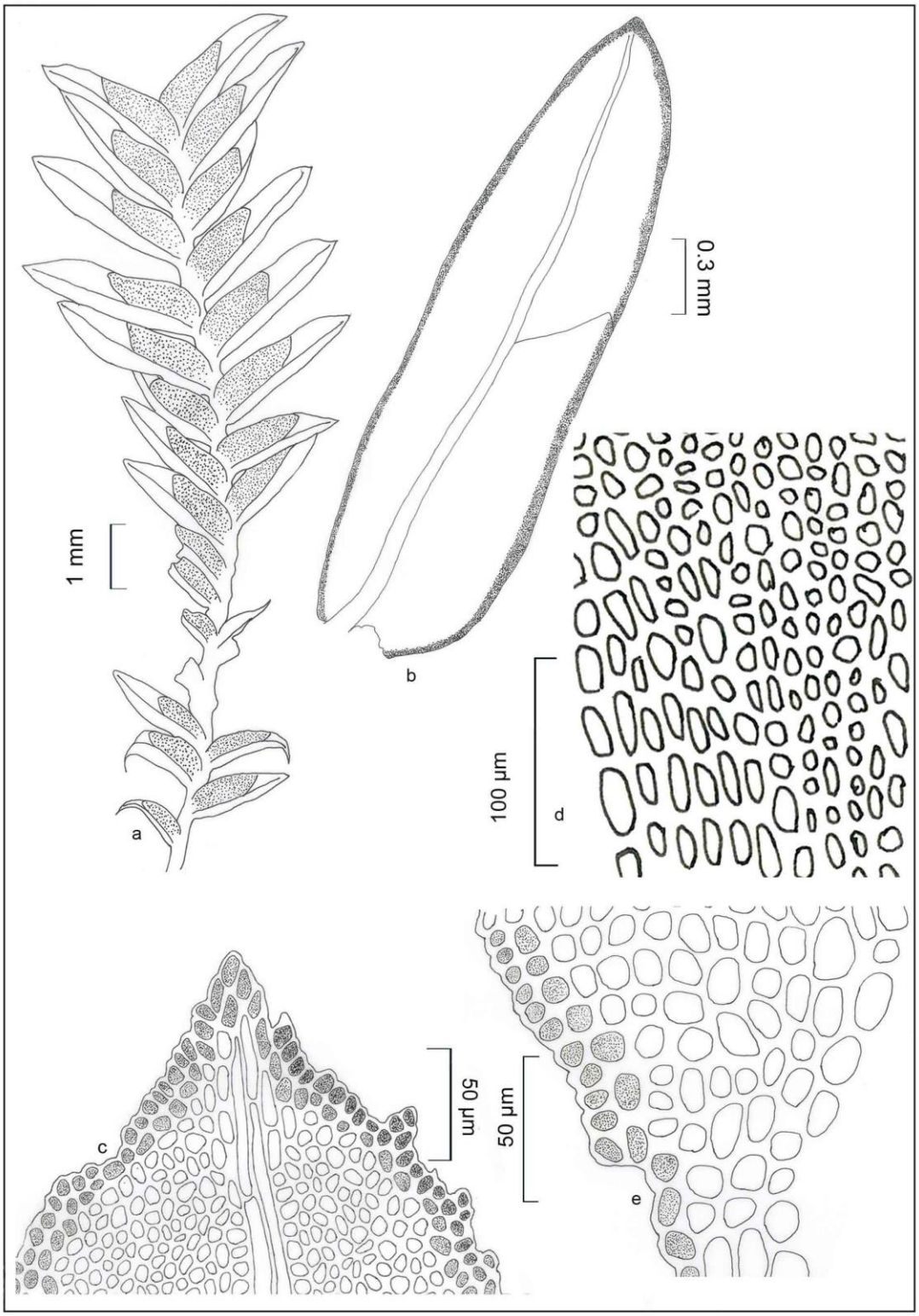


Fig. 3. *Fissidens dubius* P. Beauv., a. vegetative plant, b. vegetative leaf, c. leaf apex, d. dorsal lamina base near insertion, e. vaginant laminae base

Habitat and General Ecology: Mostly on large rocks, rarely on tree trunks or on soil at an altitude of 1200m in evergreen forests.

Distribution: India (Kerala, Khasia Hills, Tamil Nadu (Potier de la Varde, 1922: as *F. atrovirens* Cardot, *nom. nud. in synon*., Foreau, 1930 & 1961 as *F. cristatus* Wilson]. Nilgiri, Palni [Gangulee 1971: as *F. cristatus*); Africa, Alabama, Alaska, Arizona, Arkansas, California, Canada, Central America, China, Connecticut, Costa Rica, Delaware, Europe, Florida, Georgia, Guatemala, Haiti, Honduras, Illinois, Indiana, Indonesia, Jamaica, Japan, Kansas, Kentucky, Korea, Maine, Massachusetts, Mexico, Michigan, Minnesota, Mississippi, Missouri, Nebraska, Nepal, New Guinea, New Hampshire, New York, North America, North Carolina, Oklahoma, Pennsylvania, Philippines, Sri Lanka, South Carolina, Tennessee, Texas, Vermont, Virginia, West Virginia, Wisconsin (Beever, 2014; Iwatsuki & Suzuki, 1982; Li & Iwatsuki, 2001; Mehler, 1980; Tan & Iwatsuki, 1991; Pursell, 1994). (Map 4A&4B).

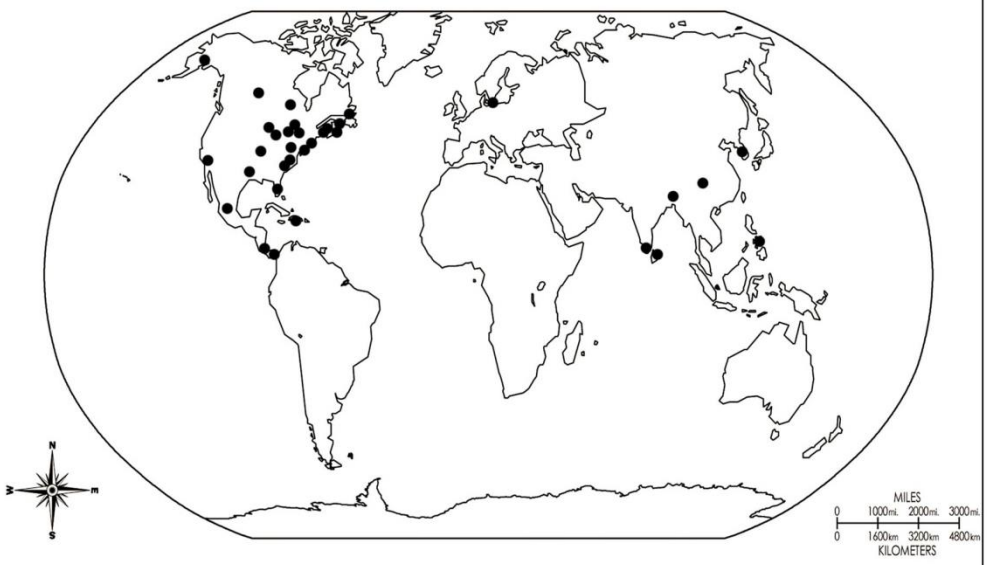
Specimens examined: India, Kerala, Thiruvananthapuram District (Neyyar WLS), 07.06.2007, Brijithlal 33 (SCCN!); Simla (7200ft), 25.03.1906, E. Long (BM!).

Etymology: The derivation of the specific epithet *dubius* (doubtful) remains obscure.

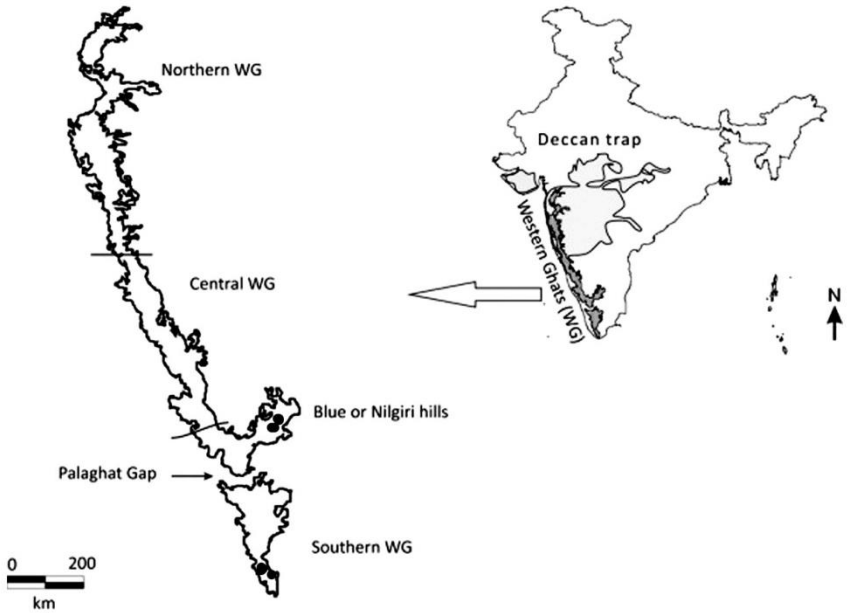
Fissidens grandifrons Brid., Muscol. Recent. Suppl. 1: 170. 1806; Bartram, Fieldiana: Botany 25: 23. 1949; Gangulee, Moss. E. India & Adj. 1(2): 564. 1971; Iwatsuki & Suzuki, J. Hattori Bot. Lab. 51: 326. 1982; Li & Iwatsuki, Moss Fl. China 2: 37. 2001; Pursell, Fissidentaceae Fl. Neo. Mono. 101: 19. 2007.

Type: U.S.A., In Nova Anglia habitat (B).

Schistophyllum strictum Brid., Bryol. Univ., 2: 701. 1827. *nom. nud. in synon.*; *Fissidens insignis* Muell. Hal., Bot. Zeit. 22: 339. 1864 *fid*. Mitt.; *F. subgrandifrons* Muell. Hal., 22: 339. 1864. (Bot. Zeitung (Berlin); *F. strictus* Schimp. in Mitt., J. Linn. Soc. Bot. 21: 559. 1885. *nom. nud. in synon.; F. yunnanensis* Besch., Rev. Bryol. 18: 88. 1891; *F. palnicaulis* Besch., Ann. Sc. Nat. ser. 7, 17: 335. 1893; *Skitophyllum strictum* Par., Index Bryol. Ed. 2, 4: 255. 1905. *nom. nud. in synon.;*



Map. 4A. World distribution of ***Fissidens dubius*** *P.Beauv.*



Map. 4B. Distribution of ***Fissidens dubius*** *P.Beauv. in Western Ghats*

F. diversiretis Broth., Symb. Sin. 4: 11. 1929; *F. grandifrons* var. *planicaulis* (Besch.) Nog., J. Hattori Bot. Lab. 7: 68. 1952.

Plants large, 2.3-4.5 cm long, linear, rigid, reddish brown in herbarium, rhizoids smooth, axillary and basal; axillary hyaline nodule differentiated; stem brownish, monomorphic, outer cortical cells small, thick walled, inner cortical cells large, thin walled, central strand absent, profusely branched, 14-57 pairs of leaves, imbricate, linear lanceolate, stiff and strong, not contorted when dry, leaf apex obtuse to rounded, margin more or less entire; limbidium absent in all laminae; costa obscure, ending few cells below apex, usually taxifolius type, vaginant laminae half or more as long as leaf, inner cells multistratose; marginal cells uni to multistratose; dorsal lamina narrowed, base more or less decurrent, wedge shaped; laminal cells quadrate to hexagonal, smooth, eguttulate, plane to bulging, 6.4-7.0 µm in apical lamina, thick walled, cells of vaginant laminae small, 5.0-7.4 µm; gemmae not found.

Fertile parts not found (Plate 22 & Fig.4).

Diagnostic characters: *F. grandifrons* is characterised by its aquatic habitat, elimbate, straight and rigid leaves with obtuse to rounded leaf apex, apical lamina multistratose, axillary hyaline nodules differentiated and percurrent costa. This species differs from most of the tropical members but shows similarity with *F. sedgwickii* Broth. & Dixon in leaf apex and leaf structure. *F. sedgwickii* have bryoides type costa and *F. grandifrons* has taxifolius type costa. But both the species are aquatic and leaf is stiff and strong.

Habitat and General Ecology: On rocks and stones in submerged conditions in flowing water in high altitude areas of evergreen forest.

Distribution: India (Tamil Nadu, Western Himalayas (Daniels, 2010; Gangulee, 1971), Canada, China, Europe, Japan, Korea, North and central Africa, Mexico, North and central America, Pakistan, Taiwan, (Iwatsuki & Suzuki, 1982; Li & Iwatsuki, 2001; Pursell, 2007) (Map 5A&5B).

Note: Gangulee (1971) mentioned this species and listed from Ooty in Tamil Nadu, Daniels (2010) also listed this species based on earlier collection. But during the present study I could not locate this species from Ooty and elsewhere.

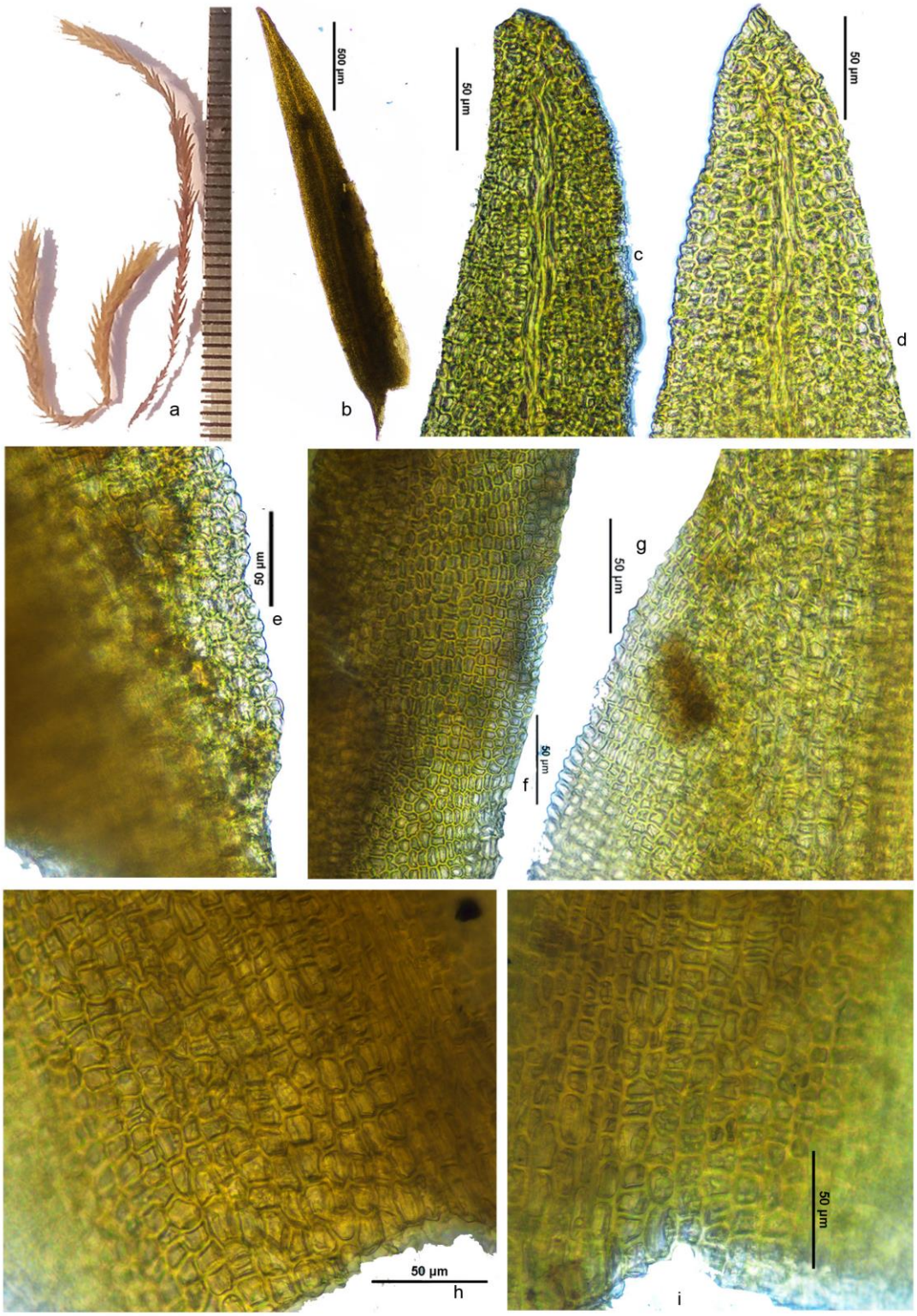


Plate 22. *Fissidens grandifrons* Brid., a. vegetative plants, b. vegetative leaves, c&d. leaf apex, e. dorsal lamina base near insertion, f. marginal cells, g. vaginant laminae apex, h&i. vaginant laminae base (photos from Ludlow & Sherrif 1341BM!).

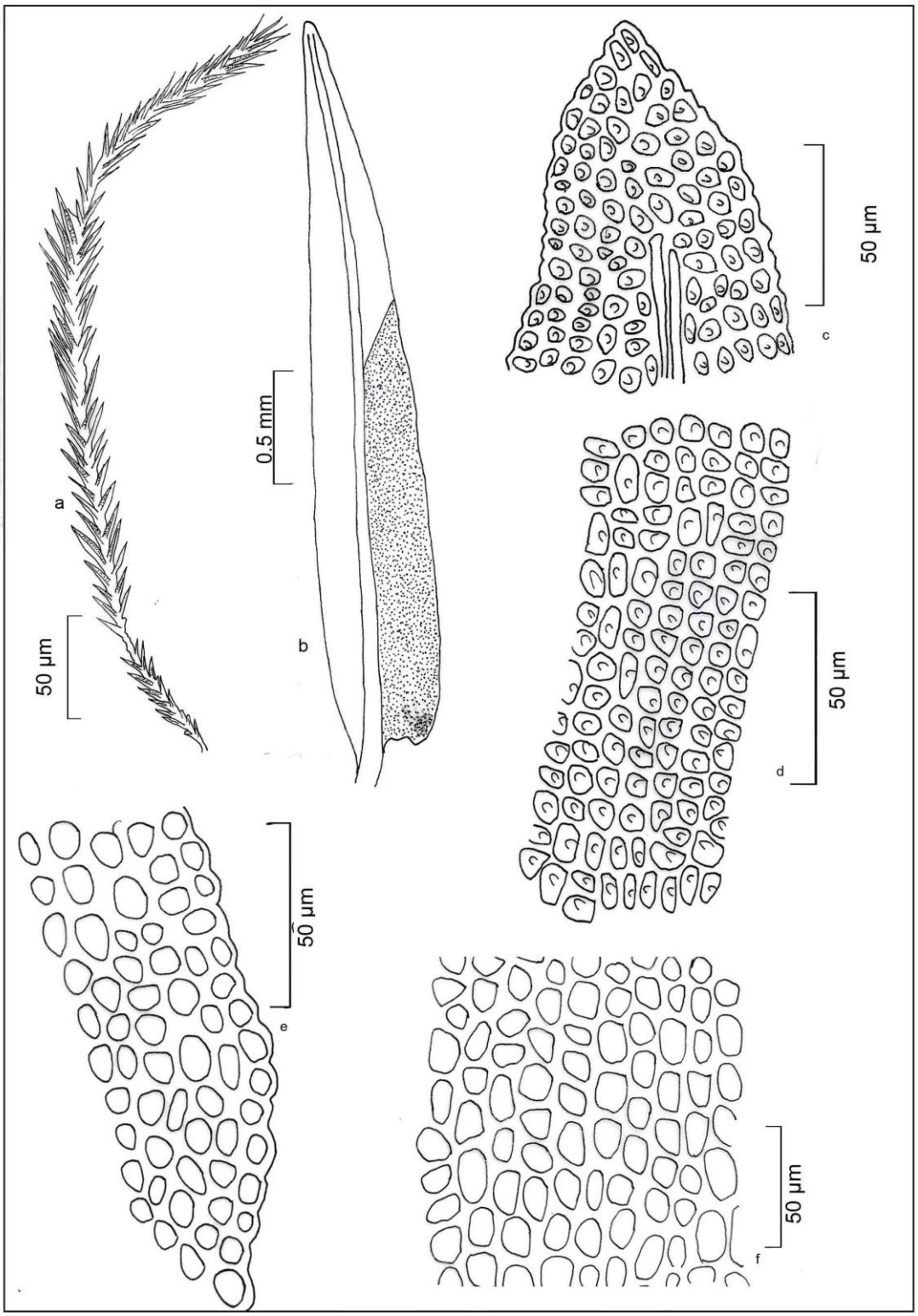
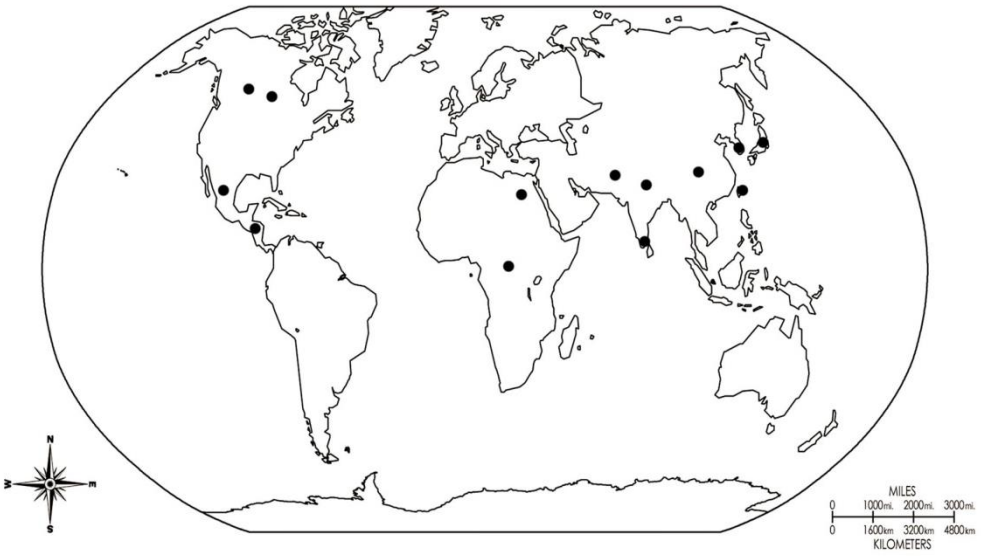
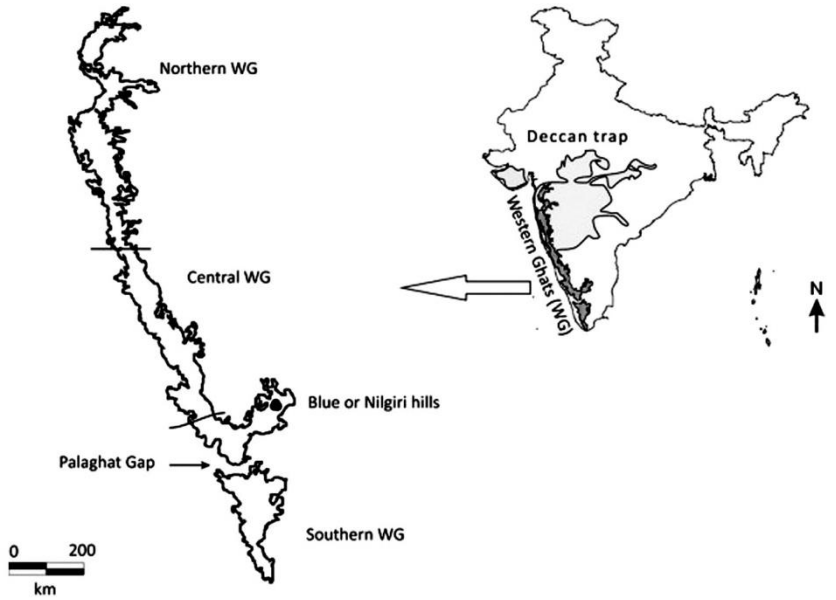


Fig. 4. *Fissidens grandifrons* Brid., a. vegetative plant, b. vegetative leaf, c. leaf apex, d. laminal cells, e. dorsal lamina base near insertion, f. vaginant laminae base.



Map. 5A. World distribution of ***Fissidens grandifrons*** *Brid.*



Map. 5B. Distribution of ***Fissidens grandifrons*** *Brid. in Western Ghats*

The description given above is based on authentic specimen collected from Natural History Museum (BM).

Specimens examined: Nepal, South Tibet, Edge of dry Tibetan Plateau zone (10500ft), 25.04.1936, Ludlow & Sherrif (1341) (BM!)

Etymology: The specific epithet *grandifrons* derived from '*grand'* (large) + '*frons'* (fronds= leaves) which refers to large leaves of this species compared to other members of this family.

Fissidens involutus Wilson *ex.* Mitt., J. Proc. Linn. Soc., Bot., Suppl. 2: 138. 1859

Considering its variability Gangulee (1971) erected a subspecies as *curvatoinvulutus* and can be keyed out as below

Key to the subspecies of *Fissidens involutus* Wilson & Mitt.

1a. Plants 3-5 mm long, leaves oblong ……. *F. involutus* subsp. *involutus*

1b. Plants 5-7 mm long, leaves ovate lanceolate …….....……..…

…… *F. involutus* subsp. *curvatoinvolutus*

Fissidens involutus Wilson *ex.* Mitt., J. Proc. Linn. Soc., Bot., Suppl. 2: 138. 1859; subsp. ***involutus*** Gangulee, Moss. E. India & Adj. 1: 507. 1971; Li & Iwatsuki, Moss. China 2. 41. 2001; Daniels & Kariyappa, Curr. Sci. 93(7): 980. 2007; Manju *et al.*, Tropical Bryol. Res. Rep. 7: 12. 2008b; Rani *et al.*, Bryo. Andhra Pradesh. 128. 2014.

Syn types. Sikkim: J. D. Hooker 641 (lectotype NY).

Plants 3-5 x 1.2-1.5 mm, 3 times long as wide, 9-12 pairs of leaves, axillary hyaline nodules slightly differentiated; rhizoids smooth, brown; leaves slightly overlapping towards tip, oblong with broad base, margin crenulated, leaf apex broadly acute; limbidium absent; vaginant laminae reaches ½ or ¾ of leaf length, apex slightly open, base broad, 12-15 cells wide, unistratose; dorsal lamina narrowing down, base round, 5-7 cells wide at base, dorsal lamina and apical lamina unistratose; costa prominent, bryoides type, ending 3-6 cells below apex; laminal cells rectangular or polygonal, medium sized, juxta costal cells slightly large; gemmae not found (Plate 23 & Fig.5).

Fertile plants not observed.

Diagnostic characters: *F. involutus* Wilson *ex* Mitt. is characterised by presence of axillary hyaline nodules, oblong leaves without limbidium and elongated juxta costal cells.

Habitat and General Ecology: Terrestrial in open grass lands and home steads at an altitude of 1800 m.

Distribution: India (Darjeeling, Kerala, Tamil Nadu, Sikkim, Western Himalayas) (Daniels, 2003; Daniels & Daniel, 2013; Gangulee 1971; Manju *et al*., 2008b); East Nepal, Thailand, Vietnam, China, Japan, Myanmar, Philippines (Li & Iwatsuki, 2001). The present report is a detailed description of this species from Kerala (Map 6A&6B).

Specimens examined: India, Tamil Nadu, Thirunelveli District (Mundanthurai, 250m), 30.07.1999, A.E.D. Daniels (633A); Kolkatta (Howrah), 11.09.56, Anon., (2445 I) (CAL!); Nepal, (Tumlinotar, 1800ft), 11.12. (1961), A.H. Norkett (8738) (BM!).

Etymology: The specific epithet *involutus* defines the involuted nature of leaves in dry and wet condition.

Fissidens involutus Wilson *ex.* Mitt. subsp. ***curvatoinvolutus*** (Dixon) Gangulee, Moss. E. India & Adj. 2: 548. 1971; Chaudhary & Deora. Moss Fl. Rajasthan 34. 1993 (as *F. curvato-involutus*); Chaudhary *et al.,* Bryoph. Fl. Gujarat: 69. 2006 (as *F. curvatoinvolutus*); Daniels & Kariyappa, Curr. Sci. 93(7): 980. 2007; Madhusoodanan *et al*., *Curr. Trends Bryol.* 260. 2007 (as *F. curvatoinvolutus*)*;* Manju *et al.,* Tropical Bryol. Res. Rep. 7: 12. 2008b; Daniels & Daniel, Bryo. South. W. Ghat. 43. 2013.

Type: India; Uttar Pradesh, Saharanpur bot. Gard., 1863. Bell s. n (E)

Fissidens curvatoinvolutus Dixon, Notes Roy. Bot. Gard. Edinburgh 19: 279. 1938.

Plants large, curls in herbarium, light green, branched or unbranched, innovations present, 5-7 x 2-3 mm, 12-16 pairs of leaves; axillary hyaline nodules differentiated, rhizoids smooth, brownish; leaves 1.5–2.0 x 0.30-0.38 mm, ovate lanceolate, tip acute or acuminate; limbidium absent; vaginant laminae 1.0-1.5 mm

Plate 23. *Fissidens involutus* Wilson *ex* Mitt. sub sp. *involutus* Gangulee, a. vegetative plants, b-d. vegetative leaves, e&f. vaginant laminae, g. axillary hyaline nodules, h-j leaf apex, k&l. vaginant laminae apex, m. dorsal lamina base near insertion, n. vaginant laminae base (photos from Norkett (8738 BM!).

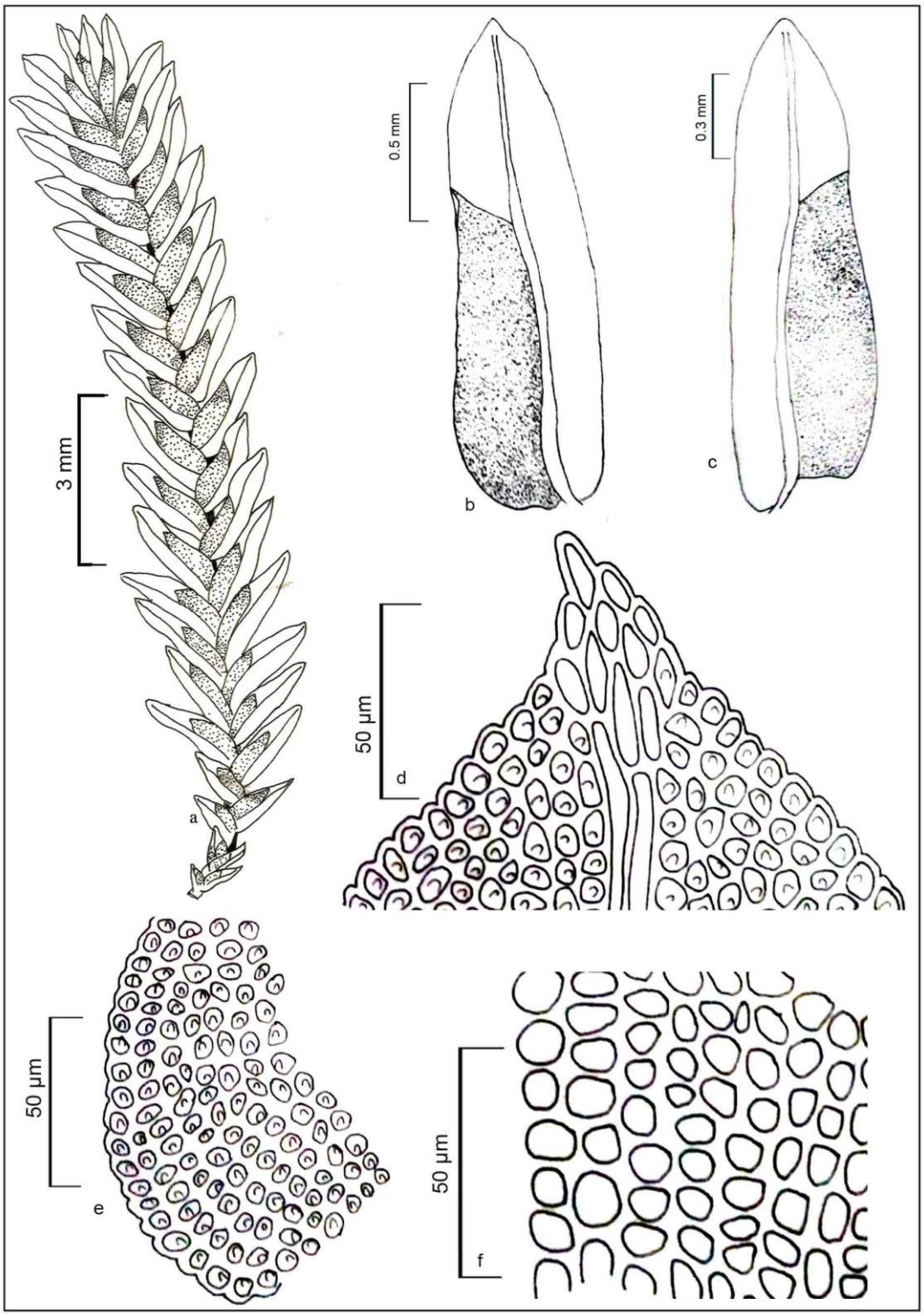
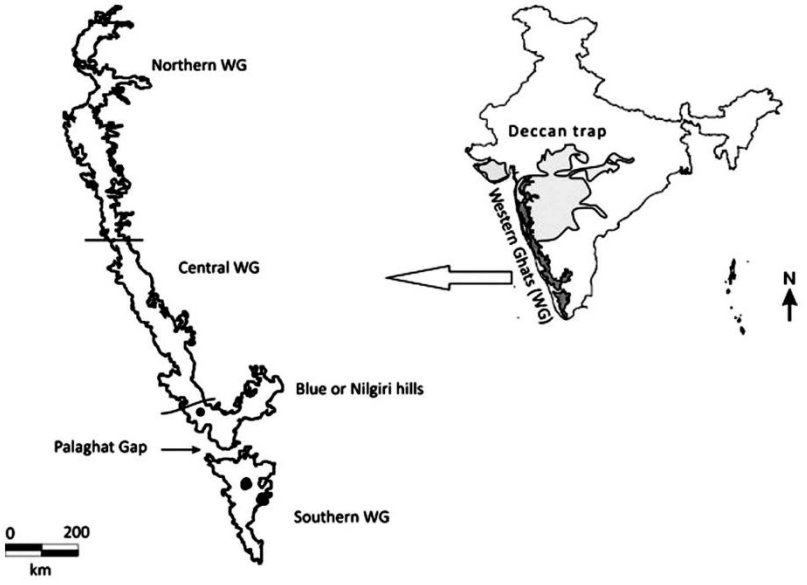


Fig. 5. *Fissidens involutus* Wilson *ex* Mitt. sub sp. *involutus* Gangulee, a. vegetative plant, b&c. vegetative leaves, d. leaf apex, e. dorsal lamina base near insertion, f. vaginant laminae base.

Map. 6A. World distribution of ***Fissidens involutus*** *Wilson ex. Mitt. subsp.* ***involutus*** *Gangulee*



Map. 6B. Distribution of ***Fissidens involutus*** *Wilson ex. Mitt. subsp.* ***involutus*** *Gangulee in Western Ghats*

long, 1.87-2.00 mm wide at base, uniseriate, slightly open, reaching ± half the length of leaves; dorsal lamina base round, decurrent with a folding or depression at the base, dorsal lamina and apical lamina uniseriate; laminal cells irregularly quadrangular or polygonal, mammillose, vaginant laminal cells 9.02-10.46 x 5.66-6.76 µm , dorsal laminal cells 8.15-12.38 x 5.29-8.81 µm, juxta costal cells elongated, 15.95-26.12 x 9.10-9.90 µm; gemmae not found (Plate 24 & Fig.6).

Fertile parts not found.

Diagnostic characters: *F. involutus* subsp. *curvatoinvolutus* (Dixon) Gangulee is characterised by stem with axillary hyaline nodules, highly curled leaf even after in wet condition, leaves elongate to linear lanceolate, laminal cells mamillose and dorsal lamina base rounded.

Habitat and General Ecology: This is a rare variety found in low and high altitude areas in Western Ghats and found in open soil, land cuttings and on large and small rocks.

Distribution: India (Kerala, Karnataka, Goa, Gujarat, Tamil Nadu (as *F. curvatoinvolutus* Dixon) (Bruhl, 1931; Daniels, 2003; Dixon & Potier de la Varde, 1927; Foreau, 1930, 1961; Madhusoodanan *et al*., 2007, Manju *et al*., 2008b) Gangulee, (1971) reported this species as separate subspecies but the distribution is mentioned in general for *F. involutus* as South–East Asiatic species and reported from Darjeeling and Chotttanagpur in India. The present collection is a new record to Karnataka. (Map 7A&7B).

Specimens examined: India, Kerala, Malappuram district (Calicut University campus, 40m), Manju, C.N., 10.10.2007, (106382(1) (CALI!); Karnataka, (Hebri, 76m), 29.06.2013, Rajilesh,V.K., (ZGC 851A); Gujarat, Gira falls, 18.09.2017, Manjula (7761, 7764); Himachal Pradesh, (Kalka Bridge), 09.11.1966, A.H. Norkett (12013-4!) (BM!).

Etymology: The specific epithet *involutus* defines the involuted nature of leaves in dry and wet condition.

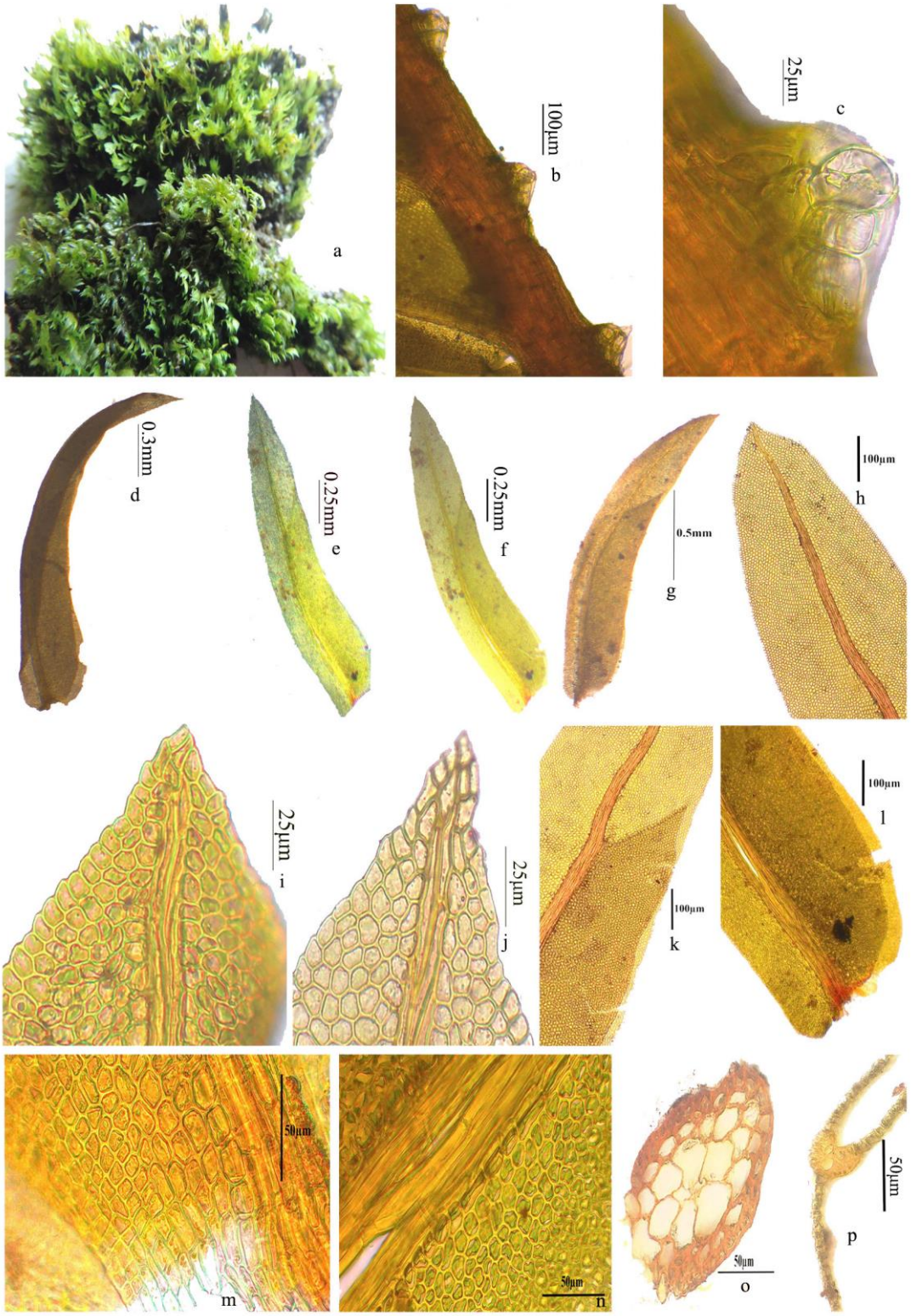


Plate 24a. *Fissidens involutus* sub sp. *curvatoinvolutus* (Dixon) Gangulee, a. habit, b&c. axillary hyaline stem nodule, d-g. vegetative leaves, h-j. leaf apex, k. vaginant laminae apex, l. leaf base, m. vaginant laminae base, n. laminal cells, o. stem T.S., p. leaf T.S.

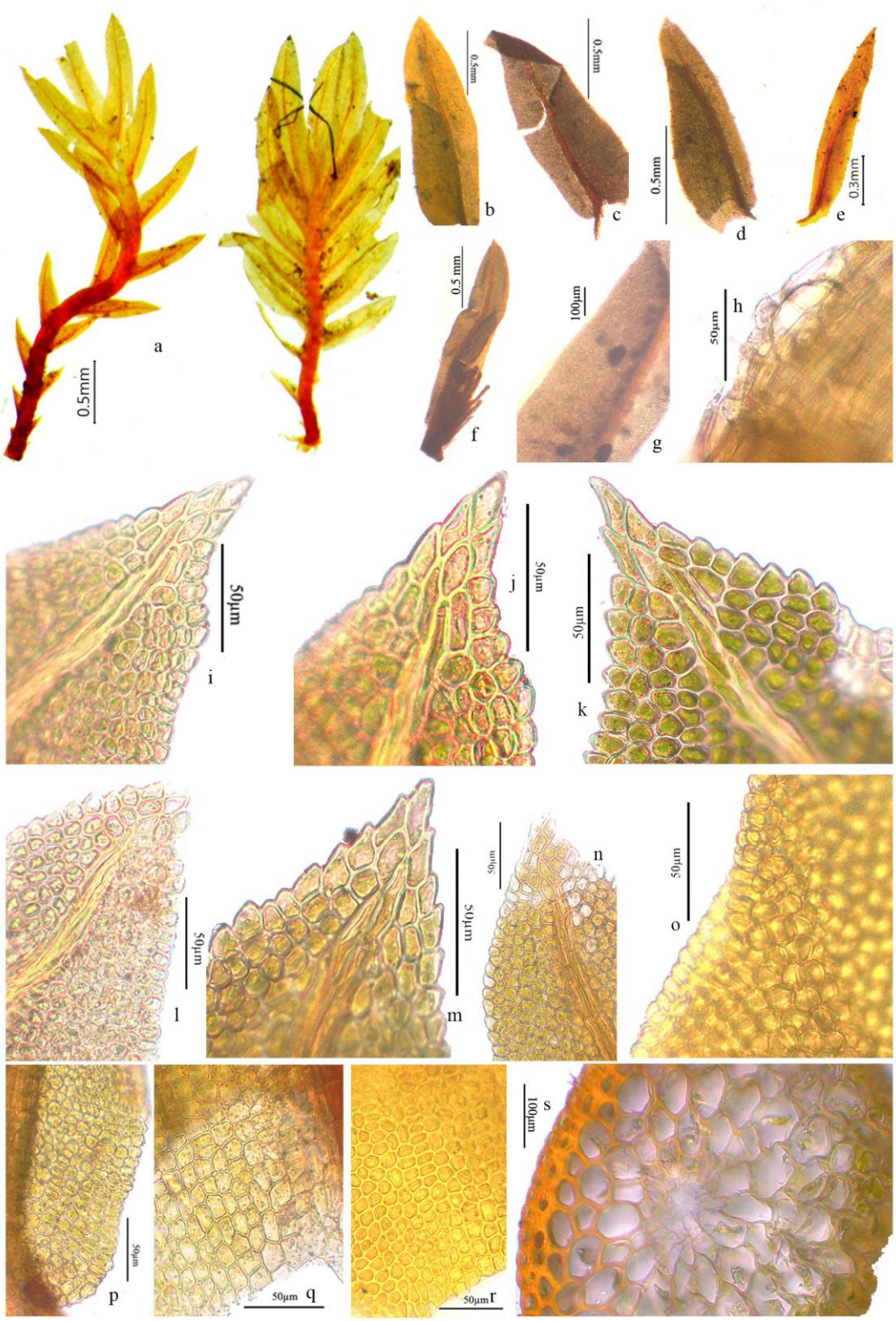


Plate 24b. *Fissidens involutus* sub sp. *curvatoinvolutus* (Dixon) Gangulee, a. vegetative plants, b-e. vegetative leaves, f. perichaetial leaf, g. vaginant laminae, h. axillary hyaline nodule, i-n. leaf apex, o. vaginant laminae apex, p. dorsal lamina base near insertion, q&r. vaginant laminae base, s. stem T.S.

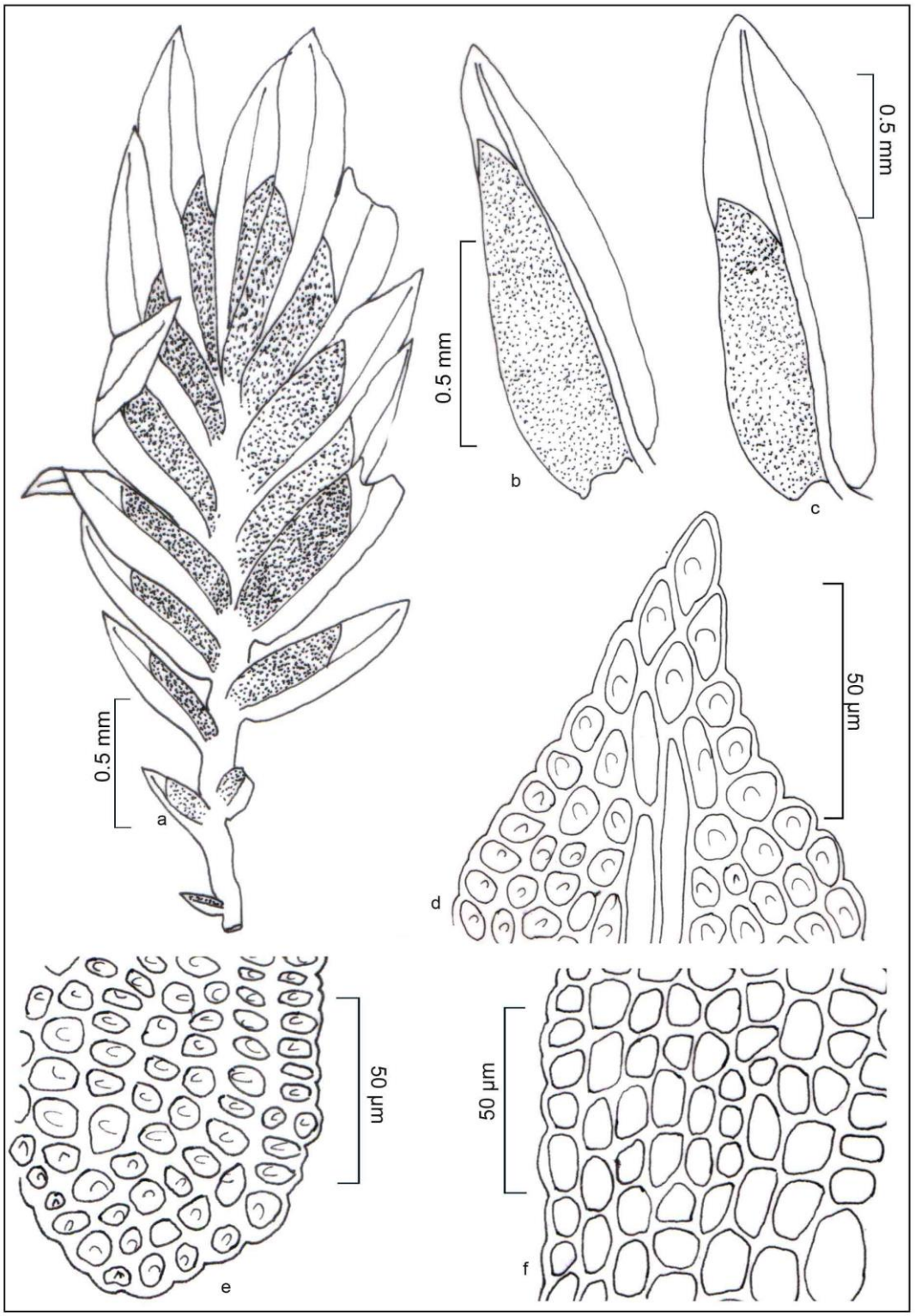
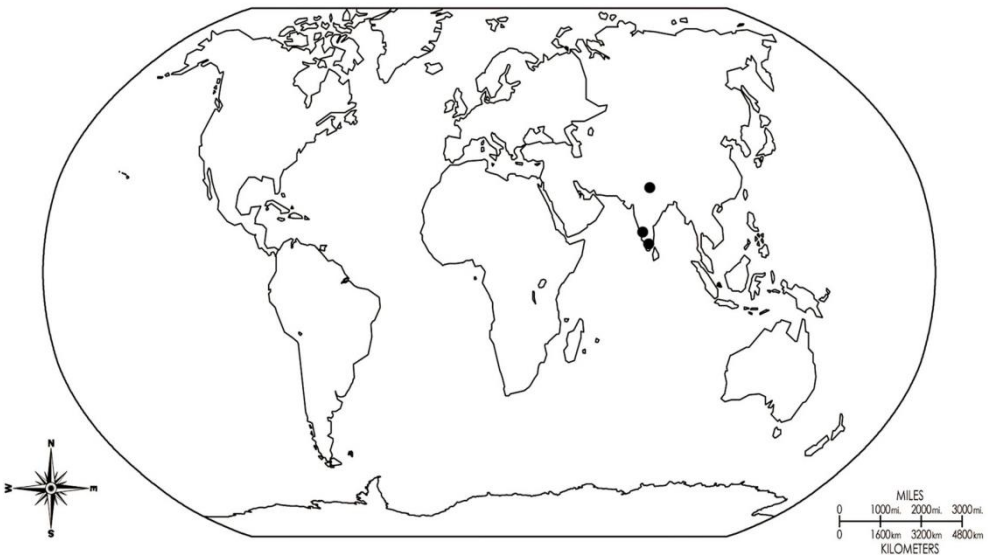
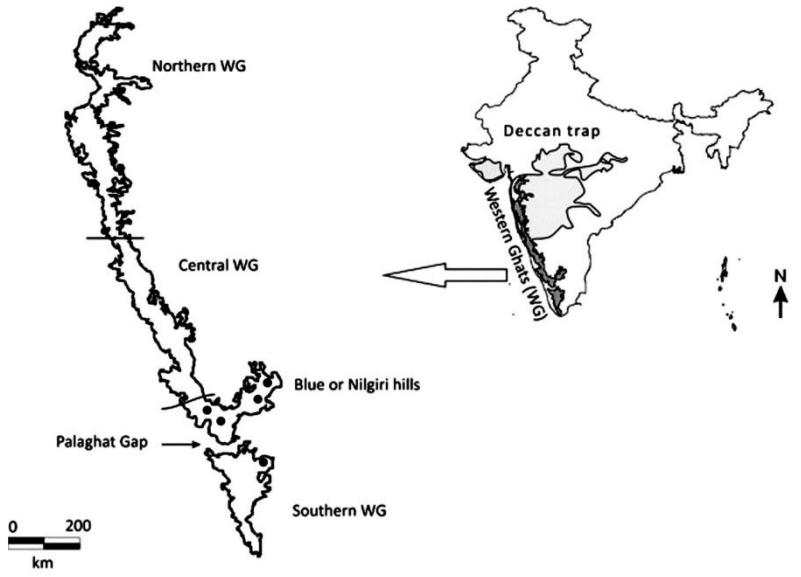


Fig. 6. *Fissidens involutus* sub sp. *curvatoinvolutus* (Dixon) Gangulee, a. vegetative plant, b&c. vegetative leaves, d. leaf apex, e. dorsal laminal cells near insertion, f. vaginant laminae base



Map. 7A. World distribution of Fissidens involutus Wilson ex. Mitt. subsp. curvatoinvolutus (Dix.) Gangulee



Map. 7B. Distribution of Fissidens involutus Wilson ex. Mitt. subsp. curvatoinvolutus (Dix.) Gangulee in Western Ghats

Fissidens jungermannioides Griffith, Calcutta J. Nat. Hist. 2: 504. 1842; Bruehl., Rec. Bot. Surv. India 13(1): 18. 1931; Gangulee, Moss. E. India & Adj. 1(2): 552. F. 263. 1971: Li & Iwatsuki, Moss Fl. China 2: 44. 2001; Lal, Checklist Indian Moss. 62. 2005; Daniels & Daniel in Nath & Asthana, Curr. Trends Bryol. 234. 2007; Manju *et al.*, Tropical Bryol. Res. Rep. 7: 12. 2008b; Daniels & Daniel, Bryo. South. W. Ghat. 44. 2013.

Type: India (Assam), Moosmai, Griffith 623 (holotype, NY) (BM!, CAL!)

Plants 3.5-7.0 mm long, caespitose, unbranched, reddish brown in herbarium; rhizoids smooth, basal, stem dark brown, axillary hyaline nodules absent, stem central strand not differentiated; leaves distant, 11-20 pairs of leaves, more or less stiff, lanceolate, leaf apex acute with short apiculus, 0.95-1.00 x 0.4-0.0.45 mm, broad at base, margin not entire; limbidium absent on all laminae; vaginant laminae reaches more than 1/2 of leaf length; minor lamina smaller, apex unequal, open towards costa at apex; margin serrulate, unistratose; dorsal lamina base wedge shaped, join to costa at leaf insertion, not decurrent, apical lamina and dorsal lamina unistratose; costa strong, excurrent, ends in short apiculus; laminal cells irregularly quadrate hexagonal, mamillose, partially indistinct in herbarium specimens, corrugate, 9.0-12 x 0.4-0.5 µm, marginal cells slightly pale in colour on apical and vaginant laminae, one or two rows of cells on dorsal lamina, margin dark coloured, cells of dorsal lamina more dark in some cases; gemmae not found (Plate 25 & Fig.7).

Fertile parts not found.

Diagnostic characters: *F. jungermannioides* Griff. is characterised by distant, lanceolate leaves, acute apex with short apiculus, pale coloured marginal cells, mamillose laminal cells and excurrent costa. This species shows similarity with *F. crenulatus* Mitt. in laminal cells and crenulated leaf margin while absence of limbidium on all laminae and excurrent costa differentiate this species from *F. crenulatus.*

Habitat and General Ecology: On land cuttings, walls and stones in plantations and shaded areas near stream in semi evergreen forests.

Plate 25. *Fissdiens jungermanioides* Griff., a. vegetative plants, b-d. vegetative leaves, e&h. leaf apex, f. vaginant laminae apex, g,i&k. leaf base, j&l. vaginant laminae base (photos from type, Griffith 623 CAL!).

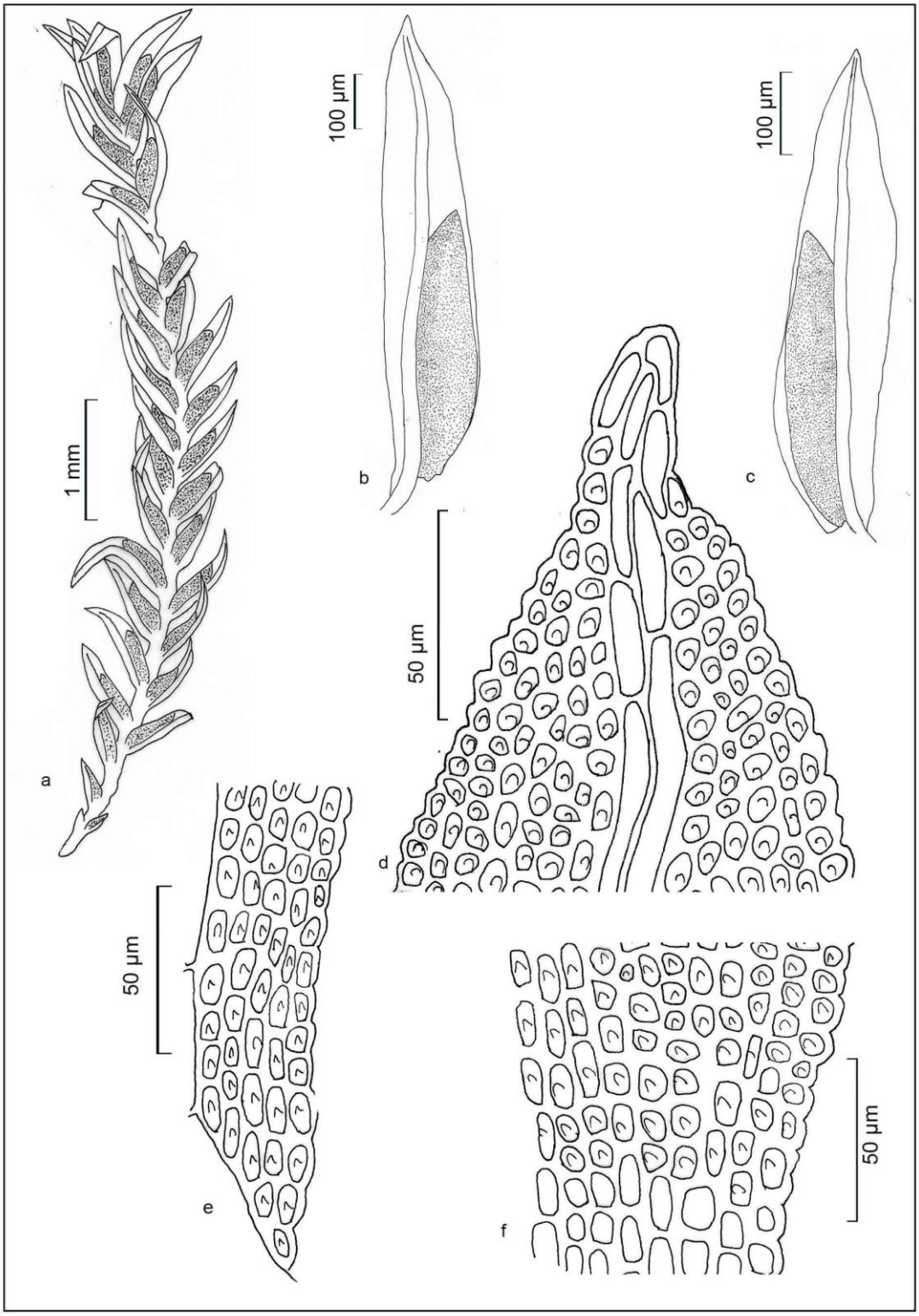
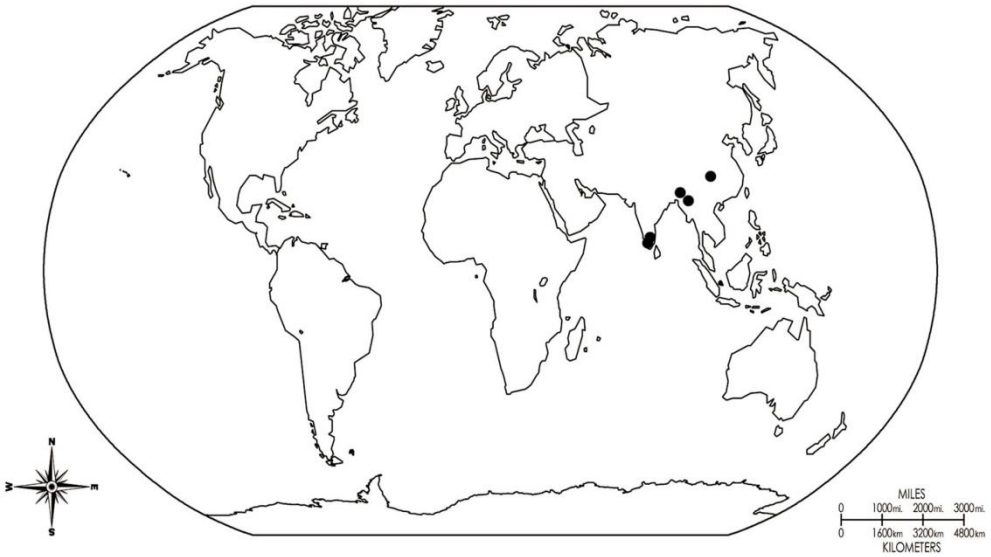
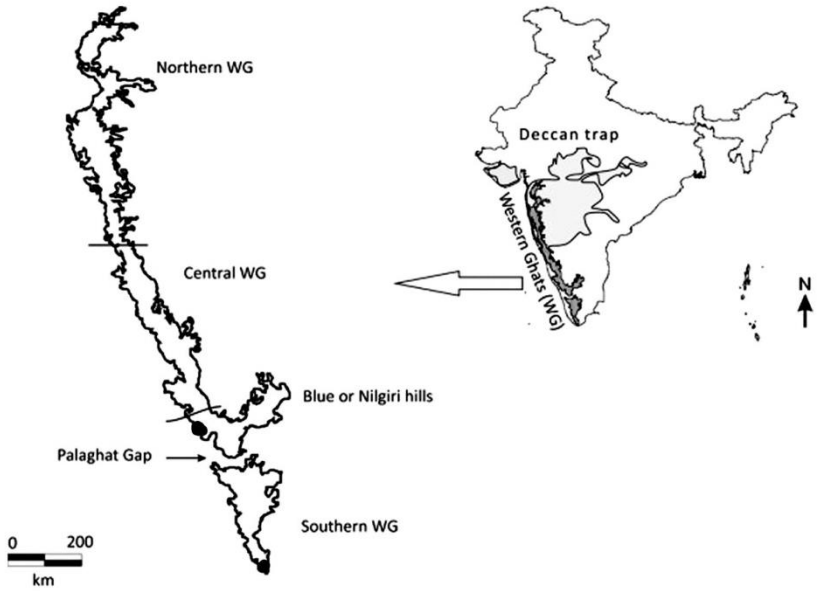


Fig. 7. *Fissidens jungermannioides* Griff., a. vegetative plant, b&c. vegetative leaves, d. leaf apex, e. dorsal lamina base near insertion, f. vaginant laminae base.



Map. 8A. World distribution of ***Fissidens jungermannioides*** **Griffith**



Map. 8B. Distribution of ***Fissidens jungermannioides*** **Griffith in Western Ghats**

Distribution: India (Assam, Meghalaya, Kerala, Tamil Nadu) (Daniels, 2003; Daniels & Daniel, 2007, 2013; Gangulee, 1971); China (Li & Iwatsuki, 2001) (Map 8A&8B).

Specimens examined: Tamil Nadu, Kanyakumari district, Kulasekharam ca 50m 12.7.1999 A.E.D Daniels 542 (SCCN!); Kerala, Kozhikode district, Kakkayam (750m) MCN 120117 (CALI!); Assam, Moosmai, Griffith 623 (holotype, NY) (BM!, CAL!), K. & J. Hills (No other details available) (CAL!).

Etymology: The plant habit looks like *Jungermannia* a leafy liverwort hence the name jungermannioides.

Fissidens obscurus Mitt., J. Proc. Linn. Soc. Bot. Suppl. 1: 138. 1859; Gangulee, Moss. E. India & Adj. 2: 557. 1971; Li & Iwatsuki, Moss Fl. China 2: 51. 2001; Lal, Checklist Indian Moss. 62. 2005; Daniels & Kariyappa, Curr. Sci. 93(7): 980. 2007.

Type: India, Moflong, Khasi Hills, Griffith 9 (Isotype H).

Plants medium sized, green colour, grow as dense tufts; stem erect, 12.0-12.50 x 3.2-4.0 mm, usually unbranched except some small axillary branches; rhizoids smooth, basal; axillary hyaline nodules not differentiated; stem brown, central strand not differentiated; 23-30 pairs of leaves, slightly overlapping, crispate in herbarium, leaves linear lanceolate, 2.7-3.2 x 0.75 µm, apex broadly acute to round, margin more or less smooth; limbidium absent on all laminae; costa percurrent to slightly subpercurrent, stout; vaginnant laminae 1/2 to 3/5 of leaf length, unequal, minor lamina unequal, uniseriate; dorsal lamina base round, wedge shaped, dorsal lamina and apical lamina uniseriate; laminal cells irregularly polygonal to round, smooth, vaginant lamina cells more thick walled, 10-13 µm. gemmae not found (Plate 26 & Fig.8).

Fertile parts not found.

Diagnostic characters: This plant is characterised by its lanceolate leaves with obtuse to round apex, slightly open vaginant laminae and percurrent to subpercurrent costa. *F. obscurus* Mitt. can be confused with *F. asplenioides* Hedw. in leaf character while differs in rounded laminal cells and serrate margin of *F. asplenioides.*

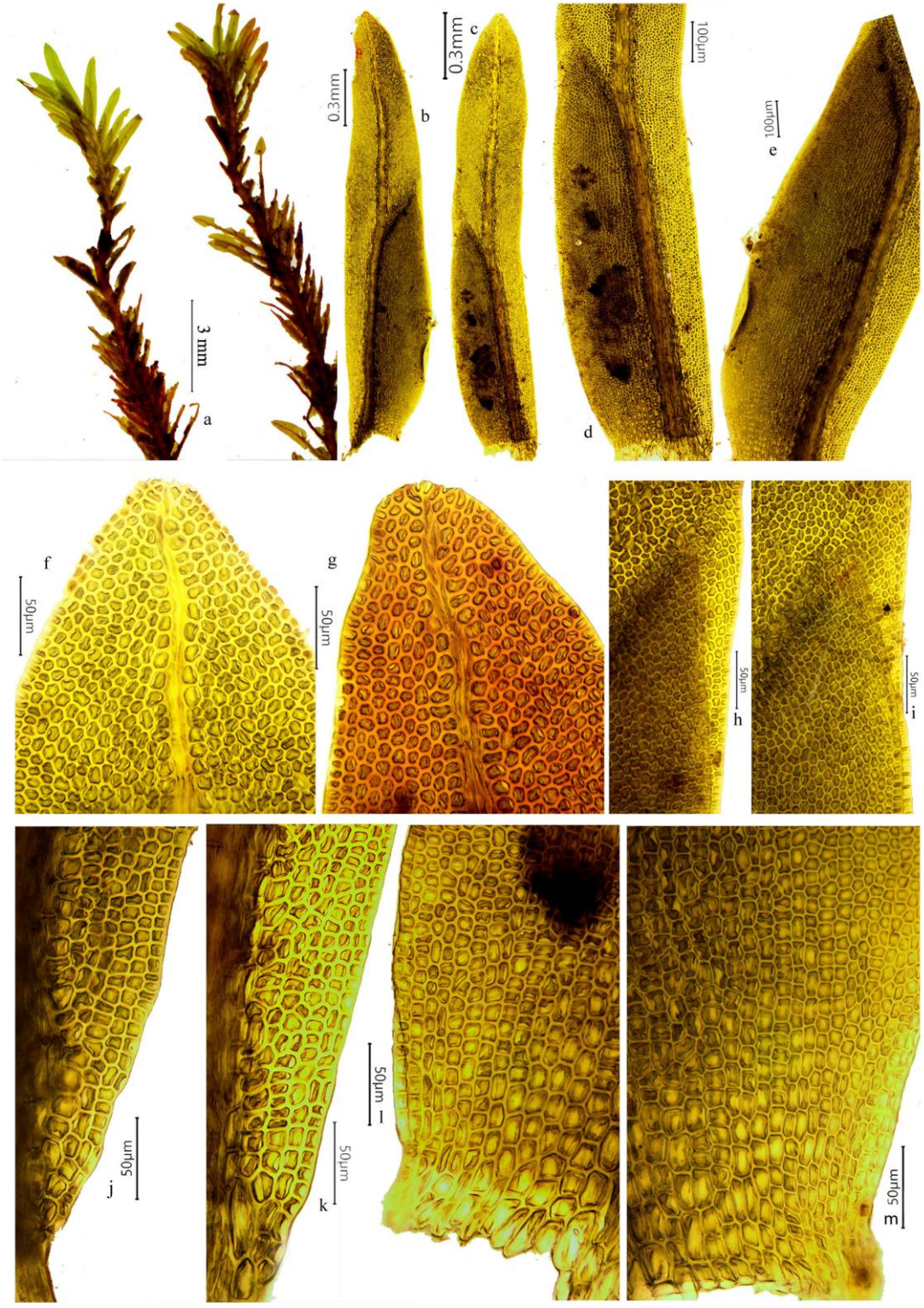


Plate 26. *Fissidens obscurus* Mitt., a. vegetative plants, b&c. vegetative leaves, d&e. vaginant laminae, f&g. leaf apex, h&i. vaginant laminae apex, j&k. dorsal lamina base near insertion, l&m. vaginant laminae base. (Photo from type, Griffith 9 CAL)

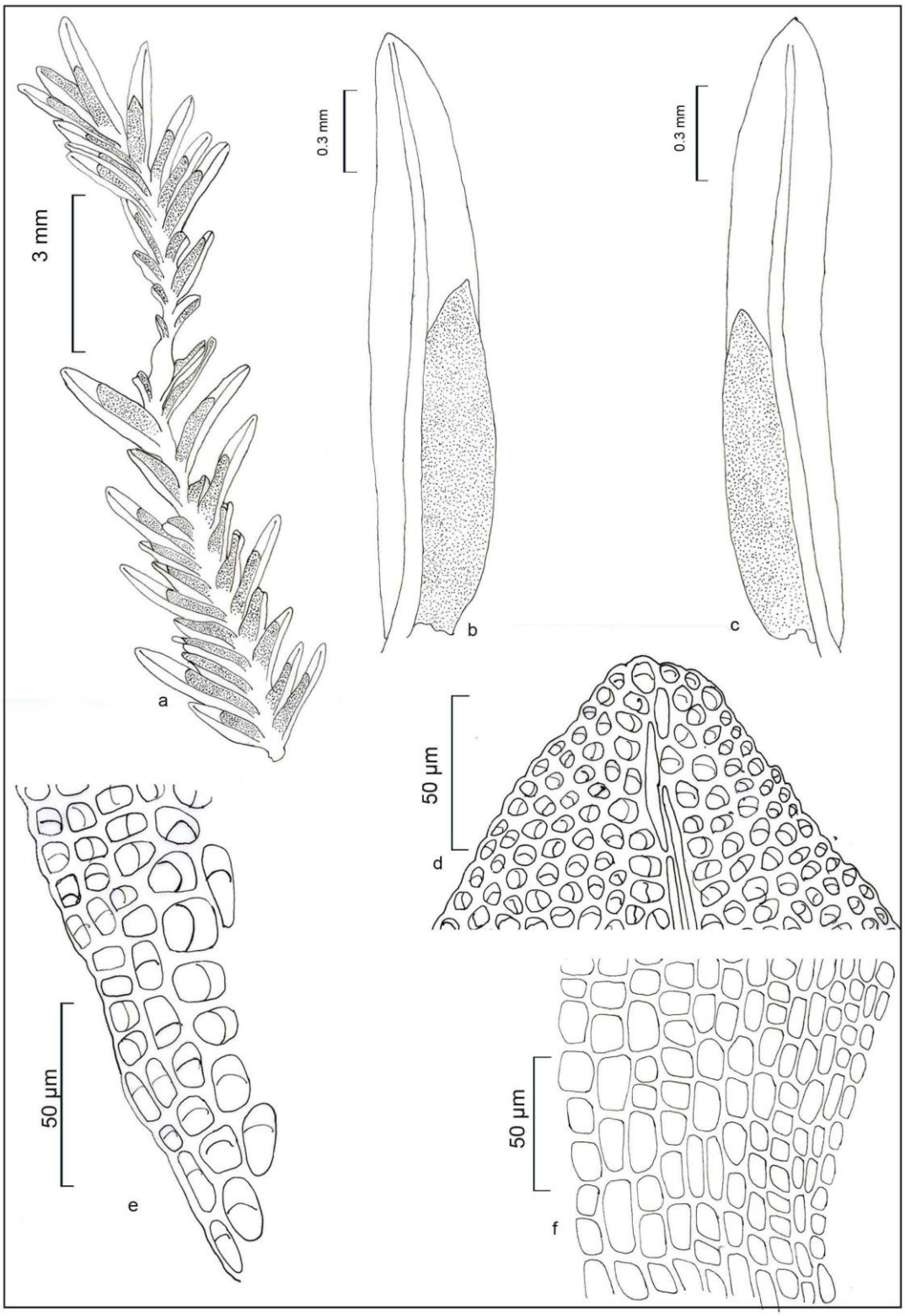
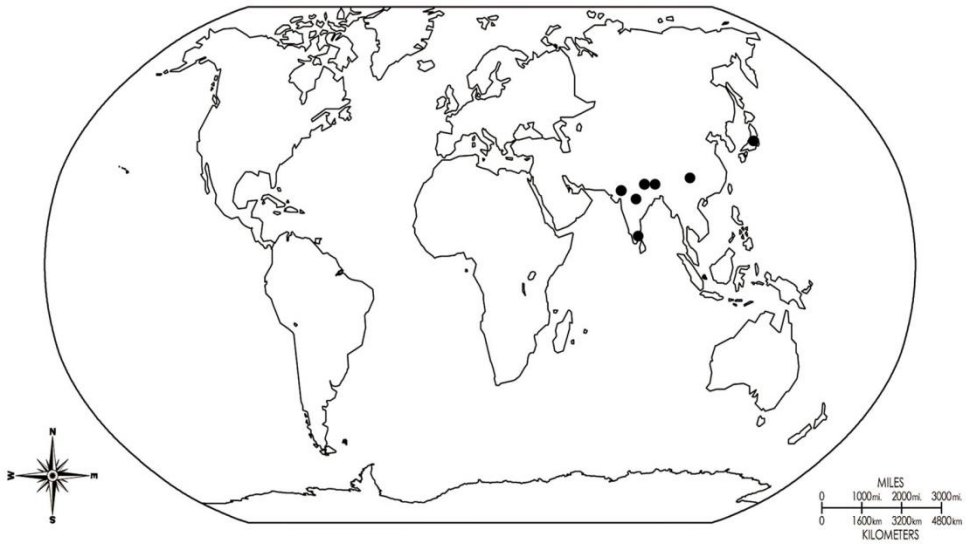
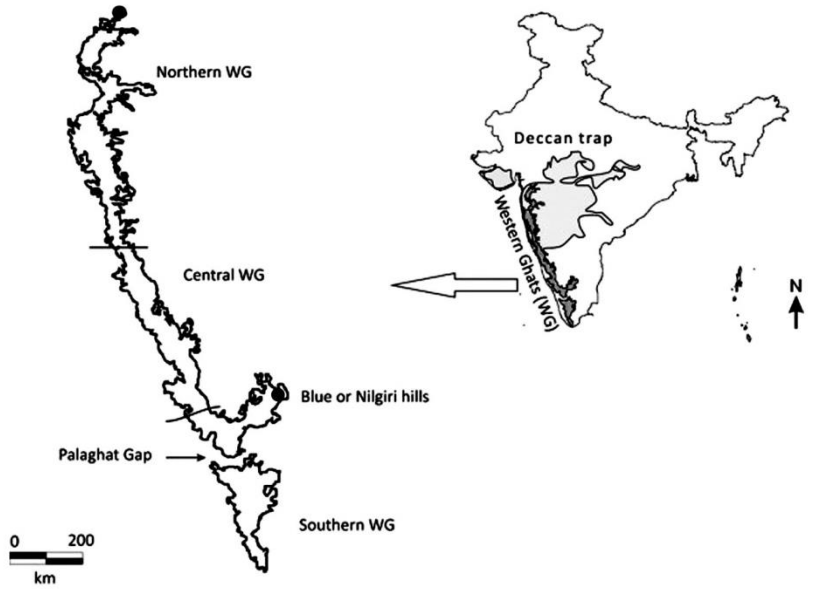


Fig. 8. *Fissidens obscurus* Mitt. a. vegetative plant, b&c. vegetative leaves, d. leaf apex, e. dorsal lamina base near insertion, f. vaginant laminae base.



Map. 9A. World distribution of ***Fissidens obscurus*** *Mitt.*



Map. 9B. Distribution of ***Fissidens obscurus*** *Mitt. in Western Ghats*

Habitat and General Ecology: On wet rocks and sandy soils in evergreen forest in medium altitudes.

Distribution: India (Central India, Gujarat, Himalaya, Tamil Nadu) (Gangulee, 1971; Lal, 2005); China, Japan, Nepal (Li & Iwatsuki, 2001) (Map 9A&9B).

Note: Gangulee (1971) listed this species from Nilgiri & Palni hills. But Daniels (2010) does not mention this species from Tamil Nadu. But as per Gangulee (1971) this species is found in Tamil Nadu. During my present survey I could not locate this species from the locality. The above description is based on type.

Specimens examined: India, Moflong, Khasi Hills, Griffith 9*s.n.* (CAL!); Nepal.

Etymology: The specific epithet is based on the obscure nature of the leaf.

Fissidens taxifolius Hedw., Sp. Musc. Frond. 1801; Blatt., J. Bombay Nat. Hist. Soc. 33: 872. 1929; Foreau, J. Madras Univ. 2: 243. 1930 & J. Bombay Nat. Hist. Soc. 61: 224. 1964 & J. Bombay Nat. Hist. Soc. 58: 16. 1961; Bruehl, Rec. Bot. Surv. India 13(1): 18. 1931; Bartram, Fieldiana: Botany 25: 22. 1949; Wadhwa, M.V.M. Patrika 4: 19. 1969; Gangulee, Moss. E. India & Adj. 1. 544. F. 259. 1971; Iwatsuki & Suzuki, J. Hattori Bot. Lab. 51: 413. 1982; Mohamed *et al.,* J. Bombay Nat. Hist. Soc. 83: 689. 1986; Lal, Checklist Indian Moss. 63. 2005; Pursell, Fissidentaceae Fl. Neo. Mono. 101; 29. 2007; Daniels & Daniel, Bryof. South. W. Ghats. 49. 2013.

Type. Europe, Hedwig s.n. (G)

Dicranum taxifolium (Hedw.) F.Weber & D. Mohr., Index Musc. Pl. Crypt. 2. 1803; *Skitophyllum taxifolium* (Hedw.) Bach. Pyl., J. Bot. Agric. 4: 166. 1814; *Schistophyllum taxifolium* (Hedw.) Brid. Bryol. Univ. 2: 693. 1827; *Fissidens sylvaticus* Griff., Calcutta J. Nat. Hist. 2: 507. 1842; *F. circinalis* Mitt., J. Proc. Linn. Soc. Bot. 1(Suppl.): 138. 1859; *F. pallidicaulis* Mitt., Nat. Hist. Azores 314. 1870; *F. angustus* Thwaites & Mitt., J. Linn. Soc. Bot. 13: 322. 1873; *F. terminiflorus* Thwaites & Mitt., J. Linn. Soc. Bot. 13: 322. 1873; *F. subobscurus* Paris, Index Byol.: 487. 1896; *F. lutescens* Broth., Rec. Bot. Surv. India 1(12): 315.

1899; *F. adelphinus* var. *submucronatus* Card., Bull. Herb. Boiss. Sér. 2, 7: 716. 1907; *F. angustiusculus* Dixon & P. de la Varde, Arch. Bot. Bull. Mens. 1: 163. 1927; *F. nipponensis* Sak., Bot. Mag. Tokyo 47: 743. 1933; *F. okinawaensis* Bartr., Bryologist 50: 160, f. c-e. 1947: *F. clebschii* Steere, Bryologist 53: 129. f. 1–8. 1950; *F. taxifolius* var. *acutifolius* Nog., J. Hattori Bot. Lab. 8: 70. 1952; *F. pallidulus* Hampe *ex* Gangulee, Bull. Bot. Soc. Beng. 11: 82. 1957.

Plants medium sized, bright green in fresh, growing in mats along with other bryophytes; axillary hyaline nodules absent; rhizoids smooth, brownish; stem gregarious, 4.0-7.0 x 2.0-2.5 mm, 8-13 pairs of leaves, light green, central strand differentiated; leaves lanceolate to lingulate, margin serrate throughout, apex mostly apiculate or mucronate; limbidium absent; vaginant laminae reaching 1/2 of apical lamina, slightly open, minor lamina apex ends in between margin and costa, margin serrate, uniseriate; dorsal lamina base round, not decurrent, slightly depressed near insertion in some leaves, apical lamina and dorsal lamina uniseriate; costa stout, ending in a short apiculus or costal cells ends at apex; laminal cells irregularly polygonal or slightly rounded, mammillose, mid vaginant laminal cells 11.6-13.78 x 10.76-14.49 µm, mid dorsal laminal cells convex, 13.59-16.85 x 6.72-8.12 µm, vaginant laminal cells at base near costa 13.66-23.65 x 4.03-9.07 µm; gemmae not found (Plate 27-29& Fig.9).

Fertile plants not found.

Diagnostic characters: *F. taxifolius* Hedw. is characterised by lanceolate to oblong lanceolate leaves, costa shortly excurrent in apiculus, highly mamillose laminal cells. This species is closely related to *F. crispulus* Brid. in the mamilllose laminal cells and elimbate leaf but differs in the undifferentiated axillary hyaline nodule, excurrent costa and more broad leaves.

Habitat and General Ecology: Growing on large rocks, land cuttings as scattered mass along with other *Fissidens* such as *F. serratus* and *F. curvatus, Asterella khasiana* and *Fossombronia sp.* in semi evergreen forest and shola forests at an altitude above 1500 m.

Note: Gangulee (1971) considered *F. taxifolius* as *F. sylvaticus* and considering its high variability proposed four varieties under *F. sylvaticus*. But *F. sylvaticus* is synonimised under *F. taxifolius* along with three varieties. One variety is kept under *F. crispulus*. Daniels & Daniel (2013) has validly published these varieties under *F. taxifolius*.

Distribution: India (Assam, Bihar, Karnataka (as *F. sylvaticus* var. *auriculatus*), Kerala, Madhya Pradesh, Maharashtra, Sikkim, Tamil Nadu (as *F. angustiusculus* Dixon & P. de la Varde), Uttar Pradesh, West Bengal (Bruhl, 1931; Daniels & Daniel, 2013; Dixon & Potier de la Varde, 1927; Foreau, 1930, 1961; Gangulee, 1971; Matthew *et al.*, 1999; Schwarz, 2014b); Alabama, Arizona, Arkansas, Brazil, California, Canada, Caribbean, Chile, China, Delaware, Florida, Georgia, Guatemala, Hawaian, Honduras, Kansas, Kentucky, Louisiana, Madagascar, Maine, Massachusetts, Mexico, Michigan, Mississippi, Missouri, Nebraska, Nepal, New Hampshire, New Jersey, New York, New Zealand, North Carolina, Ohio, Oklahoma, Oregon, Pennsylvania, Phillipines, Sree Lanka; South Carolina, Tennessee, Texas, Vermont, Virginia, Washington, West Virginia, Wisconsis (Haring, 1961; Möller & Pursell, 2003; Pursell, 1994, 2007; Pursell & Hoe, 1977; Redfearn & Wu, 1986; Tan & Iwatsuki, 1991; Li & Iwatsuki, 2001). The present collection is a new record to Kerala. (Map 10A&10B).

Specimens examined: India, Kerala; Palakkad (Nelliyampathy, $10^{0}53'55''$ N, $76^{0}68'37''$ E, 900m), 12.07.2014, Manjula, K.M. (ZGC 1139a); Tamil Nadu, Coonoor (Way to Dolphin's Nose, 1629 m), 23.12.2015, Manjula & Deepa (ZGC 16011B), Hara *et al.*, (200417, 200117 BM!), Palani hills, 28.12.1926, Foreau (511 BM!); Maharashtra, Mahabaleshwar, 868 m. 10. 11. 2016. Manjula (ZGC 16201), Nashik (Brahmagiri hills, 1020 m), 16. 09. 2017, Manjula (ZGC 7755); Nepal, (Sanghu Downs, $27^{0}21'$ N, $87^{0}33'$ E, 7000ft), 17.02.1962, A.H. Norkett (9912) (BM!).

Etymology: This specific epithet *taxifolius* is from the genus *Taxus* (Gymnosperm) + *folium* (Leaf), refers to the similarity of leaves in both the taxa.

Plate: 27. *Fissidens taxifolius* Hedw., habit & habitats; a&b. on wet large rocky patch where water drips regularly, c. on dry rocky patch where shade is available.

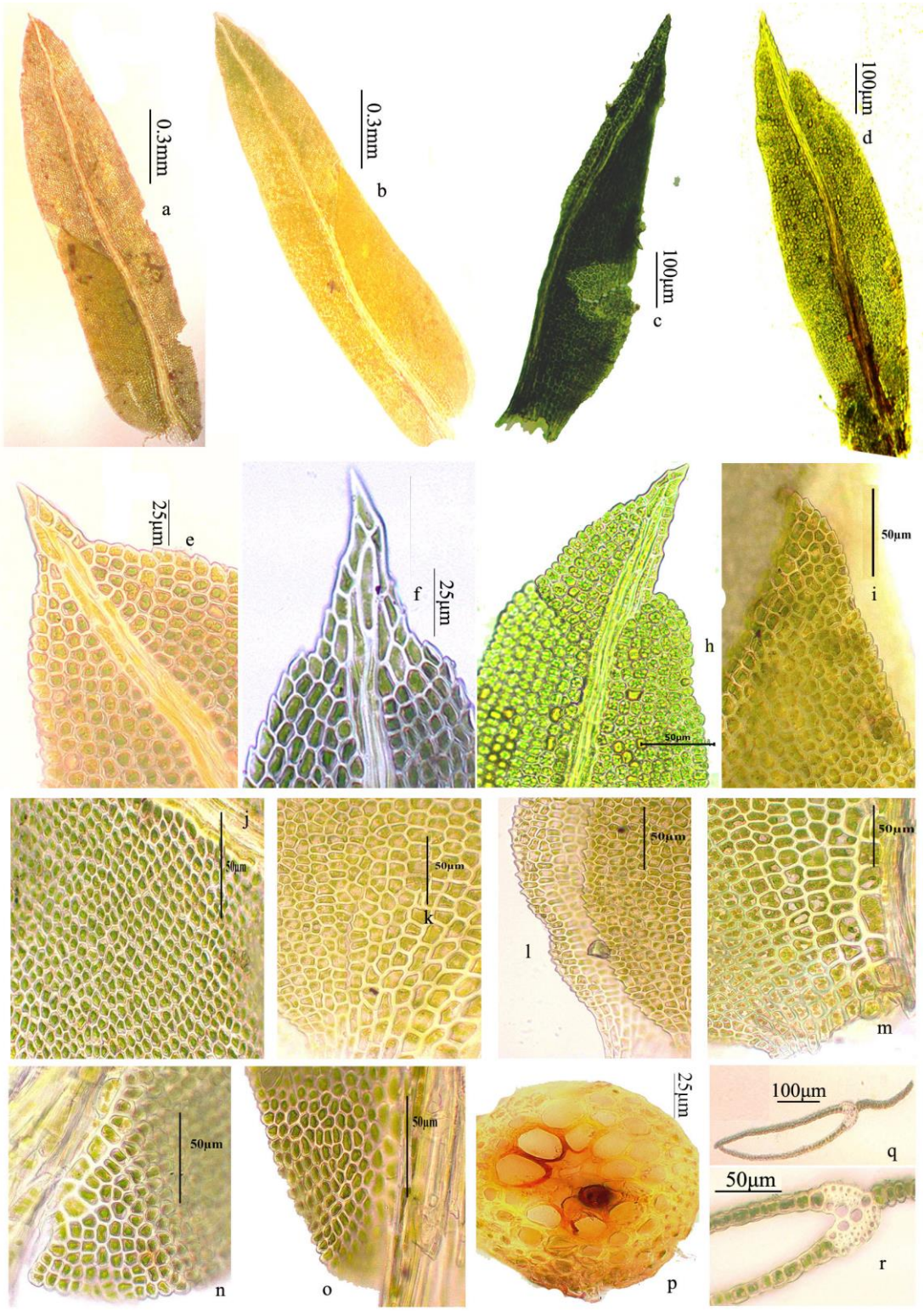


Plate 28. *Fissidens taxifolius* Hedw., a&b. vegetative leaves, c&d. perichaetial leaves, e-g. leaf apex, h. perichaetial leaf apex, i. vaginant laminae apex, j. laminal cells, k-m. vaginant laminae base, n&o. dorsal lamina base near insertion, p. stem T.S., q&r. leaf T.S.

Plate 29. *Fissidens taxifolius* Hedw., a&b. vegetative plants, c&d. vagetative leaves, e&f. leaf apex, g&h. vaginant laminae, i&k. dorsal lamina base near insertion, j. vaginant laminae base (photo from 200417BM!)

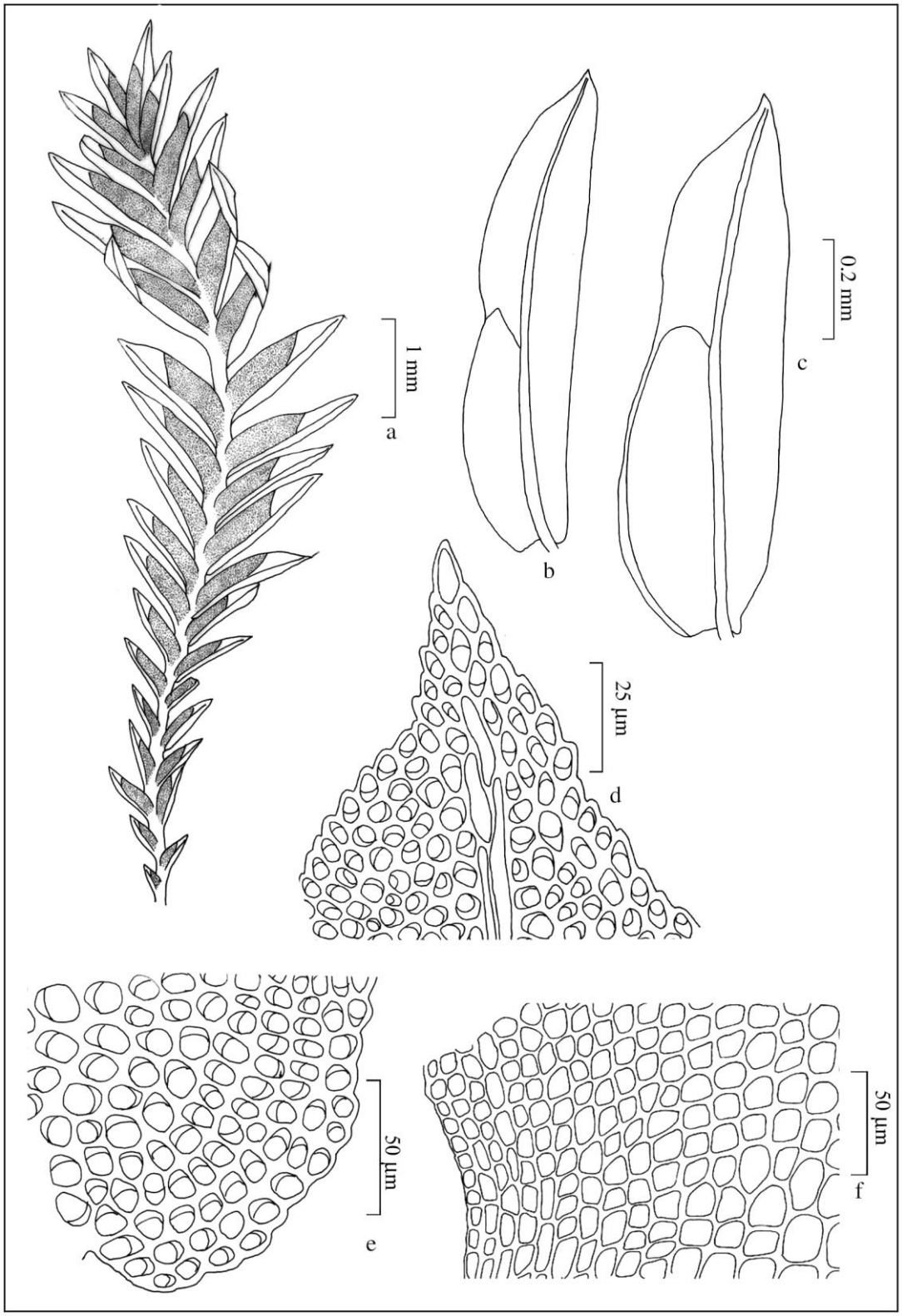
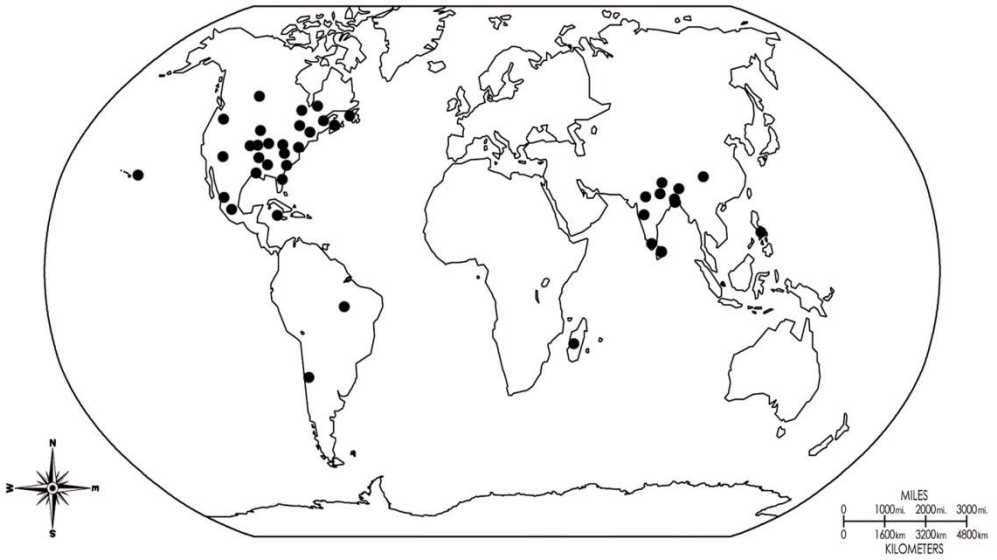
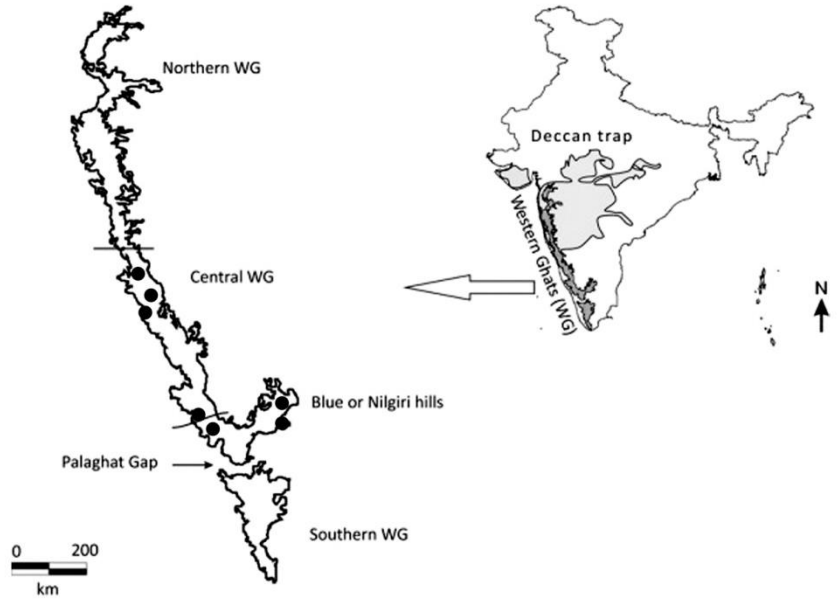


Fig. 9. *Fissidens taxifolius* Hedw., a. vegetative plant, b&c. vegetative leaves, d. leaf apex with costa, e. dorsal lamina base near insertion, f. vaginant laminae base.



Map. 10A. World distribution of ***Fissidens taxifolius*** *Hedw.*



Map. 10B. Distribution of ***Fissidens taxifolius*** *Hedw. in Western Ghats*

Key to the varieties

1a. Costa percurrent or ending below leaf apex; dorsal leaf base rounded ……..

……... *F. taxifolius* var. *calcuttense*

1b. Costa excurrent; dorsal leaf base not rounded ……..…….. 2

2a. Dorsal leaf base narrowing till point of insertion …...*F. taxifolius* var. *teraicola*

2b. Dorsal leaf base distinctly auriculate ……..…. *F. taxifolius* var. *auriculatus*

Fissidens taxifolius var**.** ***auriculatus*** (Muell. Hal.) A.E.D. Daniels & P. Daniels**,** Bryof. South. W. Ghats 50. 2013. **.**

Type: India, Bihar, Rajmahal, Kurz1800 (BM).

F. auriculatus Muell. Hal., Linnaea 37: 166. 1872. *F.sylvaticus* Griff. var. *auriculatus* (Muell. Hal.) Gangulee, Moss. E. India 1(2): 540, f. 257. 1971; A.E.D. Daniels in R. Annamalai, Tamil Nadu Biodivers.: 53. 2004.

Plants slender, long proliferating stem, semiaquatic habitat; rhizoids smooth, basal; plant up to 14 x 2 mm broad with leaves, stem light yellow, flexuose; up to 16 pairs of leaves, curled and crumbled in herbarium, oblong lingulate, 1.3 x 0.34 mm, leaf broader at base, apex apiculate; costa short excurrent; limbidium absent on all laminae; vaginant laminae closed, minor laminae equal, unistratose; dorsal lamina base rounded, forming an auricle, dorsal lamina and apical lamina unistratose; laminal cells inclined in different directions, obscure, mamillose, chlorophyllose, rounded-hexagonal, up to 8.5 µm diagonally at the apex and 11 µm at base.

Habitat & General Ecology: On soil in open degraded forest at low altitude area.

Distribution: India (Madhya Pradesh, Utter Pradesh, Western Ghats of Maharashtra & Tamil Nadu), Africa, Madagascar, South East Asia, Sri Lanka (Gangulee, 1971; Daniels & Daniel, 2013; Daniels *et al.*, 2018) (Map 11A&11B).

Note: Daniels and Daniel (2013) reported the distribution of this species also from Kerala but not added the correct locality or the reference for that distribution.

Daniels *et al.* (2018) reported the locality in Kerala as Kollam. I could not locate this variety during my present study and description is based on *Daniels 566* from SCCN.

Specimen examined: India, Tamil Nadu, Tirunelveli (Mundanthurai, ca. 240m), 30.07.1999, A.E.D. Daniels (566) (SCCN!).

Fissidens taxifolius var. ***calcuttense*** (Gangulee) A.E.D. Daniels & P. Daniels, Bryof. South. W. Ghats 51. 2013.

Plants long, upto 2.0 x 0.2 cm, 30 -32 pairs of leaves; leaves large, oblong-lingulate, up to 2.5 x 0.5 mm, costa not excurrent, vanishing one or two cells below apex, light yellow-brown; limbidium absent on all laminae; dorsal lamina base rounded to gradually narrowing down meeting nerve base at leaf attachment; leaf cells convex-mamillose on top, quadrate-hexagonal. large cells at the base of vaginant laminae.

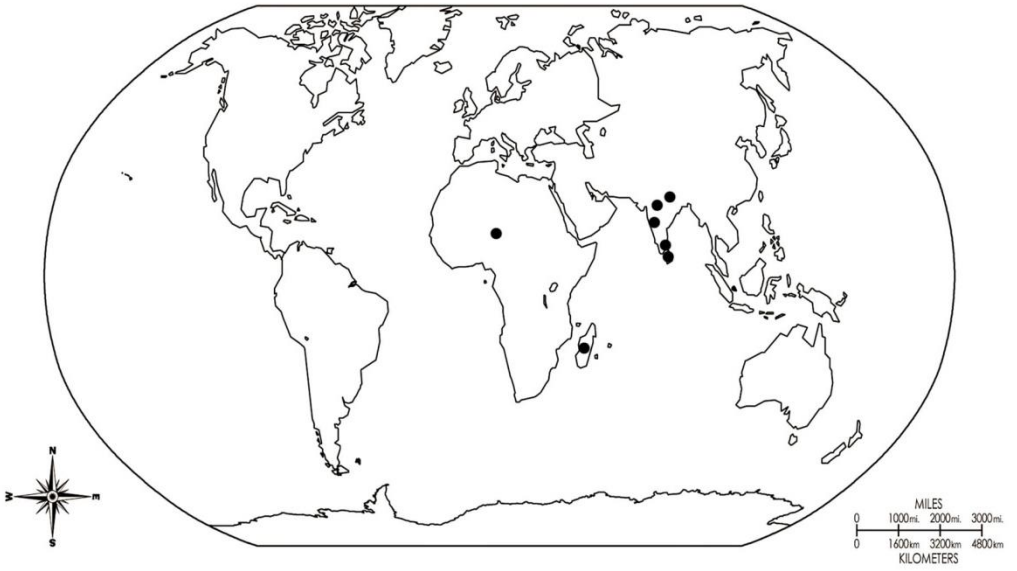
This variety is characterised by rounded dorsal lamina and costa not reaching up to apex or percurrent.

Habitat & General Ecology: On small stones in foothills at an altitude range of 200-300m.

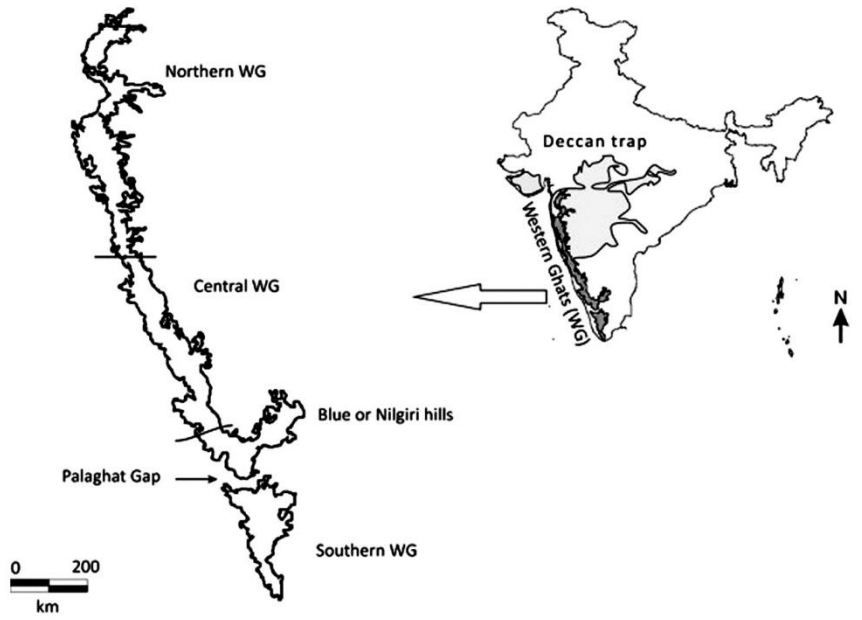
Distribution: India (Western Himalayas, Western Ghats of Maharashtra and Tamil Nadu) (Gangulee, 1971; Daniels & Daniel, 2013) (Map 12A&12B).

Note: I could not locate this variety during my present study and description is based on *Shilu 196* from SCCN.

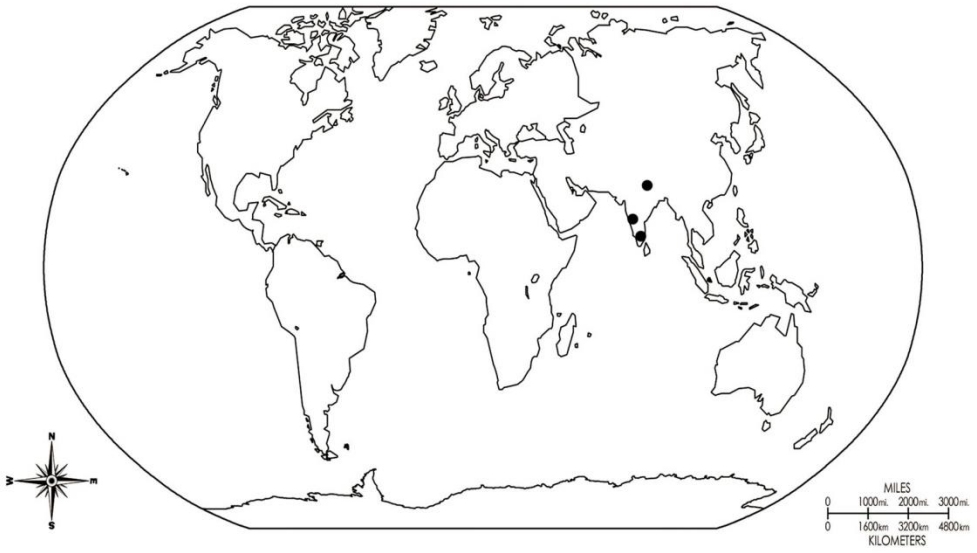
Specimen examined: India, Tamil Nadu, Kanyakumari (Arumanai, ca. 230m), 06.08.2002, G. Shilu (196) (SCCN!).



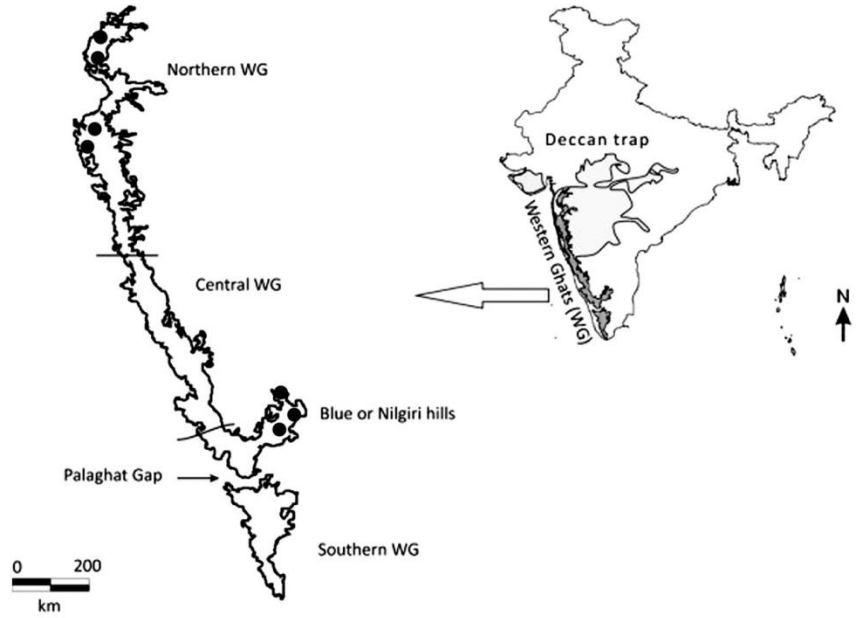
Map. 11A. World distribution of ***Fissidens taxifolius*** var. ***auriculatus*** (Müll. Hal.) *A.E.D. Daniels & P. Daniels*



Map. 11B. Distribution of ***Fissidens taxifolius*** var. ***auriculatus*** (Müll. Hal.) *A.E.D. Daniels & P. Daniels in Western Ghats*



Map. 12A. World distribution of ***Fissidens taxifolius*** **var.** ***culcuttense*** **(Gangulee)**
A.E.D. Daniels & P. Daniels



Map. 12B. Distribution of ***Fissidens taxifolius*** **var.** ***culcuttense*** **(Gangulee)**
A.E.D. Daniels & P. Daniels in Western Ghats

Fissidens taxifolius* var. *teraicola (Muell. Hal.) A.E.D. Daniels & P. Daniels, Bryof. South. W. Ghats 51. 2013.

Fissidens teraicola Muell. Hal. in Linnaea, 37: 164. 1872.

Small plant with broad leaves, 4-6 x 2 mm, proliferations are present from apex; leaves 12-15 pairs, leaves curled and crumbled in herbarium, elongated oblong-lingulate, more or less equal width upto apex and then narrows to short apiculate or mucronate apex, leaf margin more corrugate than variety *calcuttense, base smoothly crenate*; costa orange at base, excurrent, sometimes percurrent, limbidium absent on sll laminae; vaginant laminae unequql, minor lamina open, unistratose; dorsal lamina base gradually narrowing down, may vanish before insertion or reaches upto leaf inserton, base slightly decurrent or not, apical lamina and dorsal lamina unistratose, leaf cells rounded hexagonal, up to 8 µm, cells at base of vaginant laminae near costa elongated rectangular up to 16 µm long.

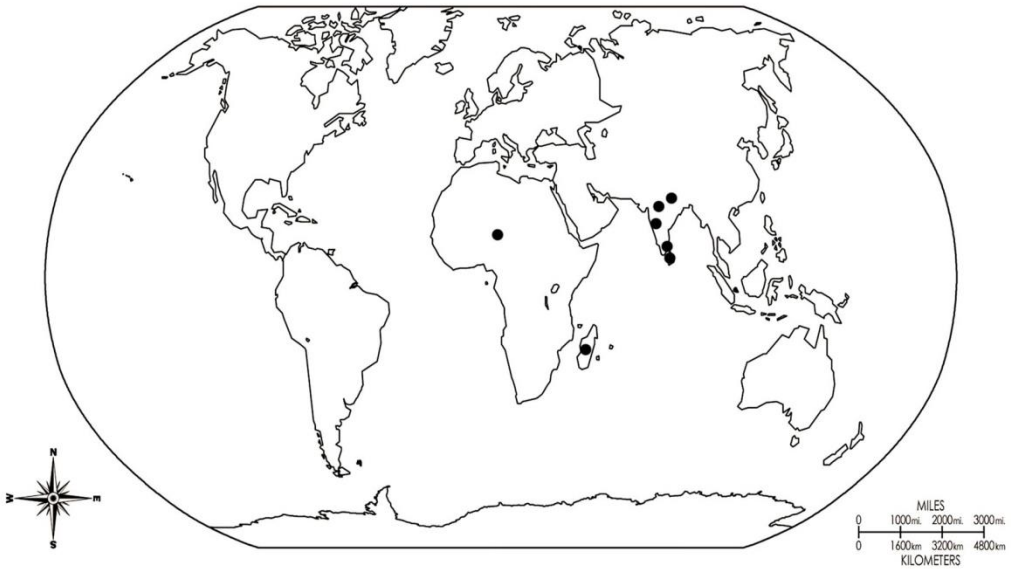
Habitat & General Ecology: On soil in open degraded forest. at an altitude range of 200-300m.

Distribution: India (Madhya Pradesh, Utter Pradesh, Western Ghats of Maharashtra & Tamil Nadu), Africa, Madagascar, South East Asia, Sri Lanka (Gangulee, 1971; Daniels & Daniel, 2013; Daniels *et al.*, 2018) (Map 13A&13B).

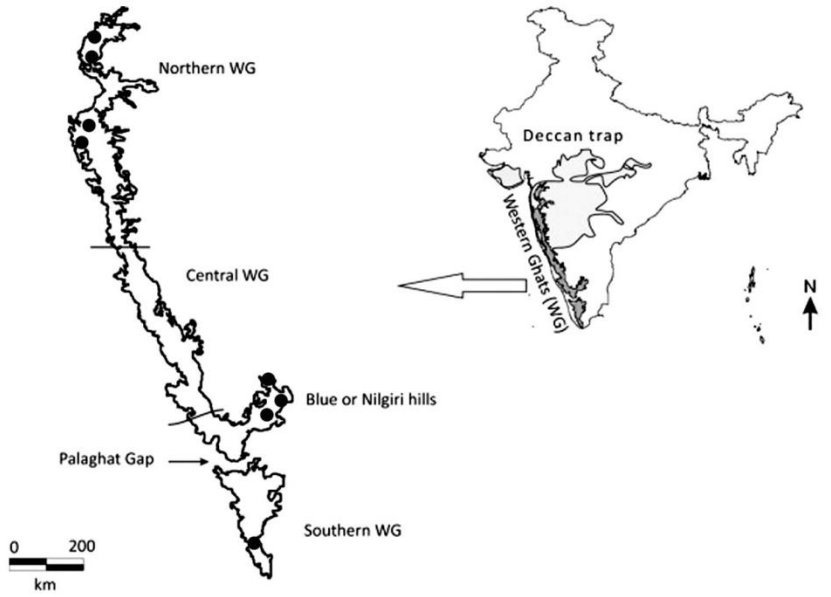
Note: I could not locate this variety during my present study and description is based on *Daniels 558* from SCCN.

Specimen examined: India, Tamil Nadu, Tirunelveli (Mundanthurai, ca. 240m), 30.07.1999, A.E.D. Daniels (558) (SCCN!); North Bengal, Sikkim, Terai, S. Kurz (1896 BM!).

Note: Daniels and Daniel (2013) reported the distribution of this species also from Kerala but not added the correct locality or the reference for that distribution. Daniels *et al.* (2018) reported the locality in Kerala as Kollam.



*Map. 13A. World distribution of Fissidens taxifolius var. teraicola (*Müll. Hal.) *A.E.D. Daniels & P. Daniels*



*Map. 13B. World distribution of Fissidens taxifolius var. teraicola (*Müll. Hal.) *A.E.D. Daniels & P. Daniels in Western Ghats*

c. Fissidens* Subgenus *Pachyfissidens (Muell.Hal.) Kindb. **section *Crispidium*** (Muell.Hal.) Pursell & Bruggemann-Nannenga, Bryologist 107(1): 9. 2004.

Plants small to medium, often robust, light to dark green, unbranched or branched; branches with basal rhizoids. Stem with basal and axillary reddish rhizoids; axillary hyaline nodules large, protruding; epidermis and outer 1–2 tiers of cortical cells small, thick-walled, often pigmented; inner cortical cells larger, thin-walled, hyaline; central strand differentiated or not. Leaves usually imbricate, pinnately arranged or often frondiform, linear-lanceolate to elliptic, elimbate on dorsal and ventral laminae, rarely weakly limbate on proximal parts of vaginant laminae of perichaetial leaves, infrequently with 1–3 rows of swollen marginal cells; costa ending 2–18 cells below apex or percurrent to long-excurrent, taxifolius-type; dorsal lamina usually reaching insertion, sometimes slightly undulate proximally; vaginant laminae acute, slightly unequal; laminal cells unistratose or regularly to irregularly bistratose, firm-walled, walls lenticularly thickened, mammillose, indistinctly or distinctly pluripapillose. All species dioicous; perigonia unknown in most species, terminal on long branches when present; perichaetia terminal on main stems or long axillary branches. Sporophytes 1(–2) per perichaetium, reddish; seta elongate; theca exserted, inclined, arcuate, bilaterally symmetric, stomatose, exothecial cells oblong, vertical walls thicker than horizontal walls; peristome zippelianus-type; operculum conic, mostly long-rostrate. Spores finely papillose to smooth. Calyptra smooth, cucullate.

This is a small section consisting of 5 to 6 species in Asia, Africa, Malesia, Australasia, and Oceania and characterised by a zippelianus-type peristome. The highly developed axillary hyaline nodules is the conspicuous feature of this section. However, as a note of caution, large axillary hyaline nodules are also present in several species of section *Pachyfissidens*. 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 *Pachyfissidens* 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. Leaves of *F. javanicus* Dozy & Molk. have dark marginal bands formed by 1–more rows of thicker walled cells that vary from 1–3 cells in thickness. Pluripapillose laminal cells are found in *F. subangustus* M. Fleisch. Laminal cells of *F. crispulus* and *F. javanicus* have mamillose cells.

Section *Crispidium* of subgenus *Pachyfissidens* contains six species with three varieties in Western Ghats

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 lamina apex …….....… *F. excedens*

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

Key to the varieties of *Fissidens crispulus* Brid**.**

1a. Costa percurrent or ending a few cells below apex, laminal cells obscure ……. ……..… *F. crispulus* var. *crispulus*

1b. Costa shortly excurrent, laminal cell wall clear ……..….2

2a. Leaves 8 pairs or less in number; dorsal lamina base wedge shaped ……..…..
……..… *F. crispulus* var. *robinsonii*

2b. Leaves more than 9 pairs of leaves; dorsal lamina base not wedge shaped ……...
……..…...…. *F. crispulus* var. *nov.*

Fissidens crispulus Brid., Musc. Rec. suppl. 4: 187. 1819. var ***crispulus***; Dixon, J. Indian Bot. 2: 180. 1921 (as *F. zippelianus*) ; Blatt., J. Bombay Nat. Hist. Soc. 33: 872. 1929; Foreau, J. Madras Univ. 2: 243. 1930 & J. Bombay Nat. Hist. Soc. 61: 224. 1964; Bruehl, Rec. Bot. Surv. India 13(1): 18. 1931; Iwatsuki & Suzuki, Journ. Hattori Bot. Lab. 51: 398. 1982; Iwatsuki & Mohamed, Journ. Hattori Bot. Lab. 62: 353. 1987; Chaudhary & Deora. Moss Fl. Rajasthan 38. 1993; Bruggeman-Nannenga, J. Hattori Bot. Lab. 81: 155. 1997; Li & Iwatsuki, Moss Fl. China 2: 25. 2001; Lal, Checklist Ind. Moss.: 63. 2005; Nair *et al.*, Bryo. Wayanad W. Ghats.: 105. 2005; Daniels & Kariyappa, Curr. Sci. 93(7): 980. 2007 (as *F. auriculatus* &*F. crispulus*); Manju, *et. al.*, Tropical Bryol. Res. Rep. 7. 2008b; Daniels, Archive Bryol. 65: 54. 2010; Daniels & Daniel, Bryo. South. W. Ghat. 52: 2013; Schwarz, Frahmia 158: 24. 2014b; Diop *et al.*, J. Bryology. 2. 2018.

Type: Réunion [Insula Borbonia], 1803, Bory St. Vincent s.n.

Fissidens zippelianus Dozy & Molk., Zoll. Syst. Verz. 29. 1854; *F. incrassatus* Sull. & Lesq., Proc. Amer. Acad. Arts Sci. 4: 276. 1859; *F. auriculatus* Muell. Hal. Linnaea 37: 166. 1872; *F. sakourae* Paris & Broth., Bull. Herb. Boissier, ser. 2, 2: 921. 1902; *F. salcifolius* Sak., Bot. Mag. Tokyo 47: 741. 1933; *F. osadae* Sak., Bryologist 39: 5, pl. II. 1936; *F. pepuensis* P.C. Chen, Sunyatsenia 6(2): 189, 31. 1941; *F. sylvaticus* var. *zippelianus* (Dozy & Molk.) Gangulee, Moss. E. India & Adj. 2: 537. 1971.

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 x 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 x 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 x 10.10-11.20 µm; gemmae not found.

Fertile parts, plant 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 (Plate 30-34 & Fig.10&11).

Diagnostic characters: *F. crispulus* Brid. is well characterised by its large, hyaline axillary nodules, lanceolate to narrowly lanceolate, elimbate leaves with acute to mucronate leaf apex, mammillose 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. *F. crispulus* Brid. also shows similarity with *F. subangustus* Fleisch. in having prominent axillary hyaline nodules and slightly differentiated marginal cells of sheathing laminae in perichaetial leaves. It differs from *F. subangustus* Fleisch. in the distinct mamilla in cells and widely acute to mucronate leaf apex of *F. crispulus* Brid.

Note: *F. crispulus* Brid. is a variable species and several authors misidentified *F. crispulus* under different names in different times. Dixon (1922) considered one of the species of *Fissidensviz*., *F. zippelianus* Dozy & Molk. as a synonym of *F. sylvaticus* Griff. Gangulee (1971) mentioned *F. sylvaticus* as a separate species with several varieties including *F. sylvaticus* var. *zippelianus*. He considered *zippelianus* as a variety of *F. sylvaticus*. However, after the careful examination of the types of both the species, Iwatsuki and Suzuki (1982) reported that *F. sylvaticus* is identical to *F. taxifolius* Hedw. and *F. zippelianus* Dozy & Molk. is a separate species. But Bruggeman-Nannenga (1997) synonimised *F. zippelianus* under *F. crispulus*. Only the variety *F. sylvaticus* var. *zippelianus* is synonimised under *F. crispulus* and all other varieties are synonimised under *F. taxifolius* Hedw. In the present study also I have considered *F. zippelianus* as a synonym of *F. crispulus*.

Plate 30. *Fissidens crispulus* var. *crispulus* Brid., habit & habitats, a-c. on wet land cuttings, d. on rocky patch, e. on exposed root of higher plant.

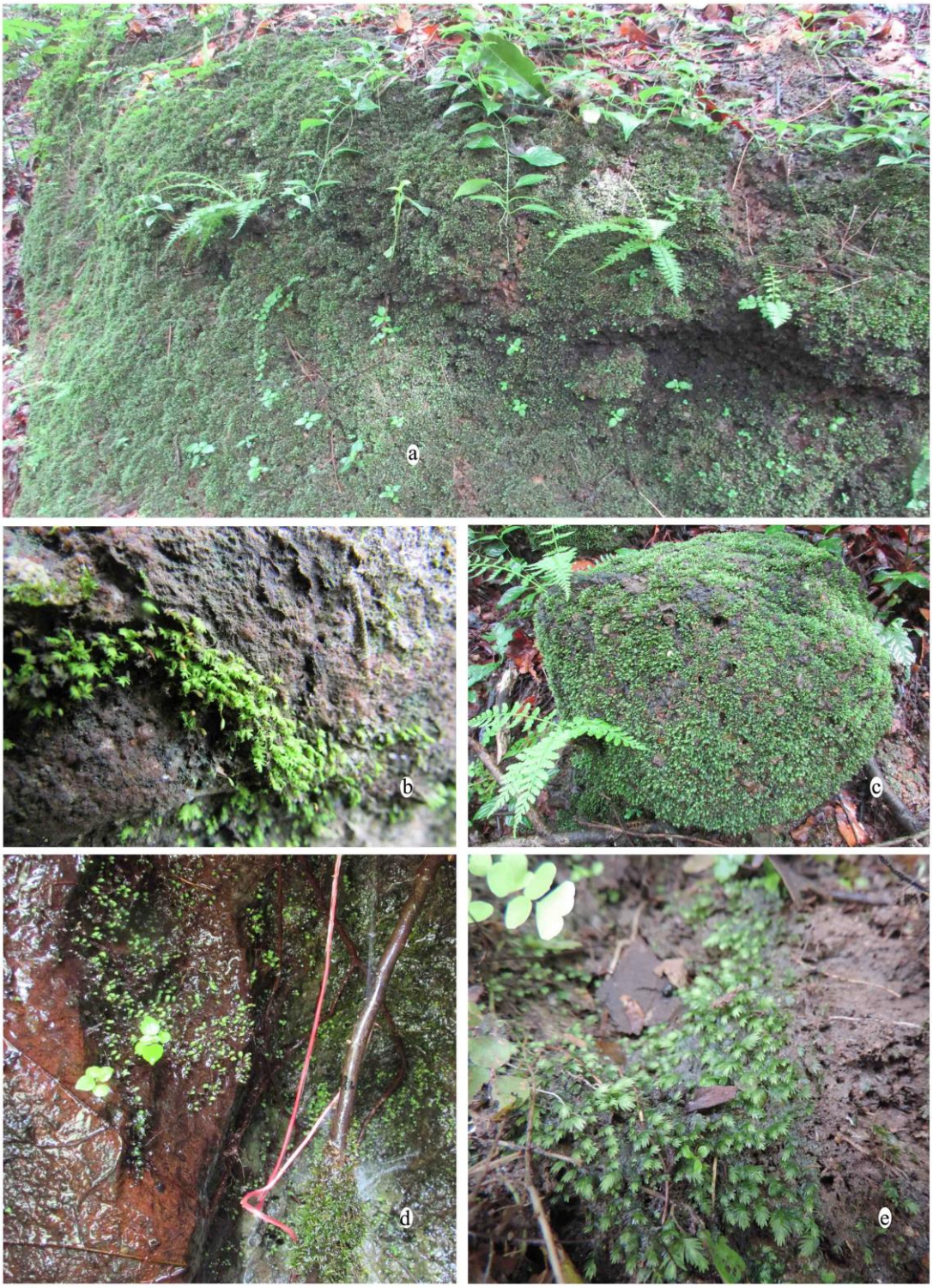


Plate. 31. *Fissidens crispulus* var. *crispulus* Brid., habit & habitats; . a-c. on rocky patch, d&e. on wet rock where water drips regularly

Plate. 32. *Fissidens crispulus* var. *crispulus* Brid., habit & habitats; a-e. land cuttings, f. on butresses.

Plate 33. *Fissidens crispulus* var. *crispulus* Brid., habit & habitats; a. on termite mount, b-d. on land cuttings, e. on muddy land.

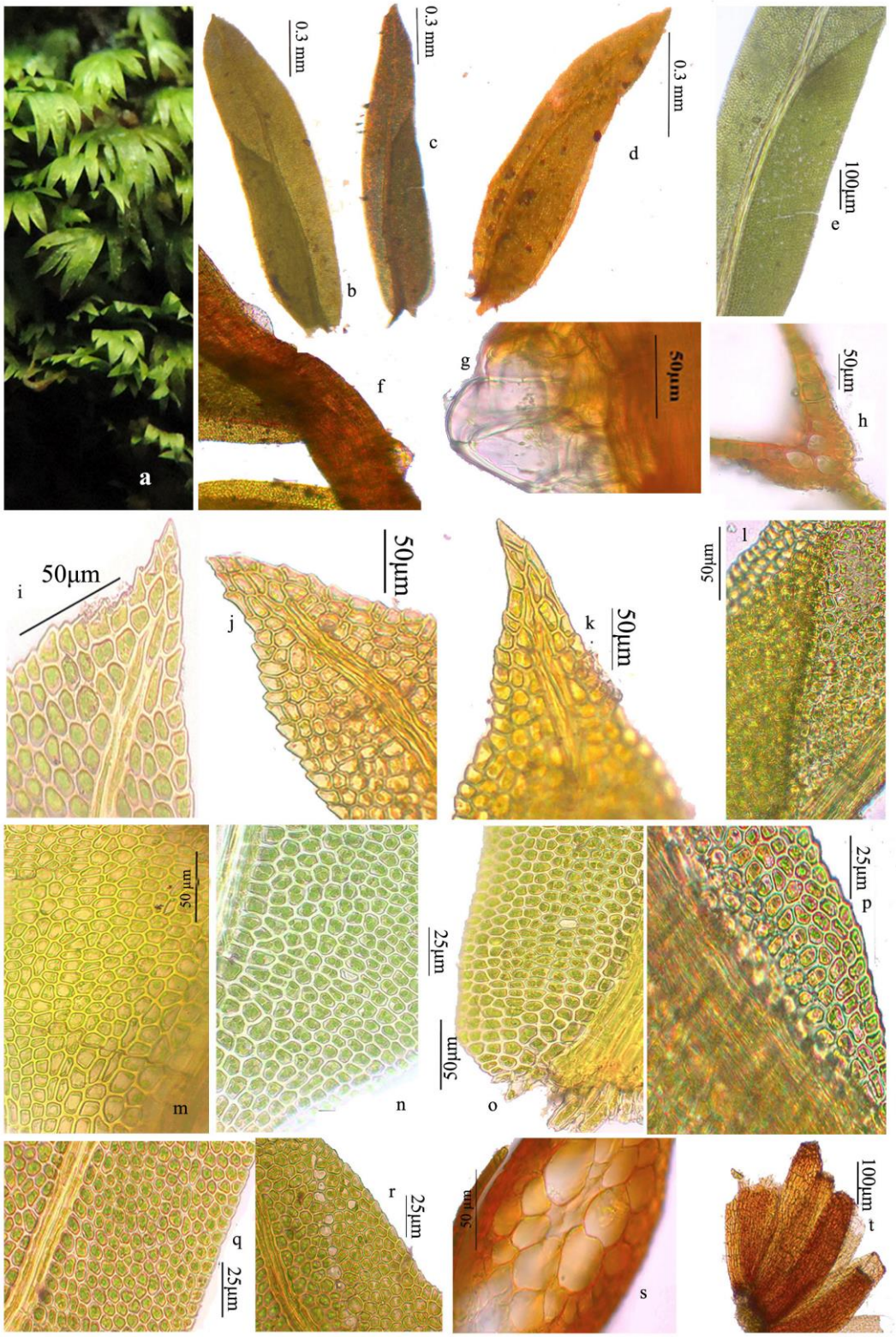


Plate 34. *Fissidens crispulus* Brid. var. *crispulus*, a. habit, b-d. vegetative leaves, e. vaginant laminae, f&g. stem hyaline nodules, h. leaf T.S., i-k. leaf apex, l. vaginant laminae apex, m&n. vaginant laminae base, o&p. dorsal lamina base near insertion, q&r. laminal cells with leaf margin and costa, s. stem T.S., t. archegonia (a, c-f, i-l, o, q-t from ZGC 1138 (A); b from ZGC 854; j, k, p, q, s from ZGC 612(B).

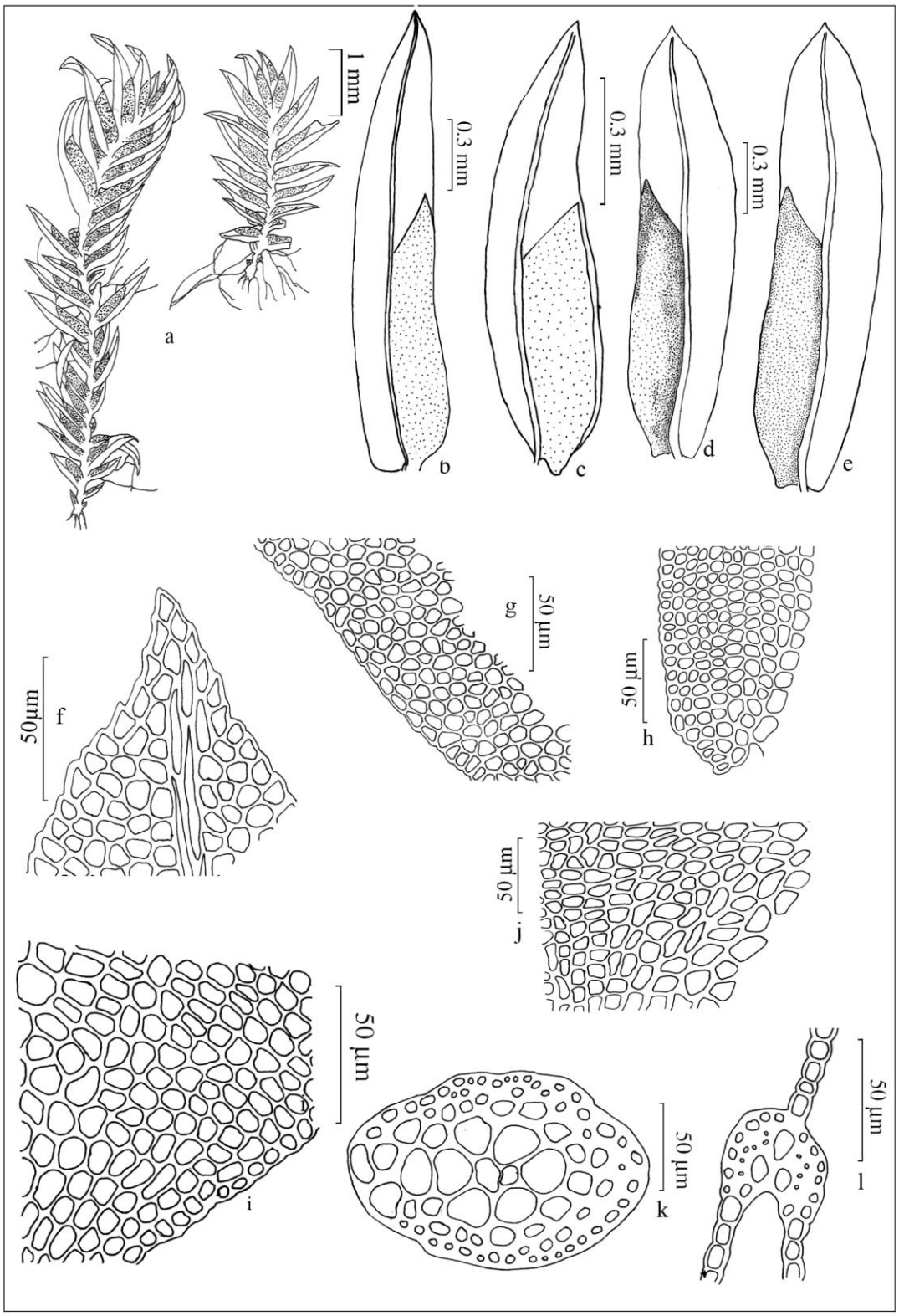


Fig. 10. *Fissidens crispulus* Brid. var. *crispulus,* a. vegetative plants, b-e. vegetative leaves, f. leaf apex, g. laminal cells, h. dorsal lamina base, i&j. vaginant laminae base, k. stem T.S., l. leaf T.S.

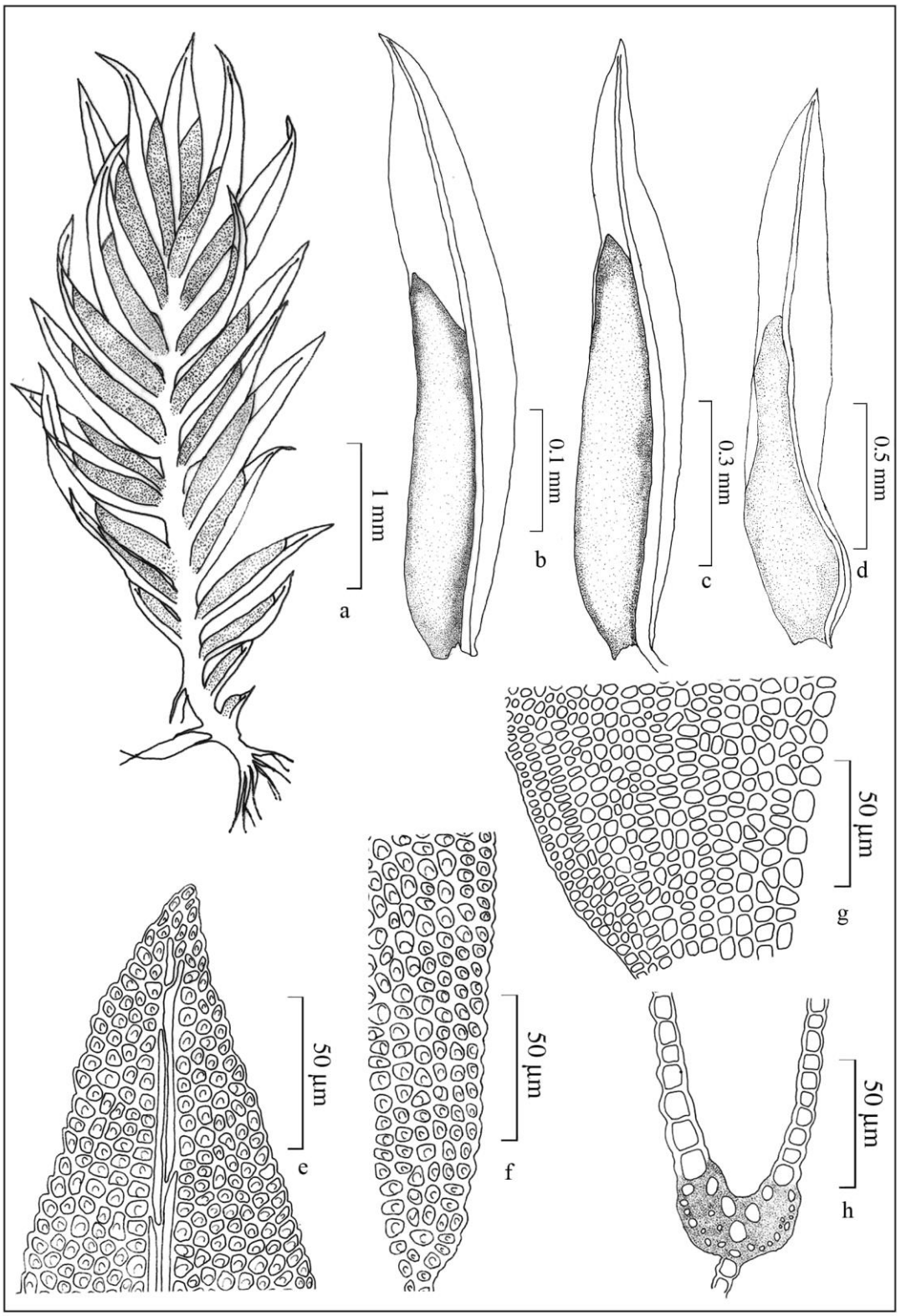


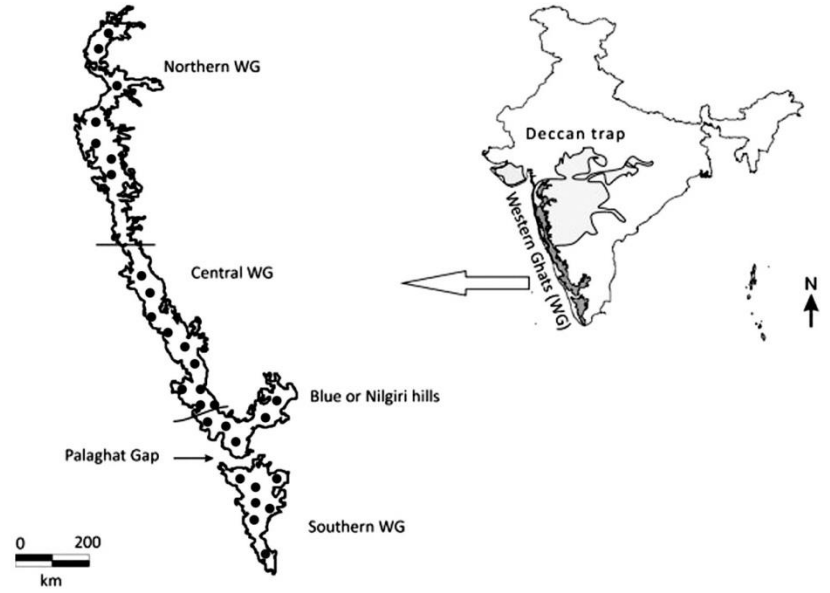
Fig. 11. *Fissidens crispulus* Brid. var. *crispulus,* a. vegetative plant, b-c. vegetative leaves, d. perigonial leaf, e. leaf apex with costa, f. dorsal lamina base, g. vaginant laminae base, h. leaf T.S.

Habitat and General Ecology: This species is the most common member of Fissidentaceae in Western Ghats in all altitudinal ranges and 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 other lower plant groups such as ferns. This species is seen along with most of other members of *Fissidens* such as, *F. pellucidus* Hornsch., *F. bryoides* Hedw., *F. walkeri* Broth., *F. subpalmatus* Muell. Hal., etc. It is not reported from upper parts of bark and twigs. This species generally forms a bed or grows as a mat near stream side and river beds where it is found and forms a substratum for higher plants to grow and the spores of ferns germinate in this bed.

Distribution: India (Andaman & Nicobar Islands, Andra Pradesh, Assam, Darjeeling, Khasia Hills, Bihar, Chhotanagpur, West Bengal, Orissa, Western Ghats of Kerala, Karnataka, Goa and Tamil Nadu (Daniels, 2010; Daniels & Daniel 2013; Schwarz, 2014b; Foreau,1930,1961; Gangulee, 1971; Lal, 2005; Manjula & 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, Seychelles, Sierra Leone, Sudan, Tanzania, Togo, Zambia, Zimbabwe (Iwatsuki & Suzuki, 1982; Li & Iwatsuki, 2001; O' Shea, 2006). The present collection is a new record to Goa. (Map 14A&14B).

Specimens examined: India, Kerala; Pathanamthitta district, Ranni, Way to Erimeli from Plapally (29.01.2017), Manjula (ZGC 360, ZGC 16365); Idukki district (Munnar), 05.02.2014, K.P.Rajesh (ZGC 995), Manjula (ZGC 993), Manju & Manjula (ZGC 992, ZGC

Map. 14A. World distribution of *Fissidens crispulus* Brid. var *crispulus* Brid.



Map. 14B. Distribution of *Fissidens crispulus* Brid. var *crispulus* Brid. *in Western Ghats*

999a); Ernakulam district, Neriamangalam, Near Idukki kavala (125m), 24.07.2015, Manjula (ZGC 15079), Kothamangalam, Thalakkod, Pattayam kudi, Padavu (83m), 25.07.2015, Manjula (ZGC 15101); Thrissur district (Way to Valparai from Vazhachal, 70m), 02.03.2015, Manjula (ZGC 4141); Palakkad district (Nelliyampathy, $10^0 53' 55''$ N, $76^0 68' 37''$ E, 1200m), 13.07.14, Manjula, K.M. (ZGC 1138 A), Silent Valley NP (Near Sairandri,), Manjula (ZGC 1001, ZGC 1002), Kerala, Palakkad district, Silent valley NP, Near welcome board (740m), 26.08.2015, Manjula & Deepa (ZGC 15550, ZGC 15528), Near Arikan para boundary (), 26.08.2015, Manjula & Deepa (ZGC 15557a); Malappuram district (Canoli plot, Nilambur, $11^0 26' 62''$ N, $76^0 20' 59''$ E, 40m), 24.07.2014, Manjula (ZGC 671), (Manoor), 21.09.2013, Manjula & Chandini (ZGC 811, ZGC 812), Calicut University campus (Botanical garden), 18.07.2014, Manju (1165a (CALI!), Nilambur (Nadukani Churam), 24.07.2013, Hareesh (ZGC 664); Kozhikode district (Marippuzha, $11^0 44'98''$ N, $76^0 09' 80''$ E, 637m), 18.07.2013, Manjula, K.M. (ZGC 612 B, ZGC 613, ZGC 614, ZGC 616), Olichuchattam, 1090m, 08.08.2015, Aswathi & Pournami (ZGC 15315), (Thusharagiri, $11^0 28'33.168''$ N, $76^0 0'47.592''$ E, 470m), 22.07.2013, Rajilesh (ZGC 636a, ZGC 627a, ZGC 629, ZGC 630a,ZGC 631, ZGC 632,) Vellarimala, $11^0 49' 64''$ N, $76^0 14' 21''$ E, 998m), 18.07.2013, Manjula (ZGC 615, ZGC 618 A, ZGC 623, ZGC 622, ZGC 621), Manakkadavu, $11^0 13'10''$ N, $75^0 52'22''$ E, 17m) 26.02.2015, Manjula (ZGC 4261), Mavoor (Pannikode,$11^0 16'17''$ N, $76^0 00'26''$ E, 38m), 18.07.2013, Manjula (ZGC 687, ZGC 690, ZGC 693, ZGC 694), (Mukkam) 18.07.2013, Rajilesh & Manjula (ZGC 686), Kakkavayal (100 m), Reshma, Manju & Rajesh 1165e (ZGC), Malabar WLS, Dam site (760m), 13.11.2014, Manjula (ZGC 3778), Thattittapara (713m), 14.11.2014, Manjula (ZGC 3800), Urakkuzhi (690m), 14.11.2014, Manjula (ZGC 3790), Sankarapuzha (), 13.11.2014, Manjula (ZGC 3789), Vadakara, Madappalli college (8m), 01.08.2017, Chandini & Deepa (ZGC 16385), Ramanattukara, Devaki Amma Memorial college (), 12.09.2017, Manju CN (ZGC 16387b); Wayanad district (Vellamunda, $11^0 73' 22''$ N, $75^0 93' 93''$ E, 1140m), 20.05.14, Manju, C.N. (ZGC 1031 B), (Kuruva dweep, $11^0 82' 184''$ N, $76^0 08' 792''$ E, 900m), 25.09.2013, Manjula, K.M. (ZGC 858), (Periya, $11^0 83' 56''$ N, $75^0 85' 63''$ E, 744m); Kannur district, Aralam WLS

(Valayamchal, $11^0$55’24.1” N, $75^0$47’54” E, 63m), 09.01.2015, Manjula (ZGC 4017), (Near Pookund, $11^0$55’81.5” N, $75^0$48’12.5” E, 70m), 10.01.2015, Manjula (ZGC 4025), Thullal (60m), 23.09.2016, Vijisha (ZGC 16163, ZGC 16164, ZGC 16166), 24.09.2016, Chandini (ZGC 10440), Chullikandam (98m), 24.09.2016, Vijisha (ZGC 16167), Moonukulam (844m), 22.01.2017, Vijisha (ZGC 16351); Paithal mala (), 17.01.2017, Shinoj (ZGC 16357); Karnataka, Uduppi district (Hebri, $13^0$45’876” N, $74^0$99’247” E, 76m), 26.09.13, Rajilesh, V.K. (ZGC 855 A, ZGC 856), Agumbe Ghat ($13^0$49’947” N, $75^0$08’736” E, 643m), 26.09.13, Rajilesh, V.K. (ZGC 852, ZGC 853, ZGC 854a, ZGC 855), North Canara district (Jog Falls, 464 m), 26.09.2013, Rajilesh, V.K. (ZGC 850), Sirsi (1750ft), 19.09.2014, Manjula & Deepa (ZGC 3632), Kodachadri (1343m), 18.09.2014, Manjula & Deepa (ZGC 3628), Hulikkal Ghat (832 m), 26.09.2014, Manjula & Deepa (ZGC 3585, ZGC 3578, ZGC 3679), Chikamangalur, Mullayanagiri shola (1930m), 23.01.2017, Shinoj A.K. (ZGC 16358), Kudremukh NP (1894m), 21.09.2014, Manjula & Deepa (ZGC 3683, ZGC 3685, ZGC 3686), Badra WLS, near water falls, 20.09.2014, Manjula & Deepa (ZGC 3653a, ZGC 3655), Kemmananundi, Santhi falls (4460ft), 19.09.2014, Manjula & Deepa (ZGC 3648a, ZGC 3649, ZGC 3659), Kumaraparvatha (1090 m), 02.05.2015, Mufeed (ZGC 4270), Sahasralinga (1480ft), 19.09.2014, Manjula & Deepa (ZGC 3629a), Maavinagundi falls (865 m), 18.09.2014, Manjula (ZGC 3619), Kilagar (1034 m), 18.09.2014, Manjula & Deepa (ZGC 3574); Goa, Cancona, (Cotigao Wildlife Sanctuary, 88 m), 15.08.2015 Manjula & Deepa (ZGC 15124), Madgaon, Near Flower valley Residence (10 m), 16.08.2015, Manjula & Deepa (ZGC 15165); Maharashtra, Mahabaleshwar, 868 m. 10. 11. 2016. Manjula (ZGC 16202), Nashik (Brahmagiri hills, 1020 m), 16. 09. 2017, Manjula (ZGC 7756), Trambakeshwar, Dhara (854m), 16.09.2017, Manjula (ZGC 7745); Tamil Nadu, Coonoor, Way to Dolphin’s nose (), 23.12.2015, Manjula & Deepa (ZGC 16013a); East Nepal, Sangu, Tamrang Khola Path (5900ft), 19.10.1961, Anonymous (6310B BM!)

Etymology: The specific epithet *crispulus* denotes the curling of dry leaves (finely curled or wrinkled).

Fissidens crispulus var. ***robinsonii*** (Broth.) B.C.Tan & Choy, J. Bryol. 24: 47. 2002; Iwatsuki & Mohamed, J.. Hattori Bot. Lab. 62: 354. 1987; Gangulee, Moss. E. India & Adj. 1(2): 534. 1971; Pursell, Moss Fl. China 2; 26. 2001; Daniels & Daniel, Bull. Bot. Surv. India 47: 95. 2005; Lal, Checklist Indian Moss.: 63. 2005; Nair *et al.*, Bryo. Wayanad W. Ghats.: 107. 2005; Manju, *et. al.*, Tropical Bryol. Res. Rep. 7. 12. 2008b; Daniels, Archive Bryol. 65: 54. 2010; Daniels & Daniel, Bryo. South. W. Ghat. 39: 2013; Beever, Flora New Zealand Moss. 8: 18. 2014.

Type: Philippines: Mindanao, W. I. Hutchinson 7607 (lectotype H-BR); Panay, Iloilo Prov. Robinson 18105 (isolectotype H-BR).

Fissidnes robinsonii Broth., Philipp. J. Sci. 13: 204. 1918.

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, differntiated; 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, 7-10.5 µm x 5-8 µm, thick walled, mamillose, walls clear, cells of extreme base of vaginant laminae larger, 15-20 x 10-14 µm, thick walled, apical lamina and dorsal lamina unistratose; gemmae not found (Plate 35-36 & Fig.12).

Fertile parts not found.

Diagnostic characters: *F. crispulus* var. *robinsonii* is characterised by its plants with axillary hyaline nodule, linear lanceolate leaves, slightly excurrent costa and differentiated central strand of stem.

Note: This species differs from *F. crispulus* Brid. var. *crispulus* in having a more or less creeping stem with differentiated cenral strand and robust costa that is slightly excurrent.

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

Plate 35. *Fissidens crispulus* var. *robinsonii* (Broth.) B.C.Tan & Choy, habit & habitats; a&c. on land cuttings, b&d. on rocky patch, e&f. enlarged view of the habit

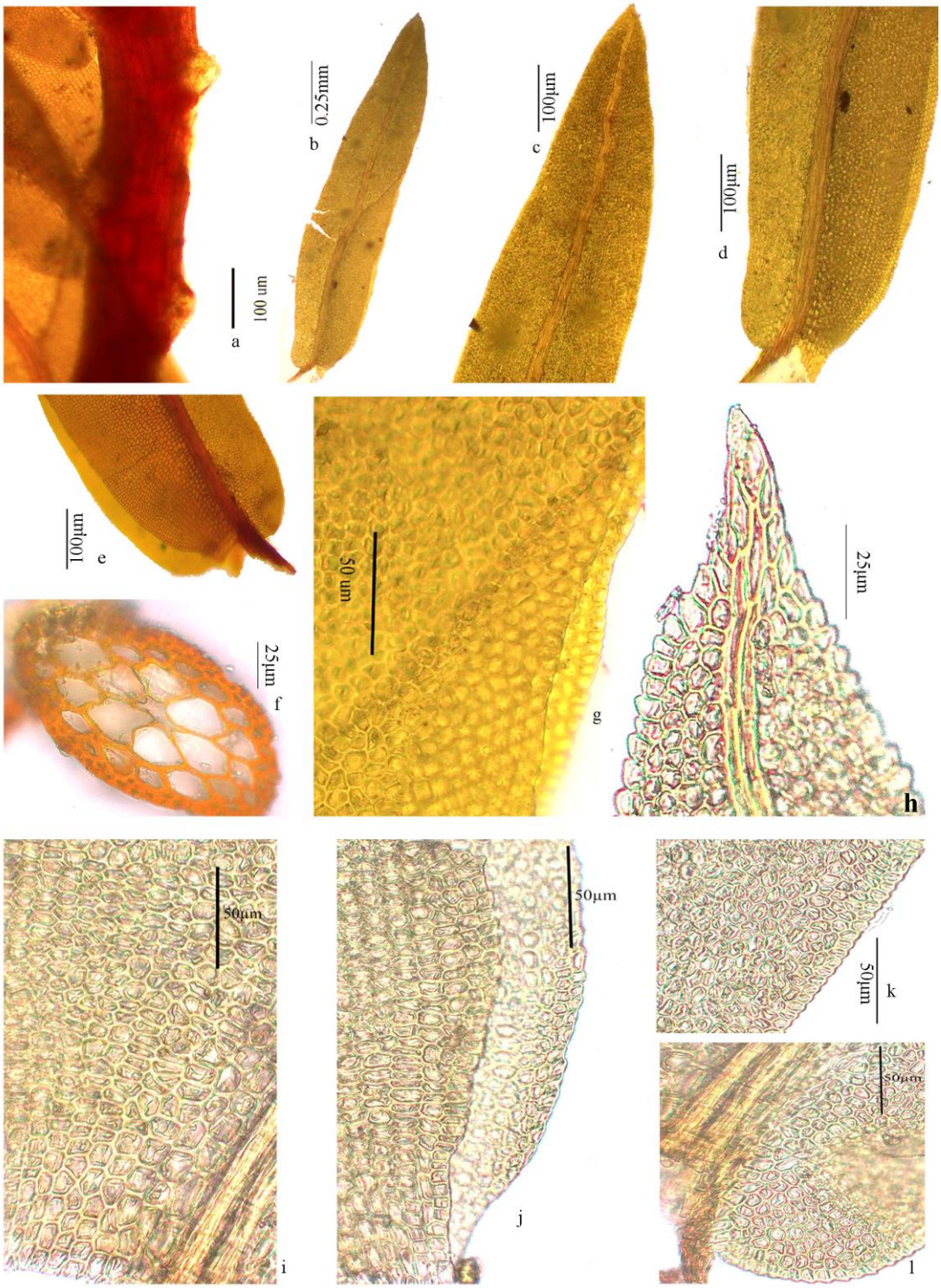


Plate 36. *Fissidens crispulus* var. *robinsonii* (Broth.) B.C.Tan & Choy., a. axillary hyaline stem nodule, b. leaf, c. leaf apex, d. vaginant laminae, e. leaf base, f. stem T.S., g. vaginant laminae apex, h. leaf apex, i & j. vaginant laminae base, k. leaf margin, l. dorsal lamina base near insertion.

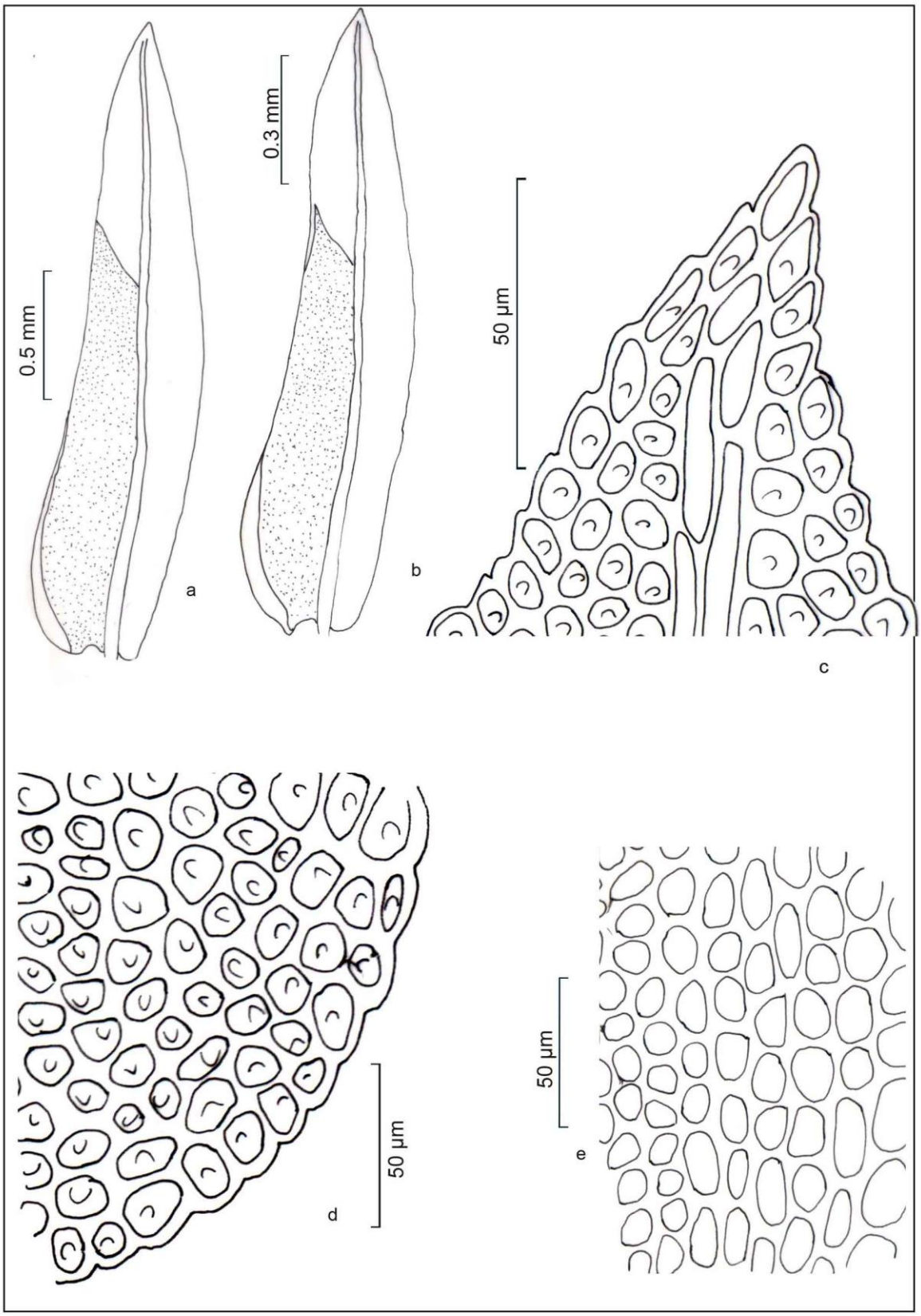


Fig. 12. *Fissidens crispulus var. robinsonii* (Broth.) T.C. Tan & Choy, a&b. vegetative leaves, c. leaf apex, d. dorsal laminal cells near insertion, e. vaginant laminae base

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 & Daniel 2005; Daniels & Daniel, 2013; Nair *et al.,* 2005; Manju *et al.,* 2008b); Australia (Queensland) China, Malaysia, New Caledonia, Oceania, Philippines (Beever, 2014; Li & Iwatsuki, 2001) (Map 15A&15B).

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

Etymology: The varietal epithet commemorates Charles Budd Robinson, specimen collector of a paratype of the basionym *F. robinsonii* Broth.

Fissidens crispulus var. *nov.*

Plants medium-sized, growing in dense tufts, unbranched, proliferation present in some plants; axillary hyaline nodules differentiated; rhizoids smooth, brownish; leafy stems 3.0-5.0 x 2.0-2.8 mm, central strand slightly differentiated, 8-11 pairs of leaves; leaves 1.40-1.64 x 0.29-0.31 mm, lanceolate, 7 times larger than width, leaf apex acute or apiculate, margine 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, mammillose, thin-walled, obscure, mid vaginant laminal cells plane or slightly convex, 13.44-14.31 x 8.18-12.21 µm, mid dorsal laminal cells slightly convex, 11.09-13.23 x 8.34-10.27 µm, vaginant laminal cells larger toward the base near costa, 14.56-18.18 x 5.21-7.16 µm; gemmae not found (Plate 37 & Fig.13).

Fertile parts; Perigonia not found; Perichaetial plant 4.0-5.0 x 2.0-2.8 mm, 5-11 pairs of leaves, perichaetium terminal, perichaetial leaves long, 1.93-2.33 x 0.28-0.33 mm; archegonium 0.24-0.33 mm long; sporophyte not found.

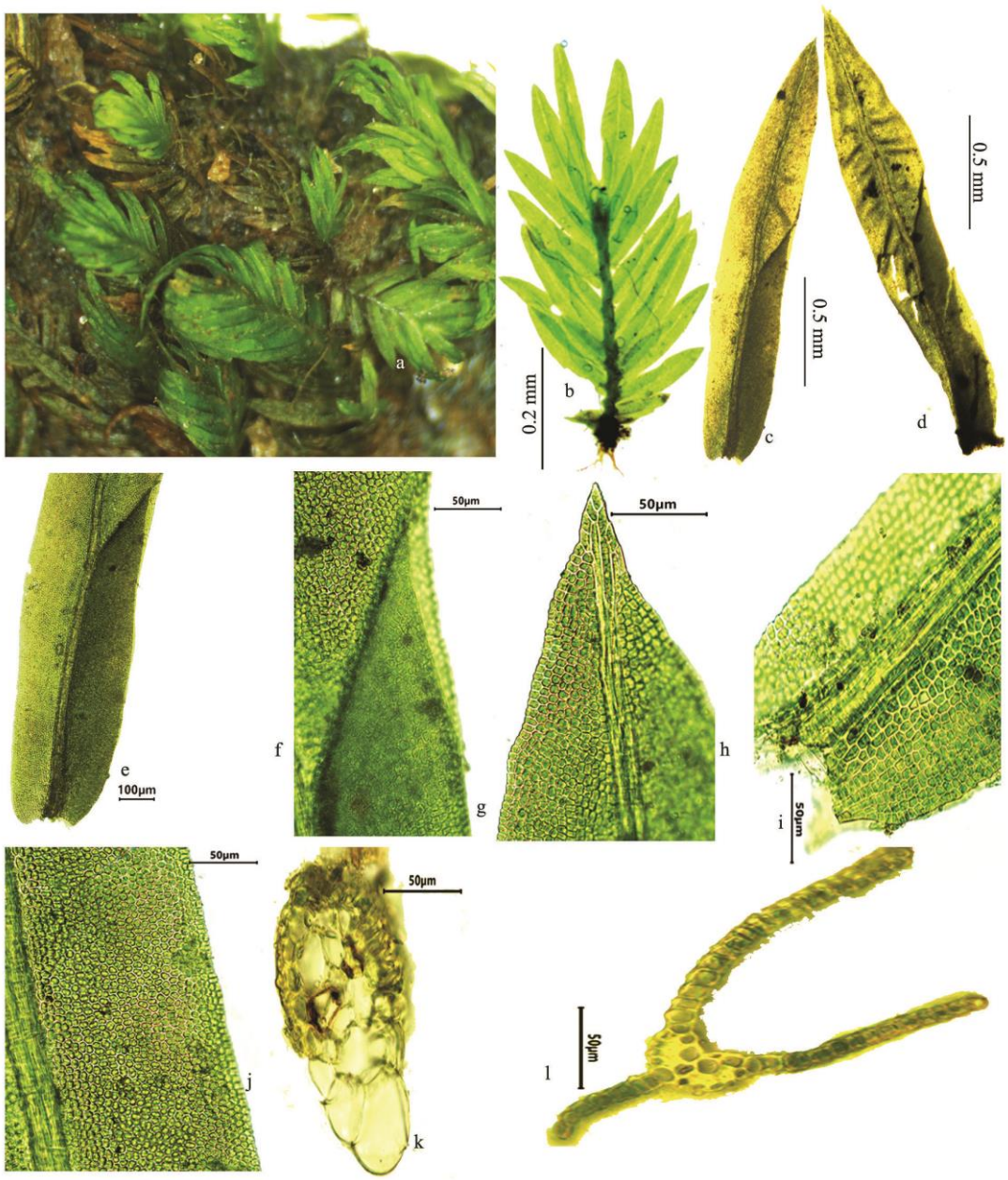


Plate 37. *Fissidens crispulus* var. *nov.,* a. habit, b. single fertile plant, c. vegetative leaf, d. perichaetial leaf, e. vaginant laminae, f. vaginant laminae apex, g. leaf apex, h. vaginant laminae base, i. stem T.S., j. leaf margin, k. leaf T.S.

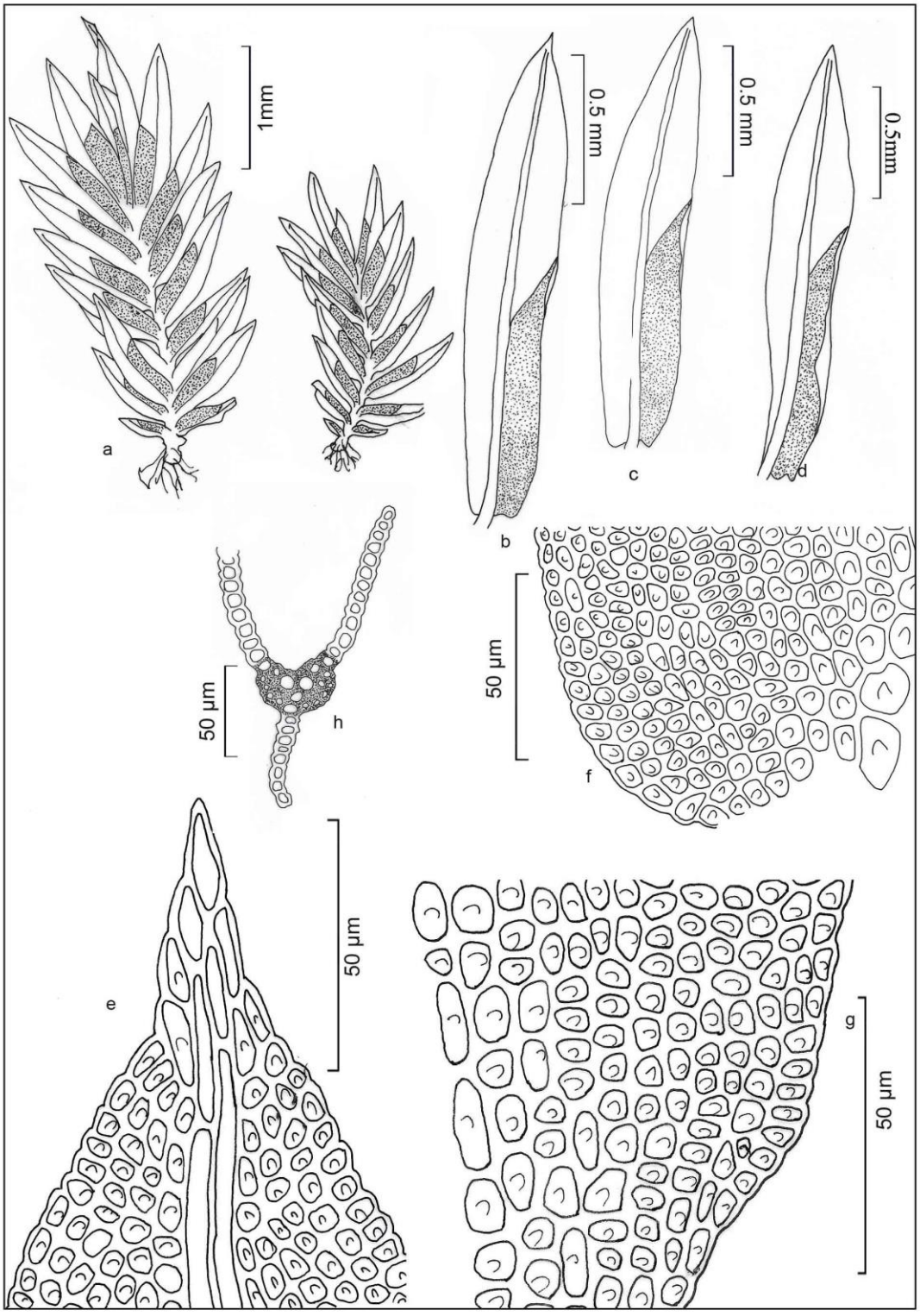
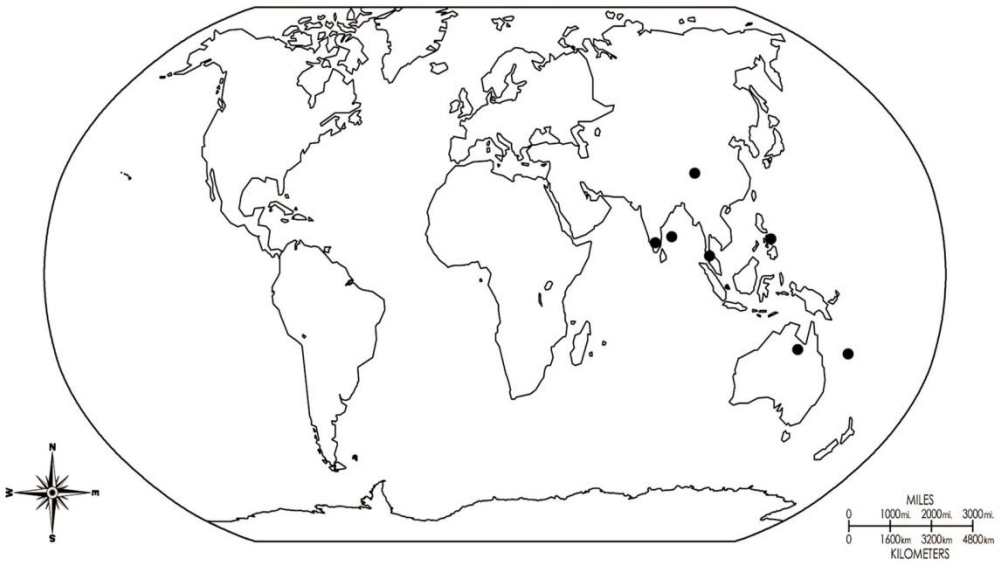
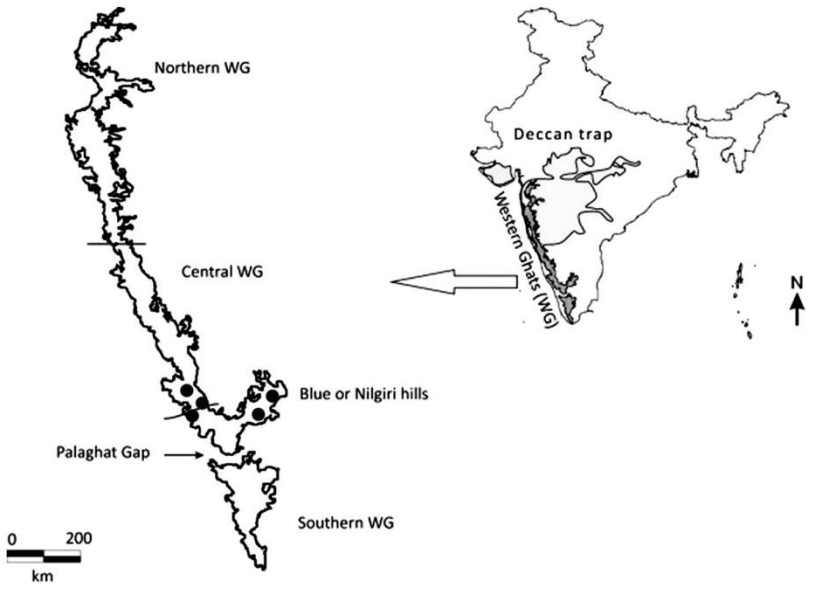


Fig. 13. *Fissidens crispulus* var. *nov.* a. vegetative plant, b&c. vegetative leaves, d. perichaetial leaf, e. leaf apex, f. dorsal lamina base near insertion, g. vaginant laminae base, h. leaf T.S.



Map. 15A. World distribution of Fissidens crispulus var. *robinsonii* (Broth.) B.C.Tan & Choy



Map. 15B. Distribution of Fissidens crispulus var. *robinsonii* (Broth.) B.C.Tan & Choy *in Western Ghats*

Diagnostic characters: This species is characterised by presence of axillary hyaline nodules, lanceolate leaves with acute or apiculate apex, mamillose laminal cells, limbidium absent and perichaetia in terminal cluster. This species is similar to *F. crispulus* and varieties of *F. taxifolius.* The elimbate, linear-lanceolate leaves and mamillose laminal cells are close to that of *F. crispulus* while differs in the decurrent base of dorsal lamina and small, obscure laminal cells. This species is similar to *F. taxifolius* var. *calcuttense* in round dorsal lamina base and mamillose laminal cells while differs in the absence of axillary nodule and costa which is percurrent or ending below leaf apex in *F. taxifolius* var. *calcuttense* in . Costa of this species is similar to *F. taxifolius* var. *teraicola* and *F. taxifolius* var. *auriculatus* but differs in the absence of axillary hyaline nodule and rounded dorsal lamina base here.

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

Specimen examined: India, Kerala, Palakkad district (Nelliyampathi, 1210m), 10.11.2015, Maya C.N. (ZGC 15814).

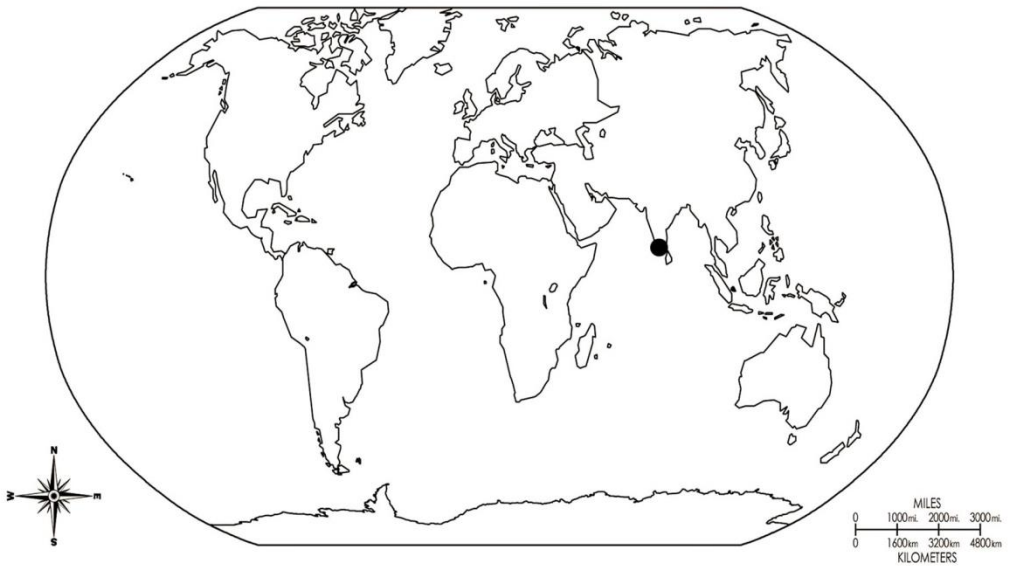
Distribution: Endemic to Kerala (Map 16A&16B).

Note: This specimen does not match with any of the species reported from India. Further investigation is needed to fix its identity and it may turn new species or new record for India.

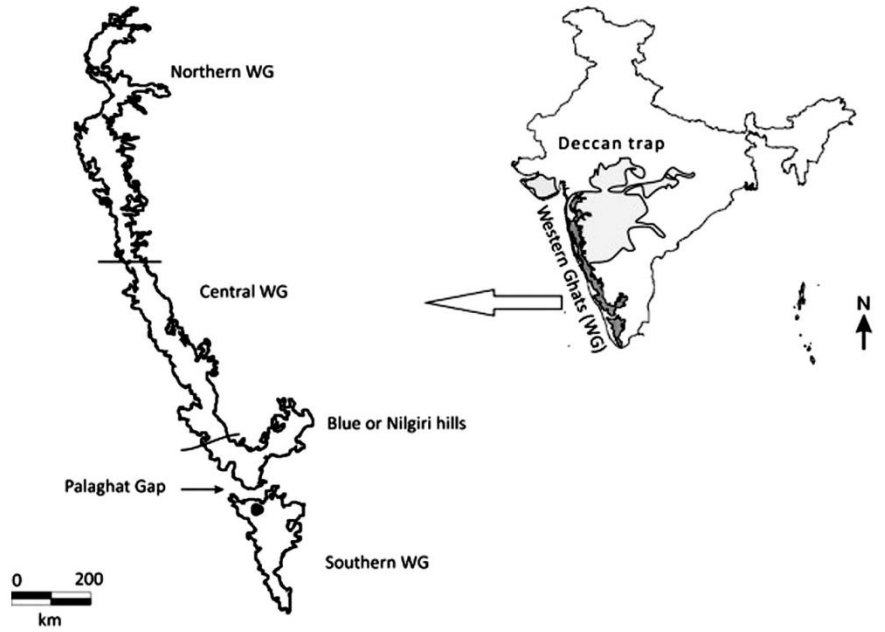
Fissidens excedens Broth., Rec. Bot. Surv. India 1(12): 315. 1899.

Type: India, Karnataka; Coorg: Sidapur (Brotherus, 1899)

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,



Map. 16A. Distribution of Fissidens crispulus var. nov



Map. 16B. Distribution of Fissidens crispulus var. *nov.* in Western Ghat

joins to costa near the insertion of leaf, apical lamina and dorsal lamina unistratose; laminal cells irregularly polygonal, cell wall moderately thickened, mamillose, 0.9-1.0 µm 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 (Plate 38 & Fig.14).

Diagnostic characters: *F. excedens* Broth. is characterised by its large plants without axillary hyaline nodules, oblong lingulate leaves, excurrent costa and mamillose laminal cells. This species shows similarity with *F. crispulus* Brid. in mamillose laminal cells and crenate leaf margin and differs in the presence of axillary hyaline nodule and oblong lingulate leaves of *F. crispulus. F. excedens* also confused with *F. taxifolius* in leaf apex, mamillose 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 collected by Brotherus (1899) from South India. But I could not locate the type during my present study. Foreau also collected this species from Palni hills. Corsby *et al.* (1999) accepted this name but commented that this species is insufficiently known because no one has collected this specimen since Index Muscorum (1963) publication. No more information about the species than, merely relisted without additional specimens in a checklist since 1963. During my present field survey I could not come across this specimen and I have listed this species based on the Foreau's collection from Palni hills. 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.

Distribution: India (Karnataka, Tamil Nadu), Thailand (Brotherus, 1899; Dixon & Potier de la Varde, 1927 & 1930; Foreau, 1930 & 1961; Schwarz, 2014b; Tixier, 1979) (Map 17A&17B).

Specimens examined: India, Tamil Nadu, Palni Hills, Shembaganur (1850m), July, 1958, G. Foreau (Foreau-1) (CAL!), 1959, G. Foreau (No coll. Number) (CAL!).

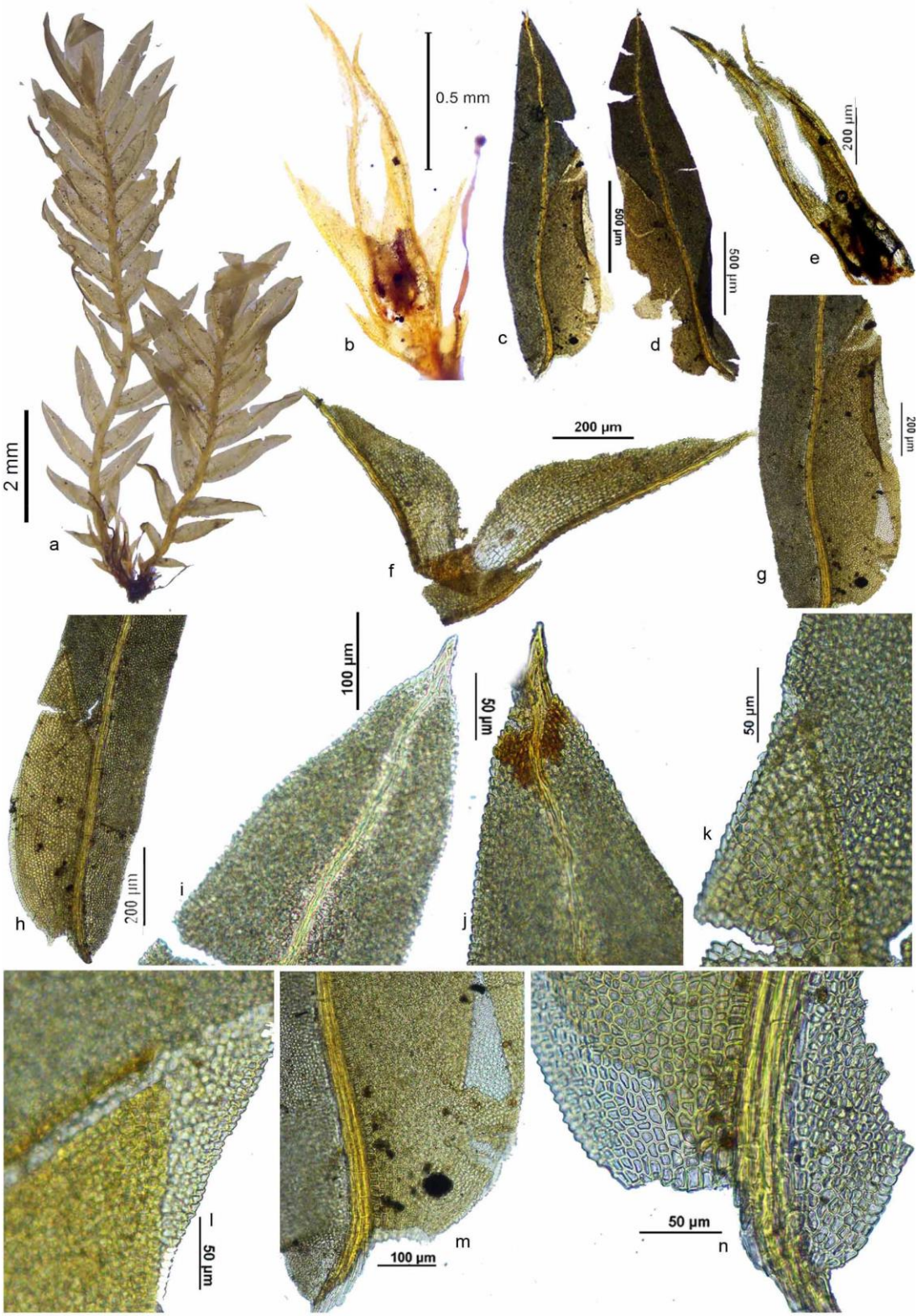


Plate 38. *Fissidens excedens* Broth., a. vegetative plant, b. fertile branch, c&d. vegetative leaves, e&f. perichaetium, g&h. vaginant laminae, i&j. leaf apex, k&l. vaginant laminae apex, m&n. leaf base near insertion (Photo from Foreau 1 (CAL)).

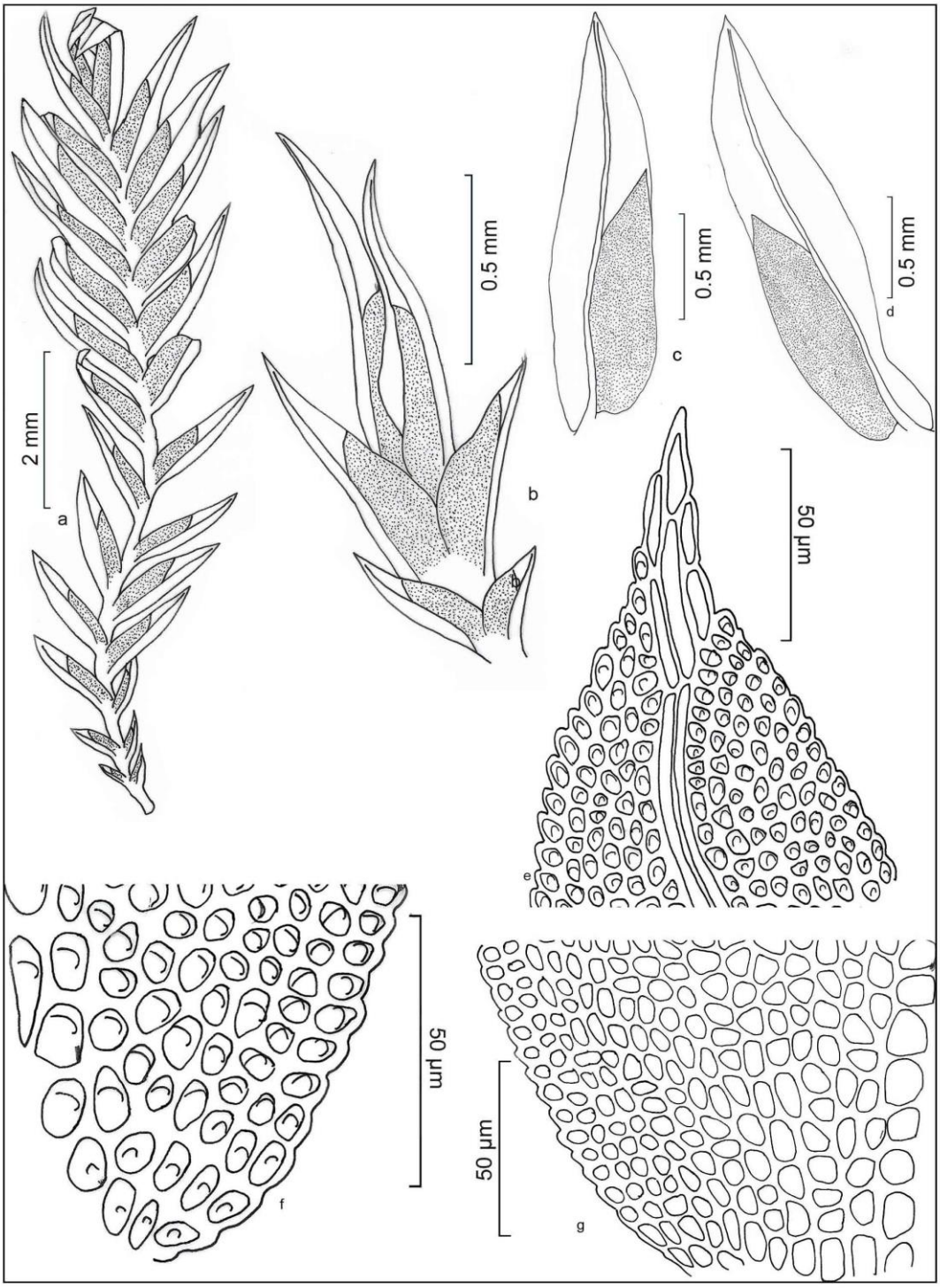
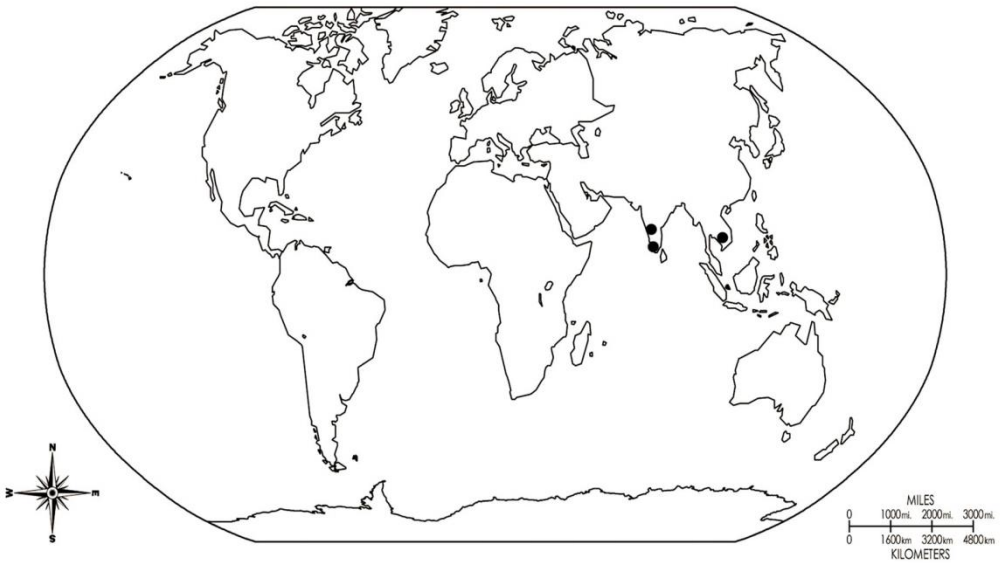
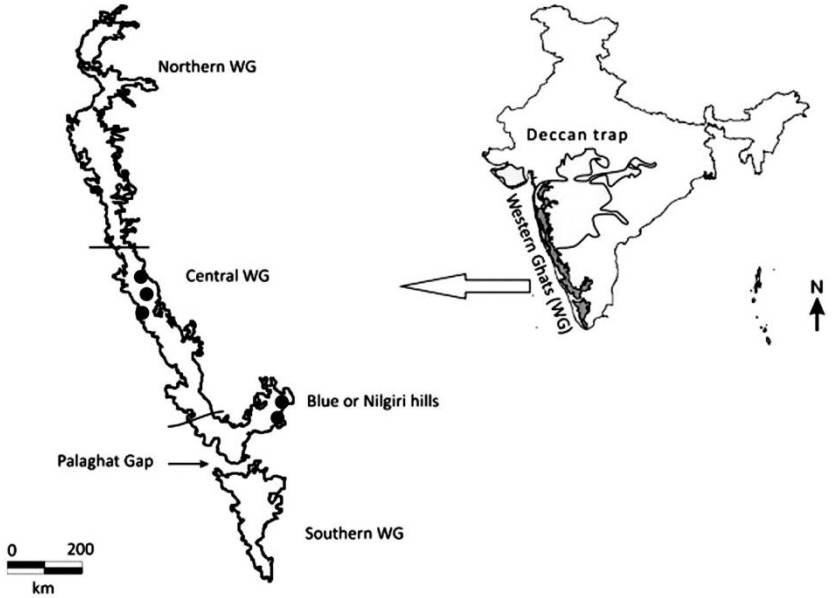


Fig. 14. *Fissidens excedens* Broth., a. vegetative plant, b. fertile plant, c&d. vegetative leaves, e. leaf apex, f. dorsal lamina base near insertion, g. vaginant laminae base.



Map. 17A. World distribution of ***Fissidens excedens*** *Broth.*



Map. 17B. Distribution of ***Fissidens excedens*** *Broth. in Western Ghats*

Fissidens geminiflorus Dozy & Molk., Pl. Jungh. 316. 1854; Chaudhary *et al.*, Bryo. Fl. N. Konkan Maharashtra-India 246. 2008.

Type: Indonesia; Java.

Fissidens geminiflorus var. *nagasakinus* (Besch.) Z. Iwats., J. Hattori Bot. Lab. 32: 272. 1969. *Fissidens nagasakinus* Besch., J. Bot. (Morot) 12: 292. 1898. *Fissidens takakii* Sakurai, Bot. Mag. (Tokyo) 49: 138. 1935.

Plants yellowish green, slender, unbranched, 3.0-12.0 x 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 x 0.5-0.7mm, 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 quadrate to polygonal, mamillose, cell wall moderately thick walled, cells of vaginant laminae base near costa elongated 10-12 µm long; gemmae not found (Plate 39 & Fig.15).

Fertile parts not found.

Diagnostic Characters: This species is characterised by plants with spreaded leaves, oblong lanceolate leaves, elimbate leaves, acute apex with apiculate apex, laminal cells mamillose. This species confused with *F. crispulus* in mamillose laminal cells, elimbate leaves and aute apex. They differs in oblong lanceolate leaves, absence of axillary hyaline nodules and slightly curved margin at vaginant laminae apex.

Note: During my present survey I could not locate this species from the study area, but Choudhary *et al.* (2008) reported this species from Western Ghats of Gujarat and the above description is based on authentic specimen BM. This description matches with the description of Choudhary *et al.* (2008). Dabhade (1998), Magdum *et al.* (2017) and Chaudhary *et al.* (2008) listed this species from Mahabaleswar and wrongly spelled as *F. gaminiflorus* Dozy & Molk. The above description is based on authentic specimen and the description of above authors match with this species.

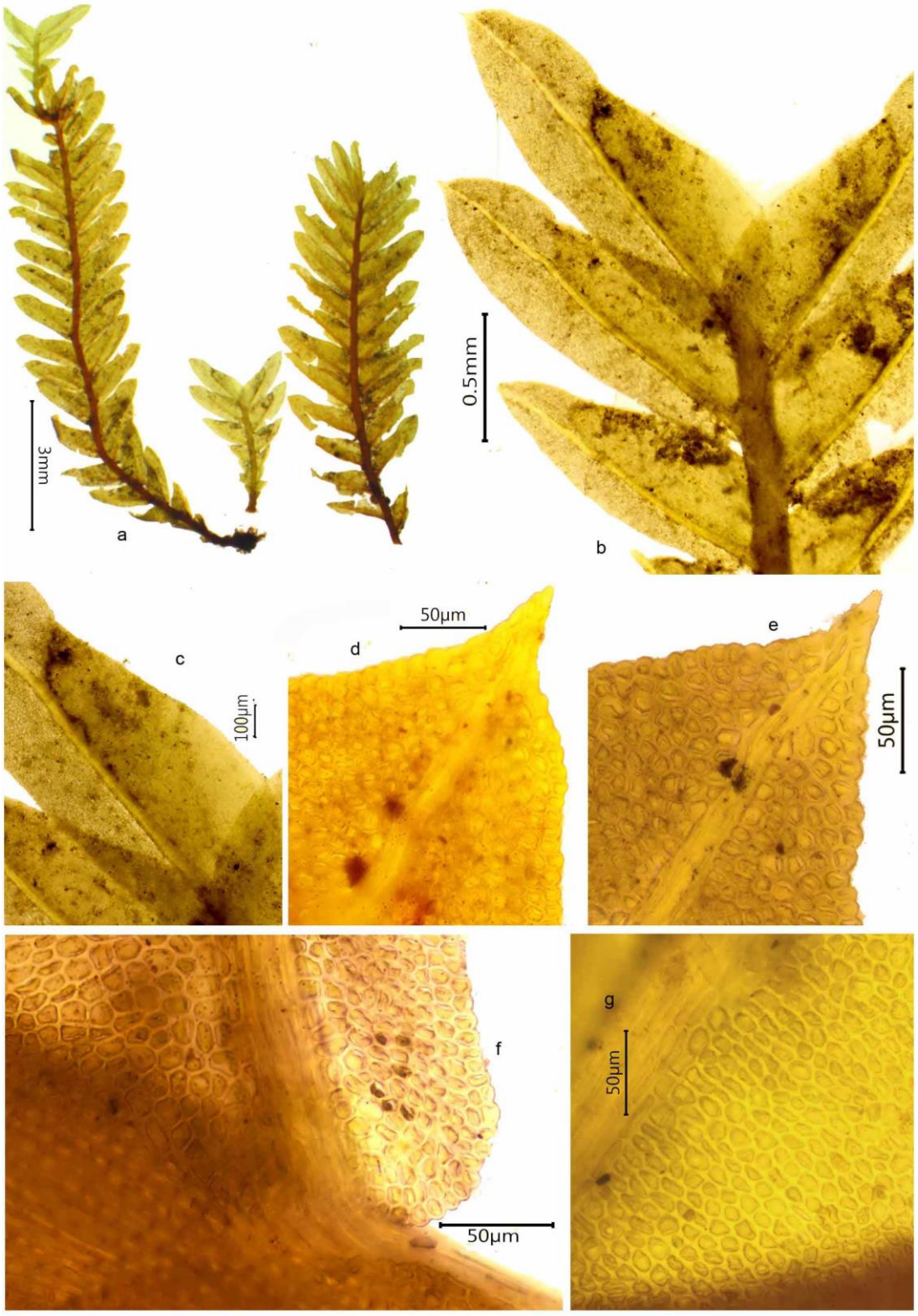


Plate 39. *Fissidens gemniflorus* Dozy & Molk., a. vegetative plants, b. vegetative leaves, c. vaginant laminae, d&e. leaf apex, f. dorsal lamina base near insertion, g. vaginant laminae base (Photo from Larse *et al.*, 2299 BM!).

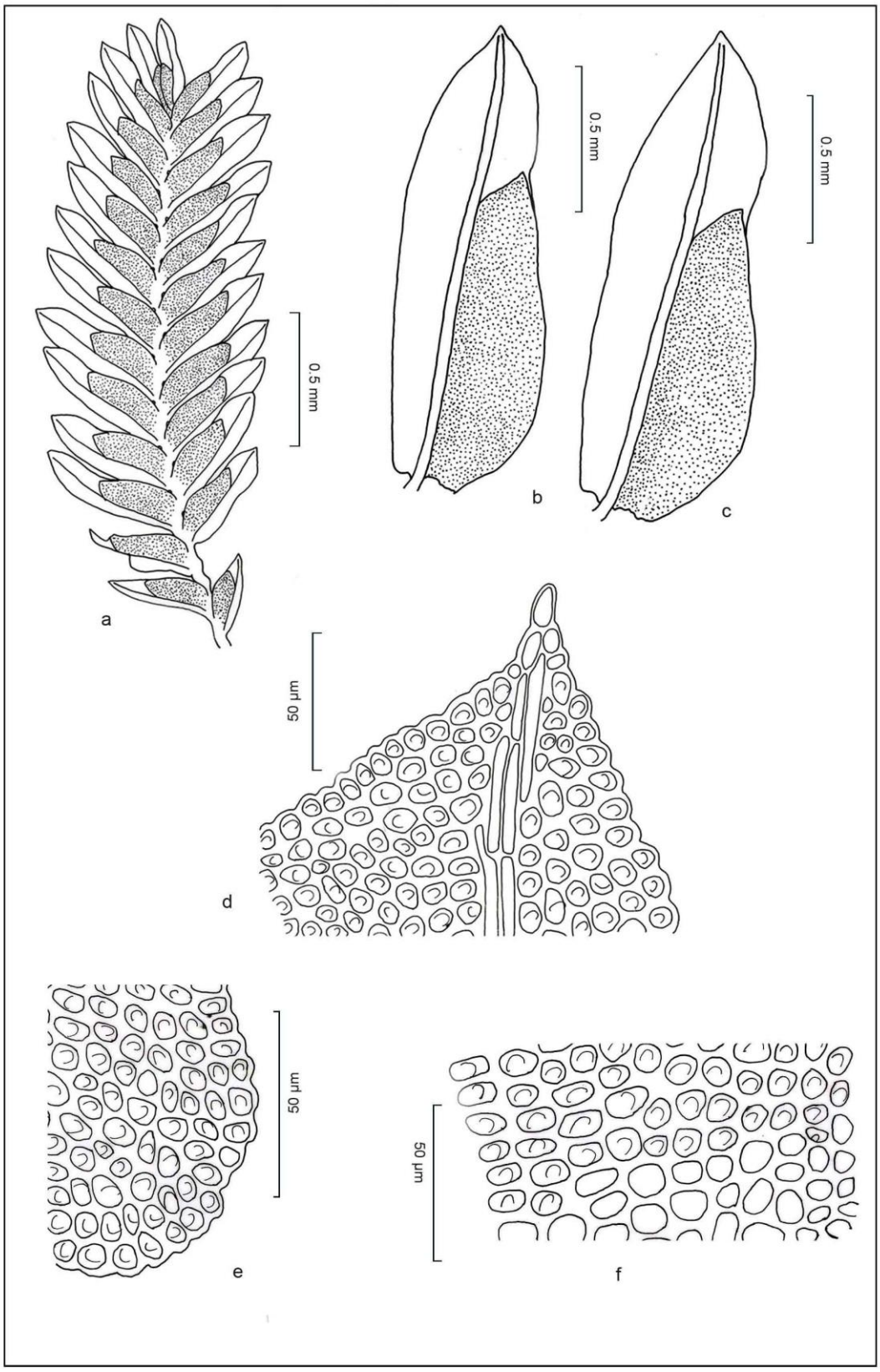


Fig. 15. *Fissidens gemniflorus* Dozy & Molk., a. vegetative plant, b&c. vegetative leaves, d. leaf apex, e. dorsal lamina base near insertion, f. vaginant laminae base

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 & Geissler, 1990; Tan & Iwatsuki, 1991; Iwatzuki & Suzuki, 1996) (Map 18A&18B).

Specimen examined: Thailand (No details), Larse *et al.* (2299) (BM!).

Fissidens javanicus Dozy & Molk., Bryol. Jav. 1:11. 1855; Gangulee, Moss. E. India & Adj. 1: 542. 1971; Li & Iwatsuki, Moss Fl. China 2: 42. 2001; Daniels & Kariyappa, Curr. Sci. 93(7): 980. 2007.

Type. Indonesia: Java, Teysmann s.n. (Fleisch. 79) (CAL)

F. acutifolius Mitt. J. Proc. Linn. Soc., Bot., Suppl. 2: 137. 1859; *F. marginatulus* Muell. Hal. Gen. Musc. Fr.: 66. 1900; *F. gozadakensis* Horik. Bot. Mag. (Tokyo) 49: 53. 3. 1935; *F. newcomeri* E.B. Bartram Rev. Bryol. Lichénol. 23: 243. 1954.

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 × 0.30–45 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, mamillose; cells of vaginant laminae similar to those of apical and dorsal laminae, but slightly larger and well demarcated with thicker cell walls (Plate 40 & Fig.16).

Fertile parts not seen.

Plate 40. *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. (a-o from m 305 (BM!)).

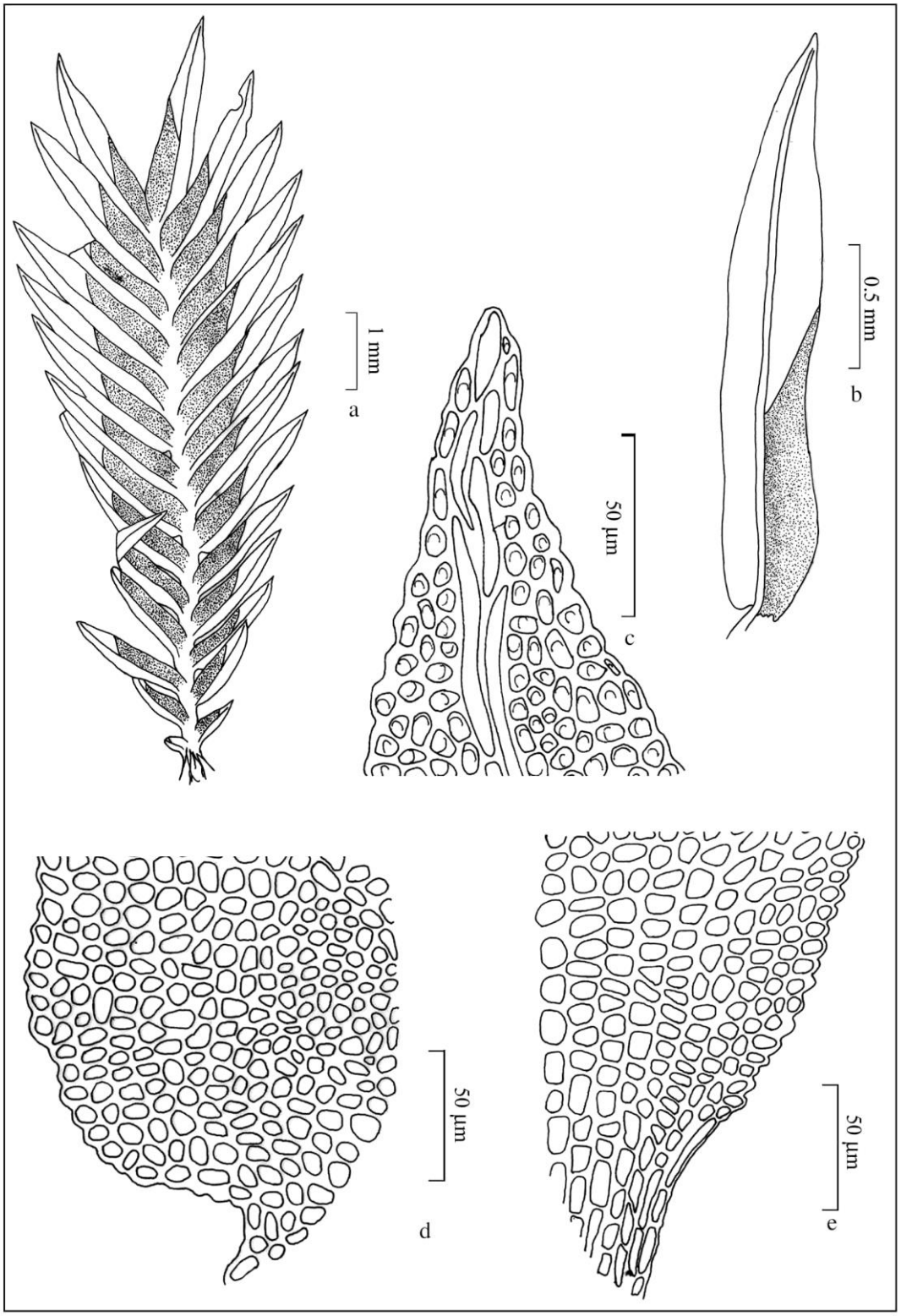
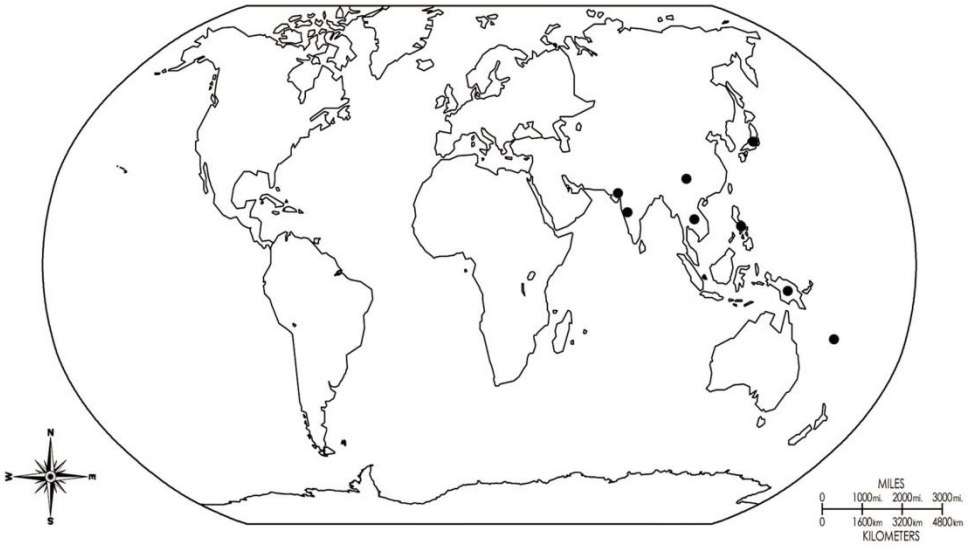
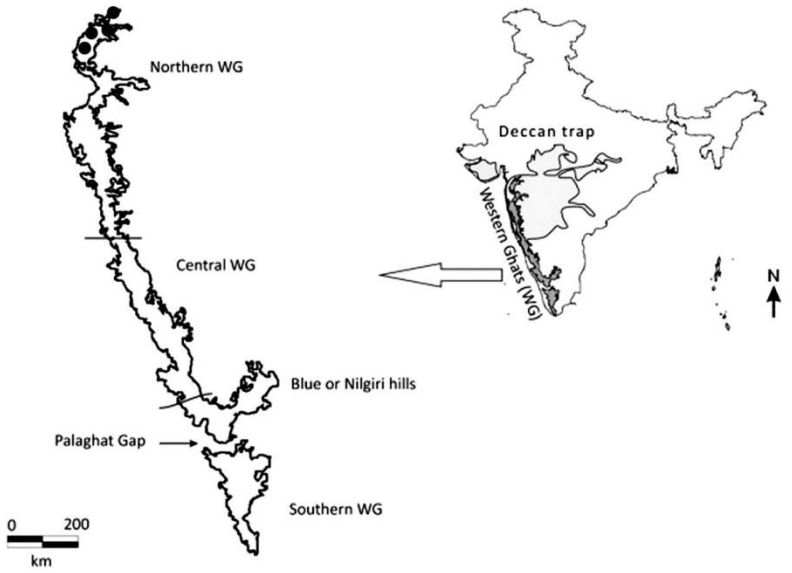


Fig. 16. *Fissidens javanicus* Dozy & Molk., a. vegetative plant, b. leaf, c. leaf apex with costa, d. dorsal lamina base near insertion, e. vaginant laminae base.



Map. 18A. World distribution of ***Fissidens geminiflorus*** *Dox. et Molk.*



Map. 18B. Distribution of ***Fissidens geminiflorus*** *Dox. et Molk. in Western Ghats*

Diagnostic characters: *F. javanicus* Dozy & Molk. 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 mamillose. This species is similar to *F. crispulus* in elimbate leaves, mamillose 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.

Note: Daniels and Kariyappa (2007) mentioned the occurrence of this species in Tamil Nadu. I could not locate this species during the present study. The above description is based on authentic specimen from CAL.

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 & Kariyappa, 2007; Gangulee, 1971); China, Indonesia, Japan, Java, Malaysia, Myanmar, Nepal, New Guinea, Philippines, Sri Lanka, Thailand, (Li & Iwatsuki, 2001) (Map 19A&19B).

Specimens examined: East Indies, Archipelagi Indici, Ser.II. No. 50-100, 1899, Fleisch (79) (CAL!); Thailand, A. Kerr (305) (BM!).

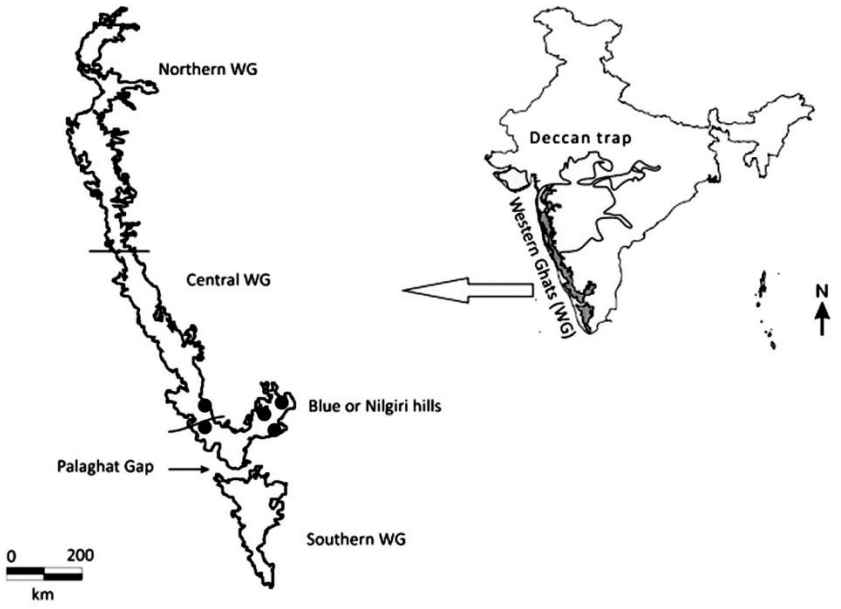
Etymology: The specific epithet *javanicus* derived from the type locality 'Java' of this species.

Fissidens lutescens Broth., Rec. Bot. Surv. India 1(12): 311–329. 1899.

Type: India, Karnataka; Coorg: Verajpet (Brotherus, 1899).

Plants in mats, rhizoids smooth, axillary and basal; stem erect, mostly unbranched, 3-5 x 1.7-2.0 mm, axillary hyaline nodules present; leaves linear lanceolate, 1.3-1.7 x 0.6-0.8 mm, margin entire, apex widely acute; elimbate; costa not excurrent, reaching 2-4 cells below apex; vaginant laminae reaching more than

Map. 19A. World distribution of Fissidens javanicus Dozy & Molk.



Map. 19B. Distribution of Fissidens javanicus Dozy & Molk. in Western Ghats

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, mamillose, vaginant laminae basal cells near costa large, 13-16 µm; gemmae not found (Plate 41 & Fig.17).

Fertile parts not found

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

Note: This species is reported by Brotherus in 1899, but the locality is unknown. After his collection, Dixon and Potier de la Varde (1930) and Foreau (1964) collected this species again from Tamil Nadu. Daniels (2010) listed this species based on these collections. During my present survey I could not locate this species and type specimen also could not locate. The above description is based on the authentic specimen from the Natural History Museum (BM), but the characters are almost similar to *F. crispulus*. This is a doubtful species, may be after getting the type specimen, only can say it is *F.lutescens* or *F. crispulus*.

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

Distribution: It is an endemic species to South India distributed in (Karnataka, Tamil Nadu (Tirunelveli, Coutrallam) (Dixon & Potier de la Varde, 1927, 1930; Foreau, 1964; Daniels, 2010) (Map 20A&20B).

Specimen examined: India, Courtallam, Tirunelveli, Foreau (13) (BM!).

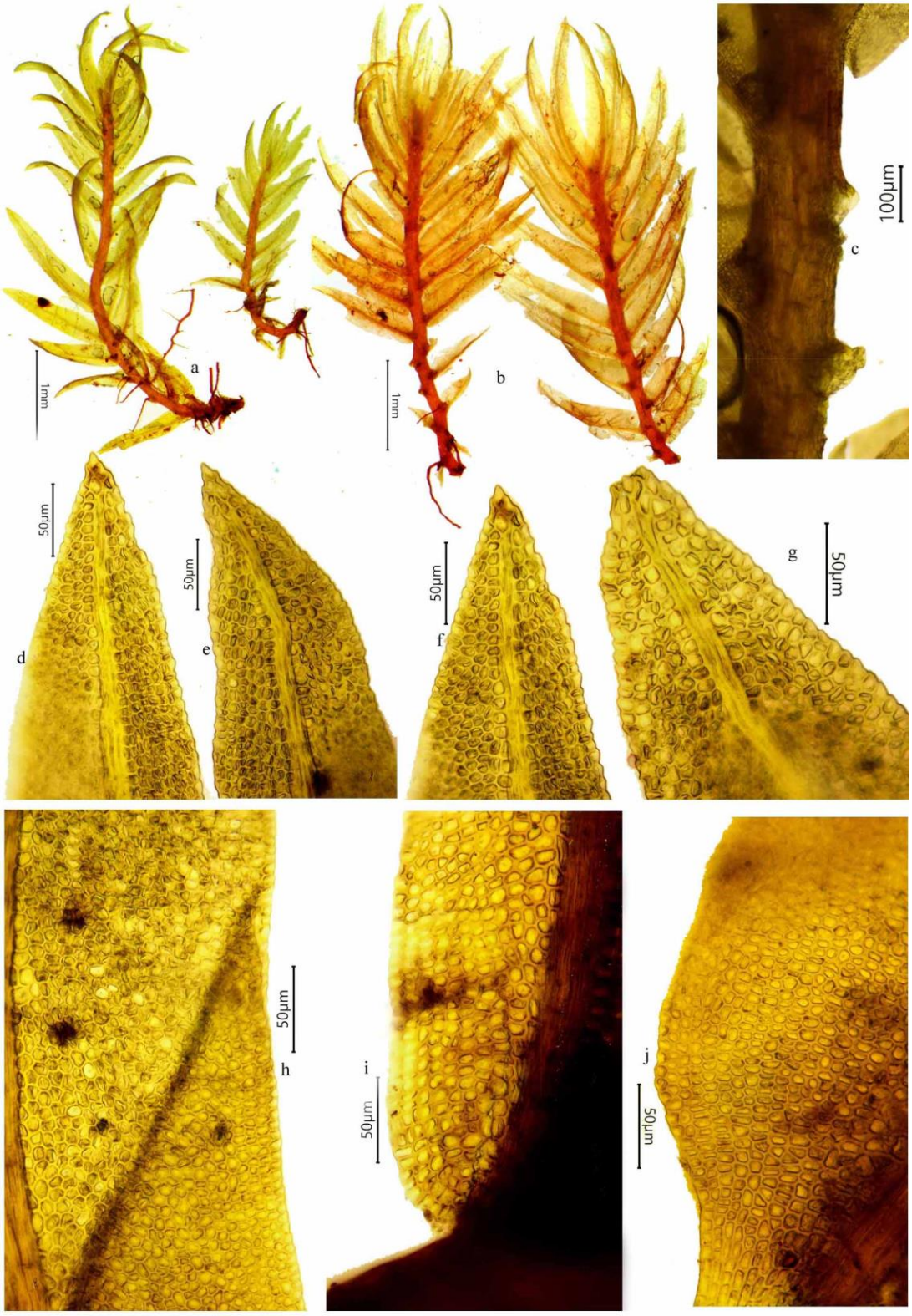


Plate 41. *Fissidens lutescens* Broth., a&b. vagetative plants, c. axillary hyaline stem nodules, d-g. leaf apex, h. vaginant laminae apex, i. dorsal lamina base near insertion, j. vaginant laminae base (photo from Foreau 13 (BM!).

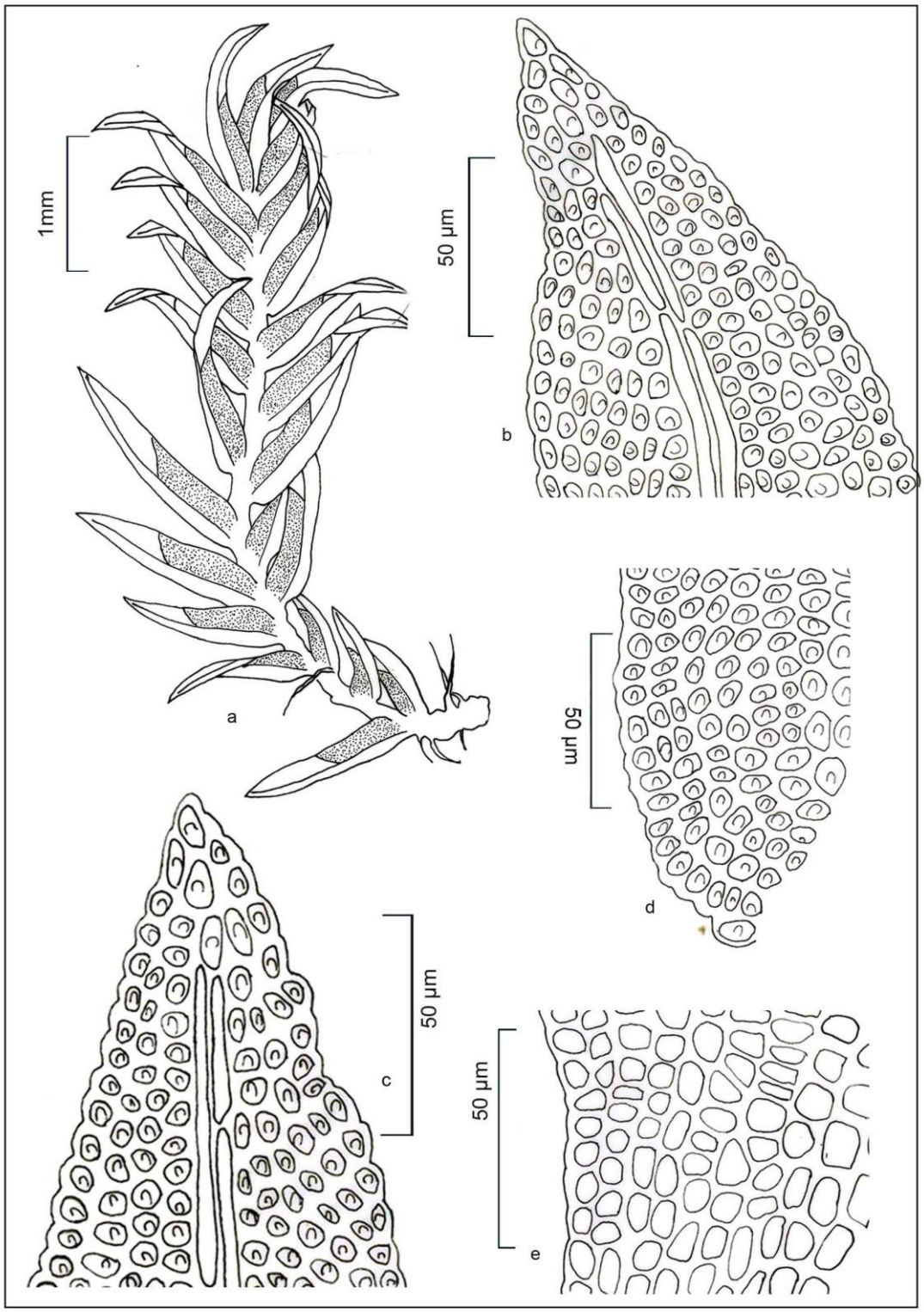
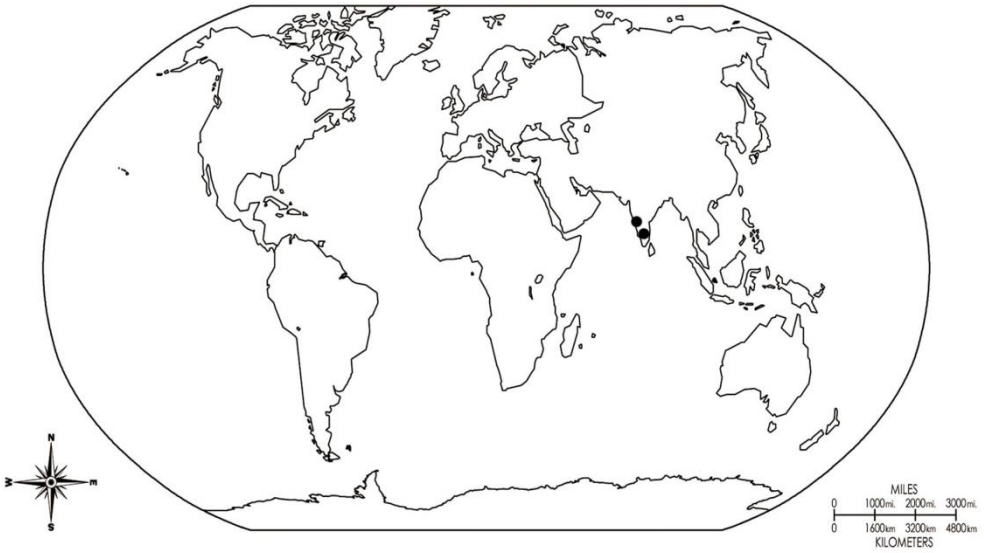
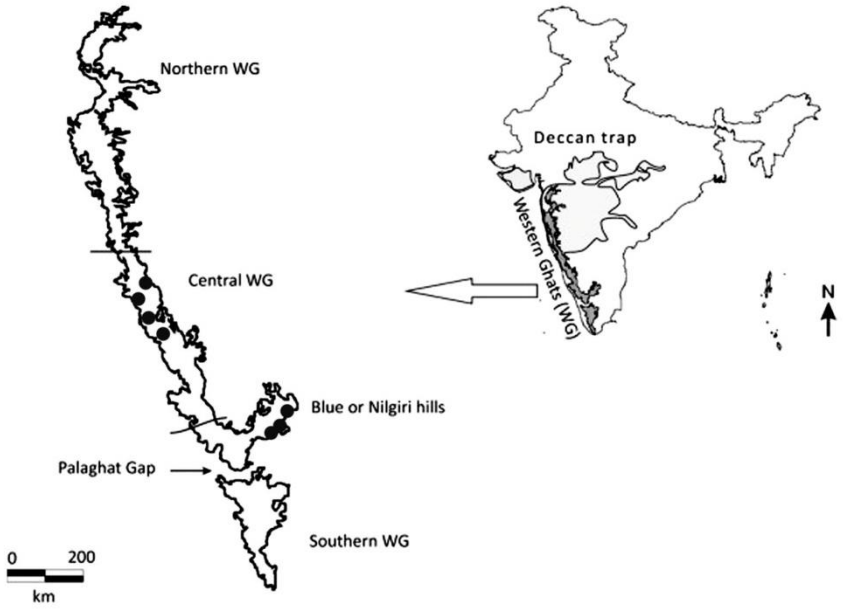


Fig. 17. *Fissidens lutescens* Broth., a. vegetative plant, b&c. leaf apex, d. dorsal lamina base near insertion, e. vaginant laminae base



Map. 20A. World distribution of ***Fissidens lutescens*** *Broth.*



Map. 20B. Distribution of ***Fissidens lutescens*** *Broth. in Western Ghats*

Fissidens subangustus Fleisch., Die Musci der Flora von Buitenzorg. 1: 47. 1904; Gangulee, Moss. E. India & Adj. 1: 532. 1971; Iwatsuki & Suzuki, Journ. Hattori Bot. Lab. 51: 400. 1982; Iwatsuki & Mohamed, Journ. Hattori Bot. Lab. 62: 354. 1987; Li & Iwatsuki, Moss Fl. China 2: 53. 2001; Daniels & Daniel, Indian J. Forest. 26 (4): 389. 2003c (as *F. leptopelma*); Lal Checklist Indian Moss. 62. 2005; Daniels, Archive Bryol. 65: 57. 2010; Daniels & Daniel, Bryof. South. W. Ghats. 45. 2013.

Type. Indonesia: Java, Tjiapoes-Schluchtam Salak, 800 m. alt., M. Fleischer s.n. (holotype FH).

Fissidens leptopelma Dixon, J. Bombay Nat. Hist. Soc. 39: 773. 1937.

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 (Plate 42 & Fig.18).

Diagnostic characters: *F. subangustus* Fleisch. 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* Brid. 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.

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 (present collection) (Daniels, 2010; Daniels & Daniel, 2003c, 2013; Gangulee, 1971), China, Japan, Java, Malaysia, Philippines, Sumatra (Iwatsuki & Suzuki, 1982; Li & Iwatsuki, 2001; Tan & Iwatsuki, 1991). The present collection is a new record to Kerala. (Map 21A&21B).

Note: The present collection is new record to Kerala.

Specimens examined: India, India, Kerala, Kannur district (Aralam WLS, Meenmutti, $11^0$56’65.5” N, $75^0$52’90” E, 800m), 17.09.2015, Manjula (ZGC 1564); Tamil Nadu, Thirunelveli (Mundanthurai, 240 m), 30.07.1999. Daniels, A.E.D. (628A!); NEFA (Foot hills of Aka Hills, 100-300m), Nov.-Dec. 1933, N.L.Ber (Ber 42) (CAL!); Hungary: Grottae prope. (300m), 25.12.1915, Pocs *et al.* (3121/c).

Etymology: It is related to the species *F. angustus* M.Fleisch.

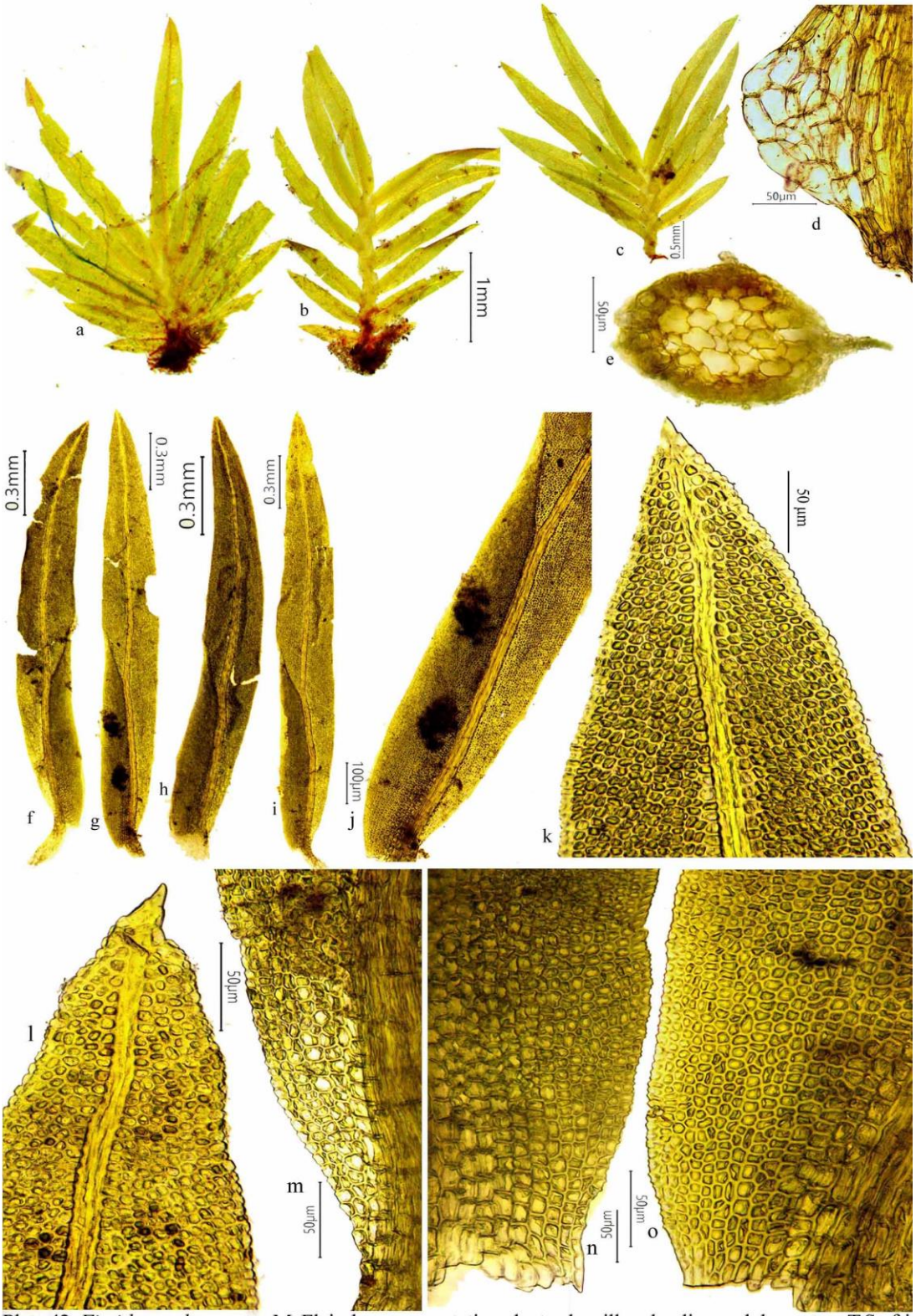


Plate 42. *Fissidens subangustus* M. Fleisch., a-c. vegetative plants, d. axillary hyaline nodule, e. stem T.S., f-i. vegetative leaves, j. vaginant laminae, k&l. leaf apex, m. dorsal lamina base near insertion, n&o. vaginant laminae base (photo from Ber 42 (CAL!)).

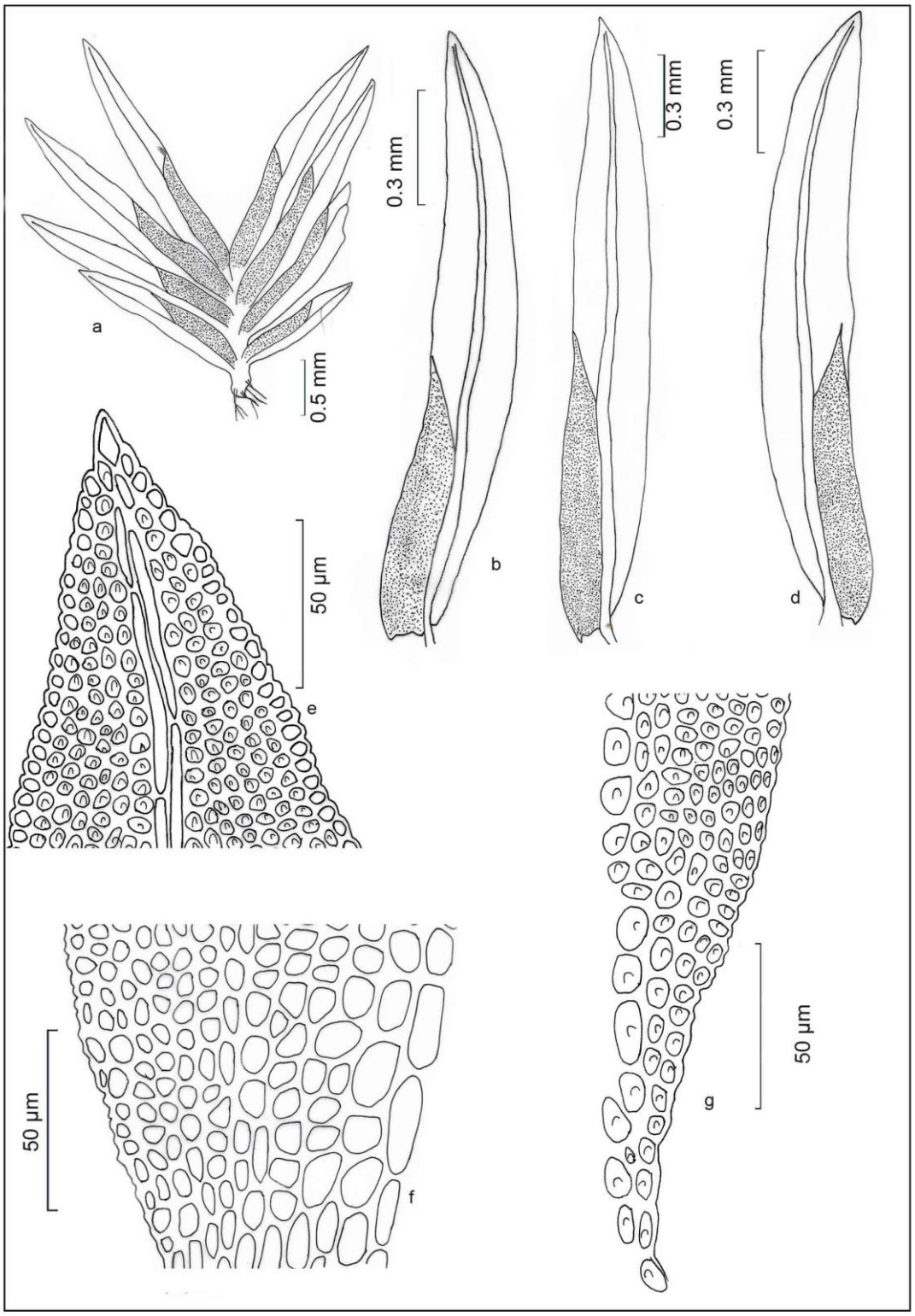
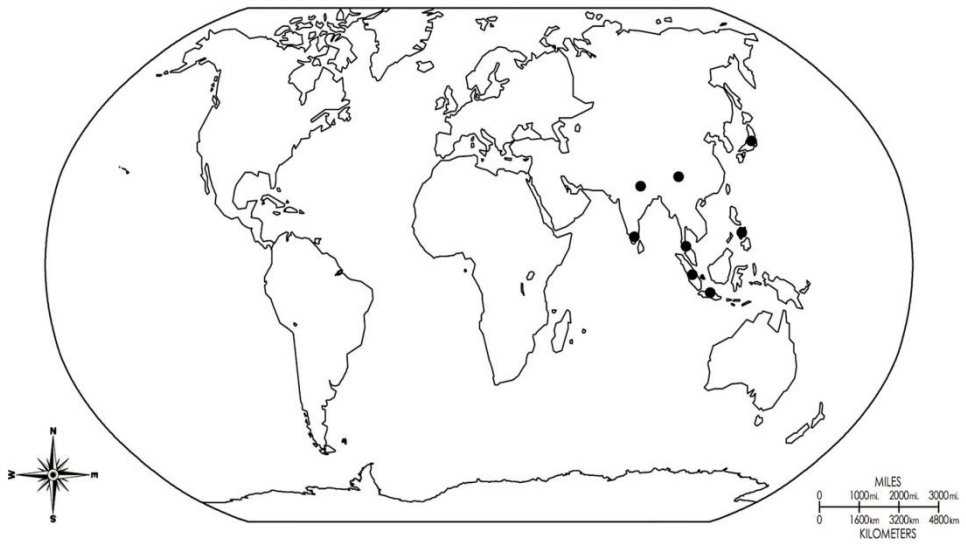
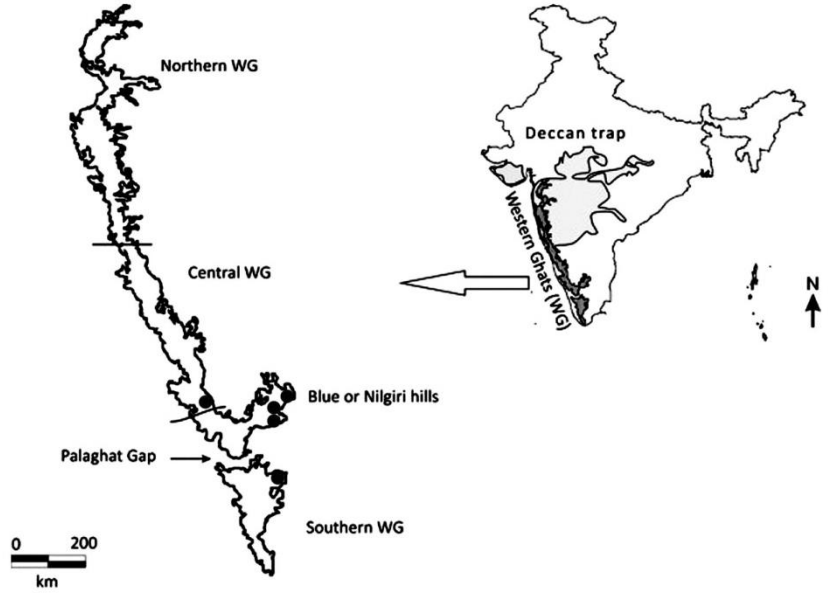


Fig. 18. *Fissidens subangustus* Fleisch., a. vegetative plant, b-d. vegetative leaves, e. leaf apex, f. vaginant laminae base, g. dorsal lamina base near insertion.



Map. 21A. World distribution of Fissidens subangustus Fleisch.



Map. 21B. Distribution of Fissidens subangustus Fleisch. in Western Ghats

Fissidens Hedw. **subgenus *Octodiceras*** (Brid.) Broth., *Nat. Pflanzenfam*. 1 (3): 361. 1909 [1901].

Plants aquatic, submerged but often emergent, delicate and feather-like in appearance, yellow to dark-green at growing tips, brown-black towards base; stems monomorphic, up to 12cm long, usually branched profusely; rhizoids basal, smooth, reddish; branches with basal rhizoids; axillary hyaline nodules absent; epidermis and outer tier of cortical cells small, incrassate, pigmented; inner cortical cells larger, thin-walled hyaline; central strand absent. Leaves ± crispate, fragile when dry, usually distant, pinnately arranged, lanceolate to linearly-lanceolate, habitually falcate, acute, variable in size, usually 10 or more as long as wide; margin more or less entire, elimbate or weakly limbate in proximal 1/3 of vaginant laminae, limbidial cells unistratose; costa bryoides type; dorsal lamina reaching the insertion or ending above, vaginant laminae of cauline leaves acute, ± equal or unequal, rounded or nearly so and ending on or near Costa; laminal cells eguttulate, unistratose or infraquently and irregularly bistratose, plane to slightly bulging, quadrate, oblong to hexagonal. Monoicous (gonioautoicus and cladautoicous); perigonia gemmiform and axillary or terminal on main stems and elongate axillary branches; perichaetia terminal on short or elongate axillary branches or terminal on main stems. Sporophytes small inconspicuous, one or more per perichaetium, reddish, persistent or caducous; theca emergent, erect radially symmetric, mostly irregularly quadrate to oblong, vertical walls thicker than horizontal walls, collenchymatous; peristome teeth reduced bryoides type, undivided or divided with filaments ± reduced; operculum conic, short or long-rostrate. Spores smooth to finely papillose large for the genus. Calyptra mitrate or cuculate, smooth. A revision of this subgenus was published by pursell (1987).

Subgenus *Octodiceras* is a group of species characterised essentially by adaptations to its aquatic habitat: stems long, weak, floating, often much branched, central strand absent; leaves flaccid, linear-lanceolate; seta short, theca estomatose; and peristome reduced. The subgenus shares the bryoides-type costa with subgenera *Fissidens* and *Aloma*, but is most closely related to subgenus *Fissidens*. Both

Octodiceras and section *Sarawakia* of subgenus *Fissidens* might be considered 'aquatic branches' of section *Fissidens* subgenus *Fissidens*. All three taxa share similar laminal cells and costae, and, although most peristomes are reduced they can be identified as the bryoides-type.

There is no report of the species in this subgenus from Western Ghats.

2. *Fissidens* Hedw. subgenus *Fissidens*

Subgenus *Fissidens* is an assemblage of species characterised by the bryoides-type costa and bryoides-type peristome, although anomalous peristomes are found in a few species. Typically, the leaves are limbate on all laminae, less often only on the vaginant lamine of some or all leaves. Rarely are all leaves elimbate. Laminal cells are smooth and flat or bulging. The subgenus is divided into two closely related sections.

Key to the sections of subgenus *Fissidens*

1a. Limbidium on almost all laminae or restricted to vaginant laminae only ……..
…… *Fissidens* (1)

1b. Limbidium restricted to vaginant laminae …… *Sarawakia* (2)

a. Fissidens* Hedw. subgenus *Fissidens* section *Fissidens

Plants small to large, light to sordid green, terrestrial, saxicolous, lignicolous, usually in humid places, or aquatic, erect to decumbent, unbranched or branched; branches with basal rhizoids; persistent protonemata rare. Stem smooth, monomorphic, more or less of equal size, or dimorphic, non-fertile stems longer with a greater number of leaves, perichaetial stems short with few leaves; axillary hyaline nodules differentiated or not; rhizoids basal and axillary, tan to reddish; epidermis and outer 1– 4 tiers of cortical cells section small, thick-walled, pigmented or not; inner cortical cells large, thinwalled, hyaline; central strand differentiated or not; subterranean and axillary, multicellular, irregularly globose, rhizoidal gemmae rare; axillary, stalked multicellular, clavate gemmae infrequent.

Leaves imbricate to distant, few to numerous pairs pinnately arranaged, variable in shape; margin entire to serrulate, expecially at leaf apex; margin limbate, limbidium on all laminae, wholly or in part, or, less often, present only on vaginant laminae, infrequently confined to proximal parts of vaginant laminae of perichaetial leaves, sometimes not differentiated, limbidial cells uni- to pluristratose; costa variable in length, bryoides-type; dorsal lamina ending well above insertion to long-decurrent, mostly ending at insertion; vaginant laminae acute, equal to slightly unequal, minor lamina infrequently ending on costa; laminal cells usually quadrate to regularly hexagonal, rarely fusiform, unistratose to irregularly or regularly bi- to tristratose, firm-walled, smooth, flator bulging, rarely unipapillose (one species), infrequently pluripapillose, eguttulate. Monoicous; position of antheridia variable, perichaetia terminal on main stems or branches. Sporophytes 1–2 per perichaetium; seta long; theca exserted, erect, radially symmetric to 6 inclined, 6 arcuate, bilaterally symmetric, stomatose or infrequently estomatose; exothecial cells quadrate to oblong, vertical walls often thicker that horizontal walls, often collenchymatous; peristome bryoides-type, sometimes reduced. Spores finely papillose to smooth. Calyptra cucullate or mitrate, smooth. The limited number of stable characters makes it difficult to adequately circumscribe many species in this section. For example, the widespread *F. bryoides* is highly variable and taxonomically diverse.

Section *Fissidens* of subgenus *Fissidens* contain seven species in Western Ghats.

Key to the species of the section *Fissidens*

1a. Central strand present, limbidium slightly intramarginal at base of vaginant laminae by marginal rectangular cells …...…….....…….. *F. crispus*

1b. Central strand absent or indistinctly differentiated, limbidium not intra marginal …….. (2)

2a. Limbidium present on all laminae; dorsal lamina base not wedge shaped …. (3)

2b. Limbidium restricted to vaginant laminae only; dorsal almina base wedge shaped ……. *F. diversifolius*

3a. Limbidium continouous on all laminae; leaves linear lanceolate to oblong

lanceolate ……..…….. (4)

3b. Limbidium not continuous on all laminae; leaves oblong lingulate ... *F. viridulus*

4a. Limbidial cells 5 or 6 rows of elongated cells at vaginant laminae base …….

…….. *F. bryoides*

4b. Less than 3 rows of elongated limbidial cells at vaginant laminae base ..…… (5)

5a. Vaginant laminae apex equal, minor lamina closed …….…… *F. microdictyon*

5b. Vaginant laminae apex unequal, minor lamina slightly open ……..…..…….. (6)

6a. Plants dimorphic ……..…….. *F. curvatus*

6b. Plants monomorphic …….……..… *F. beckettii*

Fissidens beckettii Mitt., J. Linn. Soc., Botany. 13: 325. 1873; Gangulee, Moss. E. India & Adj. 1(2): 476. 1971, as *F. curvatoxiphoides* Dixon & P. de la Varde; Iwatsuki & Suzuki, Journ. Hattori Bot. Lab. 51: 371. 1982; Chaudhary *et al.,* Fl. North Konkan 104. 2008; Li & Iwatsuki, Moss Fl. China 2: 9. 2001; Pursell, Fissidentaceae Fl. Neo. Mono. 101: 100. 2007; Daniels, Archive Bryol. 65: 54. 2010.

Type. Sri Lanka: Maanagalla, Central Prov., Beckett 9 (holotype NY).

Fissidens curvatoxiphioides Dixon & P. de la Varde, Arch. Bot. Bull. Mens. 1(8–9): 163. 3 f. 1. 1927; *F. acanthophyllus* P. de la Varde, Rev. Bryol. Lichénol. 9: 197. 2. 1937; *F. aristatus* Sim, Trans. Roy. Soc. South Africa 15: 200. 1926; *F. burmensis* E.B. Bartram, Rev. Bryol. Lichénol. 23: 242. 1954; *F. calodictyon* Broth., Öfvers. Finska Vetensk.-Soc. Förh. 33: 94. 1891; *F. jaliscensis* Pursell, Cryptog. Bryol. Lichénol. 7: 37. f. 1–2. 1986; *F. mouensis* Thér., Bull. Acad. Int. Géogr. Bot. 20: 97. 1910; *F. quisqueyanus* Pursell, Bryologist 88: 74. f. 1–5. 1985; *F. simii* Schelpe, Mem. Bot. Surv. S. Africa 43: 5. 1979; *F. smilioides* P. de la Varde, Rev. Bryol. Lichénol. 5: 84. 1. 1933; *F. subpycnophyllus* P. de la Varde, Mouss. Oubangui 4: 17. 1 f. 1. 1930.

Plants small, light green to brownish, fertile leafy stems short, simple, 1.6–2.1 mm long, 1.3–1.4 mm wide; rhizoids reddish, smooth, basal axillary hyaline nodules indistinctly differentiated or absent, stem central strand lacking; leaves in 4–

5 pairs, lower leaves smaller, upper leaves much larger, 0.8–1.5 mm long, 0.2–0.4 mm wide, lanceolate to narrowly lanceolate, acute to narrowly acute at apex, margin almost entire; limbidia continuous on upper leaves except at the base of dorsal laminae, almost reaching at apex, confluent at apex, 1–3 cells wide and 1–2 cells thick on apical lamina, 6–10 cells wide and 1–2 cells thick on vaginant laminae, vaginant laminae 1/2–2/3 the leaf length, minor lamina apex open towards costa, uniseriate, base of dorsal laminae wedge-shaped, apical lamina and dorsal lamina uniseriate; costa stout, excurrent; cells of apical and dorsal laminae rhombic to oblong-hexagonal, 17–35 µm long, smooth, more or less thick-walled, cells of vaginant laminae similar to those of apical and dorsal laminae, but longer toward the base near costa, up to 42 µm long; gemmae not found.

Fertile parts, autoicous or rhizautoicous; perigonium and perichaetium terminal, with archegonia 200–230 µm long; setae 2.5–5.5 mm long; capsules inclined to horizontal, curved, asymmetrical, urns 0.25–0.50 mm long, exothecial cells quadrate to rectangular, thin-walled, with slightly thickened corners, opercula rostrate, 0.3 mm long, peristome teeth ca. 0.1 mm long, 31–35 µm wide at base, bryoides type, spores 11–16 µm in diameter (Plate 43 & Fig.19).

Diagnostic characters: *F. beckettii* Mitt. is characterised by small, rhizoautoicous plants with long seta, narrow leaves with excurrent apex, indistinctly differentiated axillary hyaline nodules, limbidium on all laminae, minor vaginant lamina apex close to costa, dorsal lamina base wedge shaped and laminal cells smooth.

Note: Gangulee (1971) described this species as *F. curvatoxiphoides* Dixon & P. de la Varde from India & Nepal which is synonymised under *Fissidens beckettii* Mitt. by Iwatsuki & Suzuki (1982). The earlier report of this species from Western Ghats is by Dixon & Potier de la Varde, 1930 (Shembaganur, Tamil Nadu as *Fissidens curvatoxiphioides* Dixon & P. de la Varde) and Foreau, 1961 (Tiger Shola, Tamil Nadu as *F. curvatoxiphioides*). Daniels (2010) relisted this species based on the above collections. In the present study I could not come across this species in the field and the above description is based on the collection from Mussoorie hills by Norkett. The characters are similar to species reported from Tamil Nadu.

Habitat and General Ecology: On soil and stone walls and also found in open grass lands at an altitudinal range of 600-1300 m.

Plate 43. *Fissidens becketii* Mitt., a-d. vegetative plants, e. vegetative leaves, f. leaf apex, g. capsule, h. dorsal lamina base near insertion, i. vaginant laminae base (Photo courtesi Dr. M. A. Bruggeman-Nannenga of Netherlands)

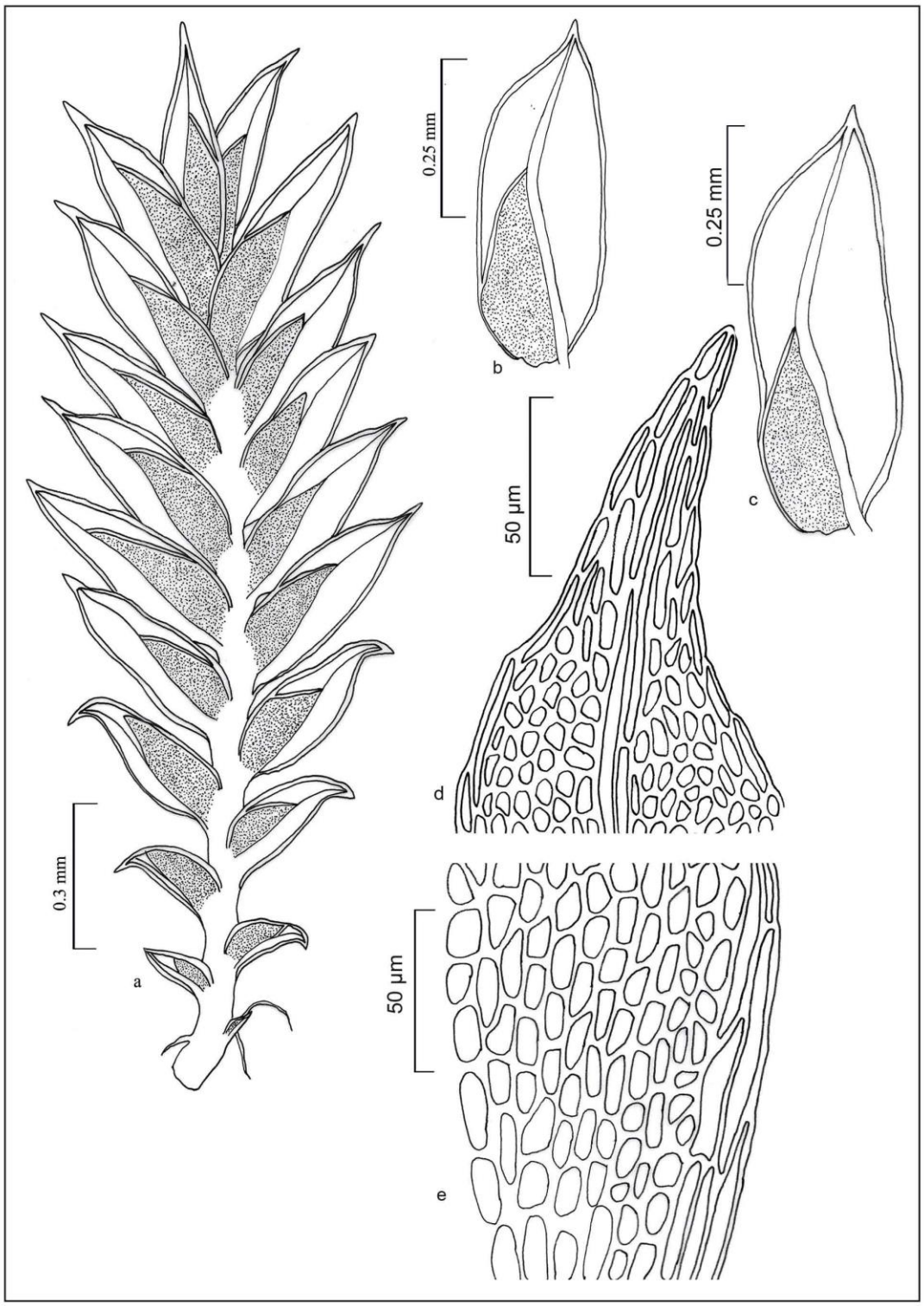
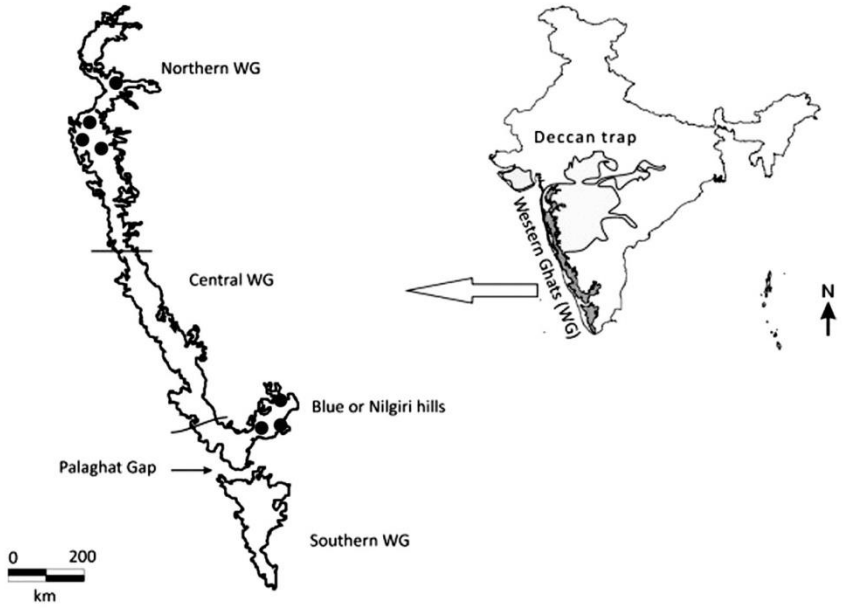


Fig. 19. *Fissdiens becketti* Mitt., a. vegetative plant, b&c. vegetative leaves, d. leaf apex, e. vaginant laminae base

Map. 22A. World distribution of ***Fissidens beckettii*** *Mitt.*



Map. 22B. Distribution of ***Fissidens beckettii*** *Mitt. in Western Ghats*

Distribution: India (Tamil Nadu, Maharashtra (as *F. curvatoxiphoides* Dixon & P. de la Varde), Western Himalaya (Mussoorie), (Chaudhary *et al.,* 2008; Daniels, 2010; Dabhade, 1998; Dixon & Potier de la Varde, 1930; Foreau, 1961; Gangulee, 1971; Magdum *et al*., 2017); Africa, China, Japan, Mexico, Myanmar, Nepal, Sri Lanka, West Indies, Yunnan (Bruggeman-Nannenga, 1997; Iwatsuki & Suzuki, 1982; Li & Iwatsuki, 2001; Pursell, 2007) (Map 22A&22B).

Specimens examined: India, Mussoorie (Path to Mossy falls), A.H. Norkett (12447) (BM!).

Etymology: The specific epithet *beckettii* honours the botanist 'Beckett' who collected the type specimen from Sri Lanka

Fissidens bryoides Hedw., Sp. Musc. Frond.153. 1801; Mont., Ann. Sci. Nat. Bot. 2, 17: 251. 1842; Dixon, Rec. Bot. Surv. India 6(3): 78. 1914 & J. Bombay Nat. Hist. Soc. 39: 772. 1937; Bruehl, Rec. Bot. Surv. India 13(1): 16. 1931; Wadhwa, M.V.M. Patrika 4: 90. 1969; Gangulee, Moss. E. India & Adj. 1(2): 469. f. 215. 1971; Iwatsuki & Suzuki, J. Hattori Bot. Lab. 51: 358. 1982; Bruggeman-Nannenga & Berendsen, J. Hattori Bot. Lab. 68: 201. 1990; Chaudhary & Deora. Moss Fl. Rajasthan 32. 1993; Dabhade, Moss. Khandala: 137. 1998; Beever, New Zealand J. Bot. 37: 661. 1999; Li & Iwatsuki, Moss Flora China 2: 12. 2001; Lal, Checkist Indian Moss.: 60. 2005; Chaudhary *et al.,* Bryo. Flora Gujarat: 69. 2006 & Bryoph. Fl. N. Konkan: 243. 2008; Manju *et al.,* Tropical Bryol. Res. Rep. 7: 12. 2008b;

Type: Europe.

Dicranum viridulum Sw., Monthly Rev. 34: 538. 1880; *Fissidens alpestris* (Lindb.) J.J. Amann, Fl. Mouss. Suisse 2: 407. 1918; *F. andersonii* Grout., Moss Fl. N. Amer.1: 252. 1939; *F. bryoides* subsp. *inconstans* (Schimp.) P. de la Varde, Rev. Bryol. Lichénol. 15: 32. 1945; *F. bryoides* var. *incurvus* (Starke *ex* Röhl.) Huebener, Muscol. Germ. 219. 1833; *F. bryoides* var. *pusillus* (Wilson) Pursell, Monogr. Syst. Bot. Missouri Bot. Gard. 49: 51. 1994; *F. exiguus* Sull., Musci Allegh. 182

[Schedae 44]. 1846; *F. exiguus* var. *falcatulus* (Renauld & Cardot) Grout., Moss Fl. N. Amer. 1: 15. 1936; *F. hawaiicus* E.B. Bartram, Bernice P. Bishop Mus. Bull. 101: 15. 1933; *F. inconstans* Schimp., Syn. Musc. Eur. (ed. 2) 114. 1876; *F. insularis* E.B. Bartram, Bernice P. Bishop Mus. Bull.101: 16. 1933; *F. longifolius* Brid., Muscol. Recent. Suppl. 1: 166. 1806; *F. minutulus* Sull., Musci Allegh. 3 [Schedae 44]. 1846; *F. viridulus* var. *pusillus* Wilson, Bryol. Brit. 303. 1855. *F. synoicus* Sull., Musci Hep. U.S. (repr.) 103. 1856; *F. pusillus* (Wilson) Milde., Bryol. Siles. 82. 1869; *Schistophyllum bryoides* (Hedw.) Lindb., Musci. Scand.; 13. 1879. *Fissidens texanus* Lesq. & James, Man. Mosses N. America 86. 1884. *F. bryoides* subsp. *alpestre* Lindb., Bot. Not. 1887: 40. 1887. *F. viridulus* var. *tamarindifolius* (Turner) Grout., Moss Fl. N. Amer. 1: 12. 1936; *F. viridulus* var. *texanus* (Lesq. & James) Grout., Moss Fl. N. Amer. 1: 12. 1936; *F. oahuensis* E.B. Bartram, Occas. Pap. Bernice Pauahi Bishop Mus. 15(8): 95. 1. 1939.

Plants light greenish, unbranched; stem with central strand, small, 2.5-6 x 1-3 mm, 4-8 pairs of leaves, monomorphic, rhizoids reddish brown, smooth, basal, axillary hyaline nodules weakly or not differentiated; leaves slightly imbricating, lanceolate to oblong, 1.39-2.03 x 0.28-0.42 mm, 4 or 5 times long as wide, apex acute to shortly apiculate, margin entire, confluent at apex; limbidium on all laminae, 5 or 6 rows on vaginant laminae base, 2-4 rows on apical lamina and dorsal lamina; vaginant laminae reaching 1/2 of leaf length, mostly equal, unistratose; dorsal lamina base narrow, some normal cells present in the margin of dorsal lamina insertion, dorsal lamina and apical lamina uniseriate; costa prominent, slightly excurrent or ending few cells below apex, bryoides type; laminal cells distinct, smooth, irregularly polygonal, compactly arranged, slightly bulged or not, mid vaginant laminal cells plane, 12.47-18.05 x 7.66-18.87 µm, mid dorsal laminal cells plane, 8.01-11.07 x 6.15-8.79 µm; gemmae not found (Plate 44-46 & Fig.20).

Fertile parts not found.

Plate 44. *Fissidens bryoides* Hedw., habit & habitats; a,b. on exposed roots, c. logs, d. rock, e. on land cuttings, f. on soil.

Plate 45. *Fissidens bryoides* Hedw., habit & habitats; a-e. habit, f. enlarged view, a&e. on rocks, b-d&f. on land cuttings

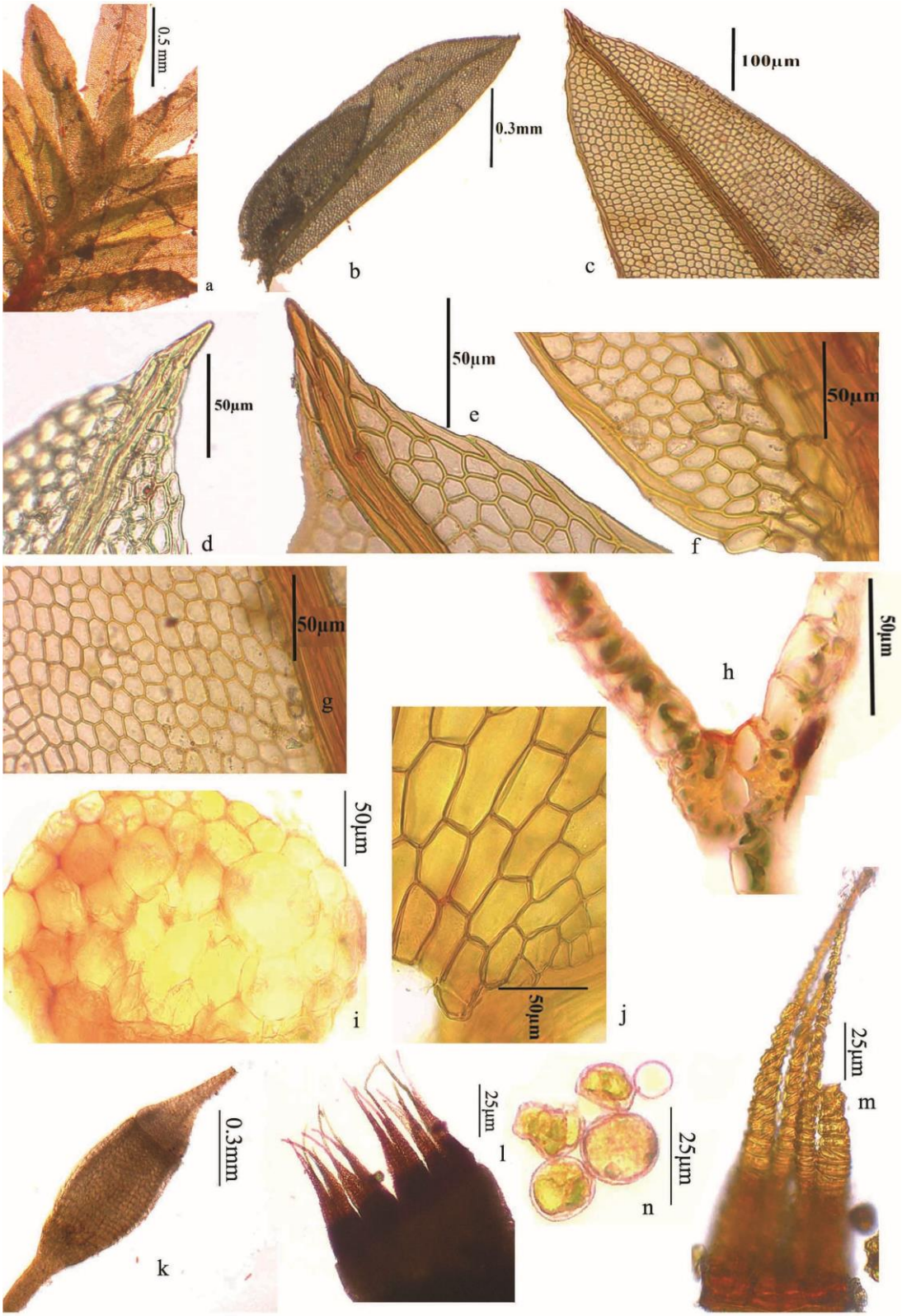


Plate 46. *Fissidens bryoides* Hedw., a. branch, b. vegetative leaf, c-e. leaf apex, f. dorsal lamina base near insertion, g. laminal cells, h. leaf T.S., i. stem T.S., j. vaginant laminae base, k. capsule, l&m peristome, n. spores.

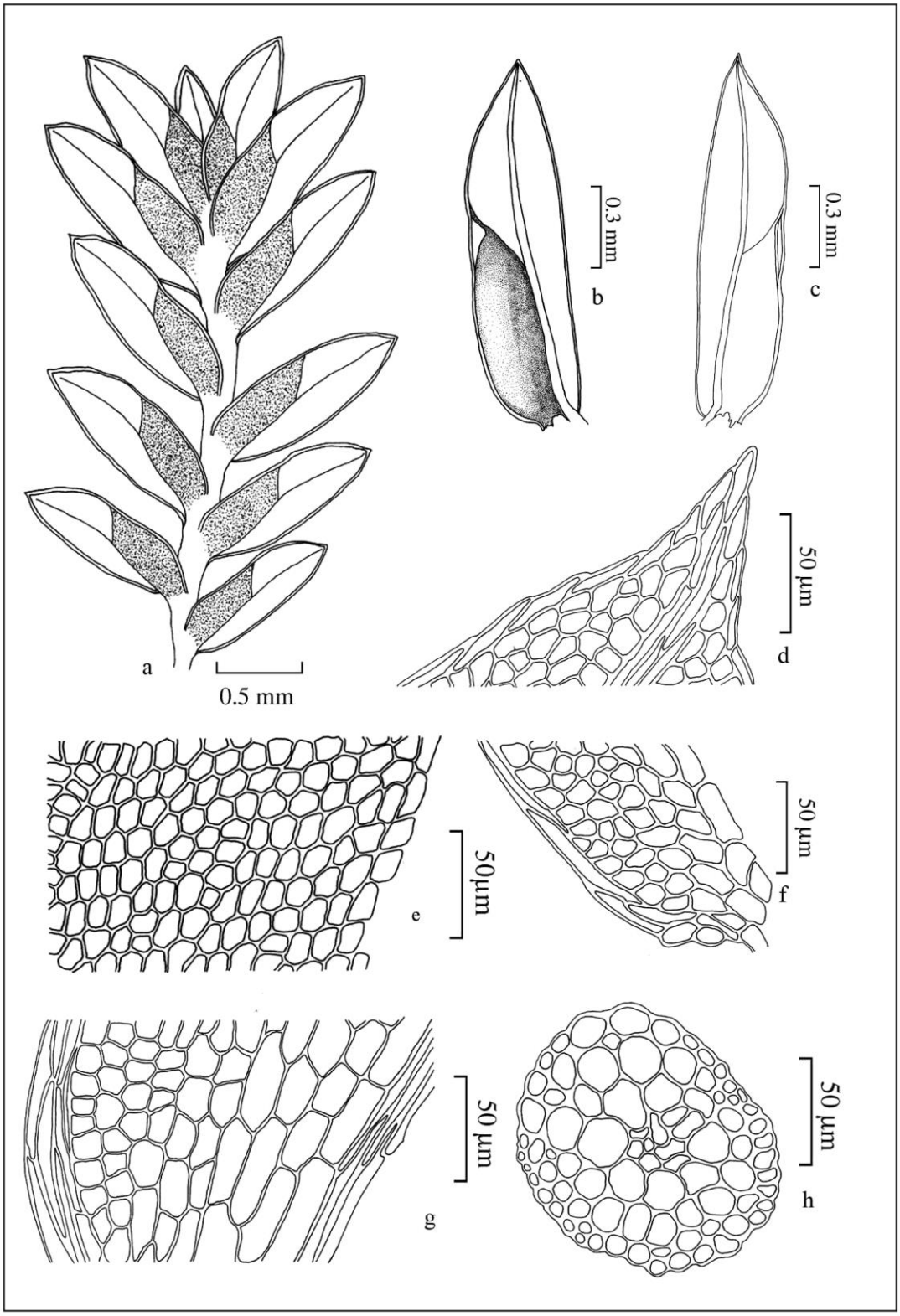


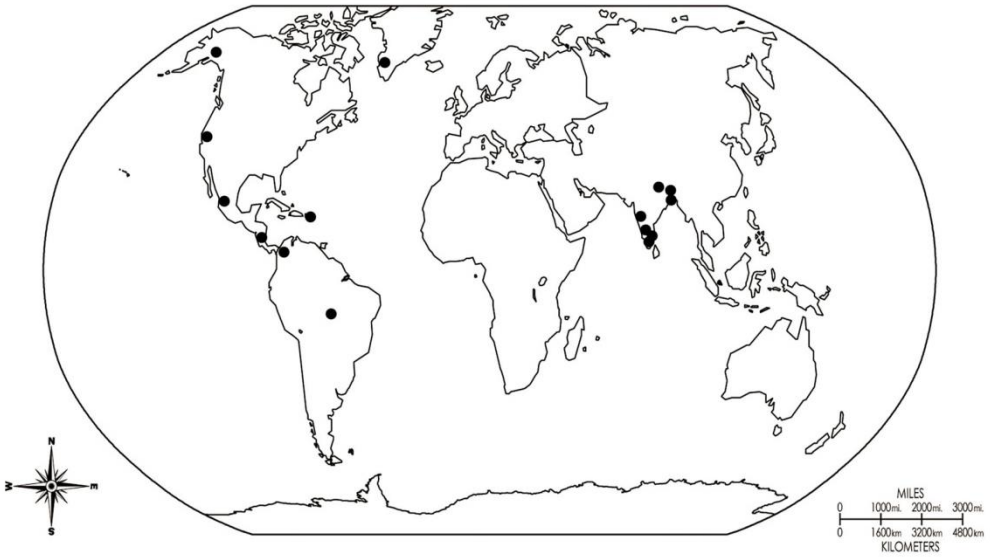
Fig. 20. *Fissidens bryoides* Hedw., a. vegetative plant, b&c. vegetative leaves, d. leaf apex, e. laminal cells, f. dorsal lamina base near insertion, g. vaginant laminae base, h. stem T.S.

Diagnostic characters: *F. bryoides* Hedw. is characterised by lanceolate to oblong leaves with complete limbidium, 1-3 cells thick, confluent at the leaf apex with the percurrent to short-excurrent costa and smooth cells.

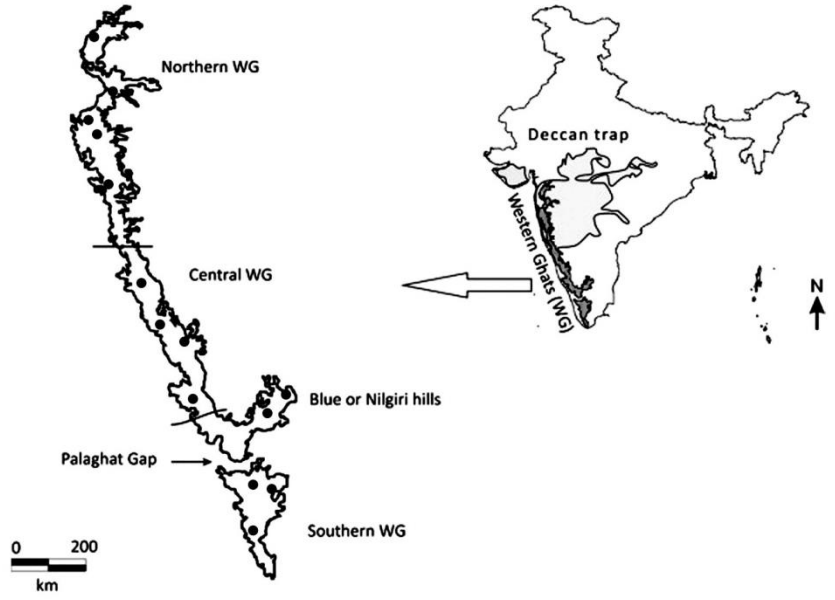
Note: *F. bryoides* is considered as a complex of species and most of the authors synonymised several species under *F. bryoides* based on wide variation in characters such as leaf shape, nature of limbidium, position and nature of perichaetium and perigonium. One of the specimen collected from Nandhi hills in Karnataka shows wide variation from F. bryoides reported from Western Ghats, hence the specimens from Koarnataka is considered as a separate species as *F. viridulus.* This species was synonimised by Pursell (1994) under *F. bryoides.* The types of varieties of *F. viridulus* could not trace now, hence kept under the synonym of *F. bryoides.* Gangulee (1971) considered *F. viridulus* this as a separate species based on the collection by Norkett from Nepal.

Habitat and General Ecology: Common species in all type of terrestrial habitats. It grows as thick mat on soil, land cuttings, large rocks, small rocks and crevices of rocks. This species is usually prefer to grow in isolated clusters but also seen as scattered along with other bryophytes such as *Cyathodium cavernarum* Kunze, *Garckea flexuosa* (Griff.) Margad. & Nork. and *Anthoceros crispulus* (Mont.) Douin., in moist deciduous forests, semi evergreen forest and in open lands.

Distribution: India (Assam, Ranikhet, Rajasthan, Shimla, N.W. Himalayas, West Bengal, Kerala, Goa, Maharashtra, Gujarat, Tamil Nadu (Nilgiri, Coonoor), Karnataka) (Chaudhary *et al.*, 2006, 2008; Dabhade, 1998; Daniels, 2010; Daniels & Daniel, 2013; Gangulee, 1971; Manju *et al.*, 2008b; Magdum *et al*., 2017; Montagne 1842; Nair *et al.,* 2005; Rani *et al.,* 2014); Alaska, California, Central America, Colombia, Europe, Greenland, Mexico, South America, West Indies, (Iwatsuki & Suzuki, 1982; Li & Iwatsuki, 2001; Lal, 2005). The present collection is a new record to Goa. (Map 23A&23B).



Map. 23A. World distribution of Fissidens bryoides Hedw.



Map. 23B. Distribution of Fissidens bryoides Hedw. in Western Ghats

Specimens examined: India, Karnataka, Sirsi (1750ft), 19.09.2014, Manjula & Deepa (ZGC 3623), Kilagar (1343m), 18.09.2014, Manjula & Deepa (ZGC 3572), Kalathagiri (3180ft), 20.09.2014, Manjula & Deepa (ZGC 3636), Southi (235m), 18.09.2014, Manjula & Deepa (ZGC 3671); Kerala, Ernakulam district, Neriamangalam, Idukki road (115m), 24.07.2015, Manjula (ZGC 15084); Malappuram district (Canoly's plot, 60 m), 24.07.2013, Manjula, K.M. (ZGC 666); Goa, Cancona, (Cotigao Wildlife Sanctuary, 88 m), 15.08.2015 Manjula & Deepa (ZGC 15124); Maharashtra, Mahabaleshwar, 868 m. 10. 11. 2016. Manjula (ZGC 16203), Nashik (Brahmagiri hills, 1020 m), 16. 09. 2017, Manjula (ZGC 7755), Kolhapur, Way to Mahabaleshwar (868m), 10.11.2016, Manjula (ZGC 16200); Gujarat, Gira fall, 18.09.2017, Manjula (ZGC 7762).

Etymology: The specific epithet *bryoides* has the defined translation, *bryo* (related to mosses) + *oides* (resembling).

Fissidens crispus Mont., Ann. Sci. Nat., Bot., sér.2 9: 57. 1838; Pursell, Fissidentaceae Fl. Neotrop. Monogr. 101: 78. 2007; Erzberger, Studia. Bot. Hung. 47(1): 76. 2016.

Type: Argentina, Sylvis Provinciae (holotype: PC) Isotype (BM!, FH, PC)

Fissidens repandus Wilson, Hooker's J. Bot. Kew Gard. Misc. 3: 52. 1851; *F. limbatus* Sull., Rep. Expl. Surv. Railr. Route. Mosses & Liverw. 4(5): 185. 1856; *F. tortilis* Hampe & Muell. Hal. in Muell. Hal., Bot. Zeitung (Berlin) 22: 340. 1864; *F. subcrispus* Besch. Mém. Soc. Sci. Nat. Cherbourg 21: 260. 1877; *F. chrysopoma* Muell. Hal. *ex* Pol., J. Bot. 6: 227. 1877; *F. reclinatulus* Muell. Hal. *ex* Pol., J. Bot. 6:227. 1877; *F. reclinatulus* Muell. Hal. *ex* Renauld & Cardot, Bull. Soc. Roy. Bot. Belgique 31(1): 153. 1892; *F. lonchothecius* Muell. Hal., Linnaea 42: 239. 1879; *F. fendleri* Muell. Hal., Linnaea 42: 465. 1879; *F. oligophyllus* Muell. Hal., Nuovo Giorn. Bot. Ital., n. ser., 4: 6. 1897; *F. stenosemus* Schimp. *ex* Muell. Hal., Nuovo Giorn. Bot. Ital., n. ser., 4: 6 and 164. 1897; *F. carionis* Muell. Hal., Bull. Herb. Boissier 5: 171. 1897; *F. fasciculato-bryoides* Muell. Hal., Bull. Herb. Boissier 5:

172. 1897; *F. aequalis* E.S. Salmon, Ann. Bot. 13: 120. 1899; *F. crispans* Schimp. *ex* E.S. Salmon, Ann. Bot. 13: 120. 1899; *F. percrispus* Muell. Hal., Gen. Musc. Frond. 57: 1901 (1900); *F. circinatulus* Besch. *in* Geh., Rev. Bryol. 28: 64. 1901; *F. pusillus* (Wilson) Milde, var. *brevifolius* Cardot & Thér., Bot. Gaz. 37: 365. 1904; *F. chilensis* Dusén, Ark. Bot. 6: 1. 1906; *F. subaloma* Dusén, Ark. Bot. 6: 2. 1906; *F. pringlei* Cardot, Rev. Bryol. 36: 69. 1909; *F. reclinatulua* var. *brevifolius* Cardot, Rev. Bryol. 36: 69. 1909; *F. heribaudii* Broth. & Paris *ex* Cardot, Rev. Bryol. 40: 33. 1913; *F. sanctae-crucis* Broth. in Herzog, Biblioth. Bot. 87: 26.1916; *F. pauper* Herzog, Biblioth. Bot. 87: 166. 1916; *F. costesii* Thér., Revista Chilena Hist. Nat. 25: 292. 1921; *F. pseudoincurvatus* Muell. Hal. *ex* Broth., Akad. Wiss. Wien, Math. Naturwiss. Kl., Denkschr. 83:272. 1927; *F. pseudoincurvatus* var. *latifolius* Broth., Akad. Wiss. Wien, Math. Naturwiss. Kl., Denkschr. 83:272. 1927; *F. alticaulis* Broth., Akad. Wiss. Wien, Math. Naturwiss. Kl., Denkschr. 83:272. 1927; *F. fernandezianus* Broth. in kottsb., Nat. Hist. Juan Fernandez 2: 416. 1924; *F. arsenei* Broth. & Paris *ex* Thér., Smithsonian Misc. Collct. 78: 8. 1926; *F. pennaeformis* Paris *ex* Thér., Smithsonian Misc. Collct. 78: 9 1926; *F. longidecurrens* Thér., Smithsonian Misc. Collct. 78: 10. 1926; *F. flexuosus* Thér., Smithsonian Misc. Collct. 78: 11. 1926; *F. tortilis* var. *cubensis* Thér. Mem. Soc. Cub. Hist. Nat. "Felipe Poey" 13: 205. 1939; *Fissidens bryoides* subsp. *schmidii* (Muell. Hal.) Norkett in Gangulee, Moss. E. India & Adj. 471. 1971.

Plants in mats, main stem usually unbranched, stem with or without central strand, 2-4 tiers of thin walled large inner and two or three tiers of small thick walled outer cortical cells; vegetative stem 4-10 x 1.50-2.50 mm, 6-12 pairs of leaves; rhizoids bright brown to red, smooth, axillary hyaline nodules present; leaves slightly crispate and curls when dry, oblong-lingulate with acute to sub-acute apex, margin entire, 1.03-1.80 x 0.35-0.46 mm; limbidium and costa often brown in older specimens, limbidium complete and reaching up to leaf apex, confluent at the apex of vaginant laminae, three to five stratose at vaginant laminae, marginal or intramarginal by one row of cells near the insertion of vaginant laminae, one or two

stratose at apex, 2 stratose throughout in dorsal lamina; vaginant laminae slightly open or closed and reaches 1/2 of leaf length with a small bend where it leaves apical lamina, 0.20-0.30 mm wide at base, vaginant laminae and apical lamina base wider than dorsal lamina, unistratose; dorsal lamina narrows towards base, not deccurrent, ending before insertion, 3-5 cells wide; costa prominent, yellowish green in young specimens and reaches upto leaf apex or ending one or two cells below leaf apex and joins to limbidial cells, sometimes slightly excurrent, bryoides type; laminal cells irregularly quandrangular to hexagonal, obscure, justa costal cells elongated quadrangular, mid dorsal laminal cells slightly oval, convex 14.49-14.70 x 8.23-9.10 µm, apical cells 33.50-40.91 x 7.64-8.62 µm; mid vaginant laminal cells 9.48-12.70 x 8.90-11.92 µm, vaginant laminae basal cells 21.60-30.93 x 9.79-10.48 µm; gemmae not found.

Fertile parts, perigonial branch attached to the main stem by rhizoids, 5-8 pairs of leaves, 3.00-4.50 mm long, eight or nine row of limbidium, perigonia terminal, 0.26-0.30 mm long; perichaetia terminal, perichaetial leaves long 1.30-1.50 x 0.26-0.40 mm, archegonia 0.20-0.30 mm long; sporophyte not found (Plate 47 & Fig.21).

Diagnostic characters: *F. crispus* Mont. is characterised by wavy leaf margin, complete limbidium, excurrent costa, obscure laminal cells and distinct mid dorsal laminal cells and mid vaginant laminal cells in cross section.

Note: *F. bryoides* Hedw. and *F. crispus* Mont. are very similar species in leaf structure and limbidium, but in *F. bryoides* some leaves are weakly serrulate near apex, costa mostly not excurrent and perichaetial leaf more or less similar to vegetative leaf and calyptra mitrate. Gangulee (1971) separated *F. schimidii* Möll. Hal. (Type- India; Nilgiri, B. Schmid 43b) to the subspecies of *F. bryoides* as *F. bryoides* subsp. *schmidii* (Muell. Hal.) Nork. Later it is synonimised *F. bryoides* subsp. *schmidii* under *F. crispus*. Sreenivasan (1974) listed this species as *Fissidens*

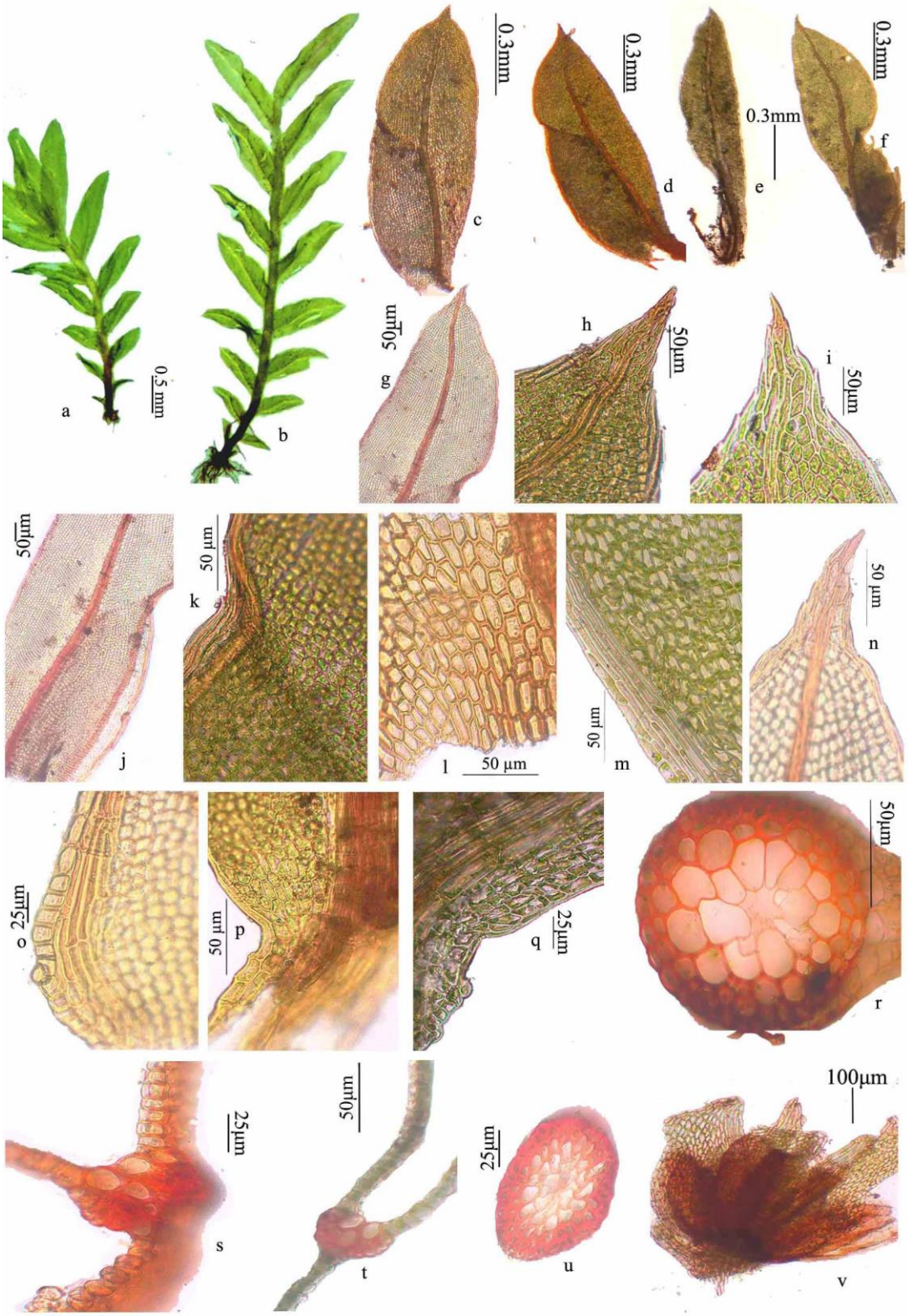


Plate 47. *Fissidens crispus* Mont., a. fertile plant, b. sterile plant, c&d. vegetative leaves, e. perichaetial leaf, f. perigonial leaf, g-i. leaf apex, j. vaginant laminae, k. vaginant laminae apex, l. vaginant laminae base, m&o. limbidium on vaginant laminae, n. leaf apex, p&q. dorsal lamina base near insertion, r. stem T.S., s&t. leaf T.S., u. seta T.S., v.perigonium (a-f, h, i, k, m, p-r, t from ZGC 1098; g, j, l, n, o, s, u, v from ZGC 111863(C).

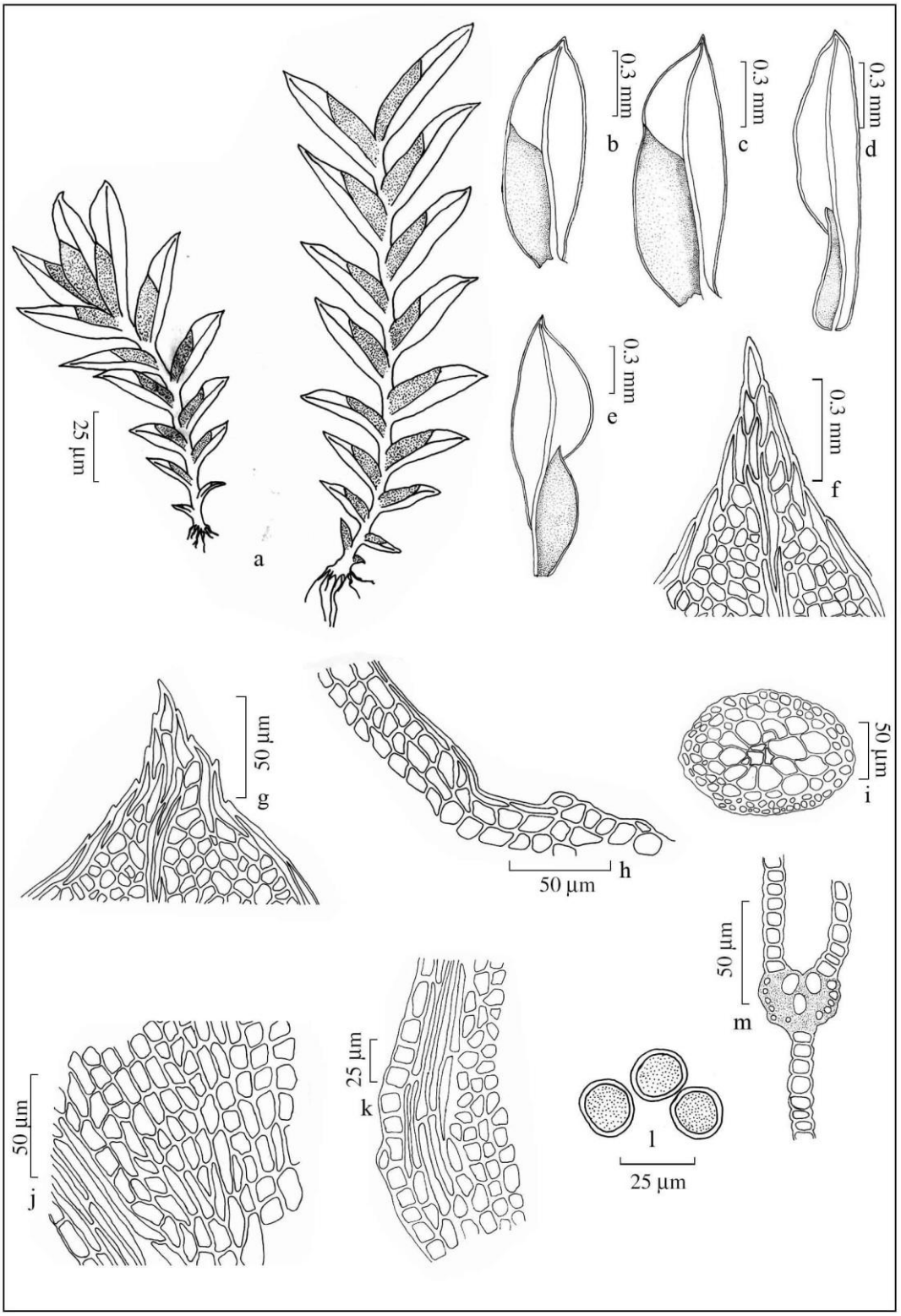


Fig. 21. *Fissidens crispus* Mont., a. vegetative plant, b&c. vegetative leaves, d&e. fertile leaves, f&g. leaf apex, h. dorsal lamina base with limbidium, i. stem T.S., j&k. vaginant laminae base with limbidium, l. spores, m. leaf T. S.

schmidii Möll. Hal. from Kerala. Then Easa (2003) and Manju *et al.* (2008b) relisted this species based on Sreenivasan (1974).

Habitat and General Ecology: On moist soil, rotting logs, tree trunks and land cuttings in evergreen and shola forests along with *Fissidens enervis* Sim, *F. crispulus* Brid. and *Philonotis hastata* (Duby) Wijk & Margad between 900-1100 m altitude. Pursell (2007) reported the occurrence of this species in an altitudinal range of 20-4300 m in the Neotropics.

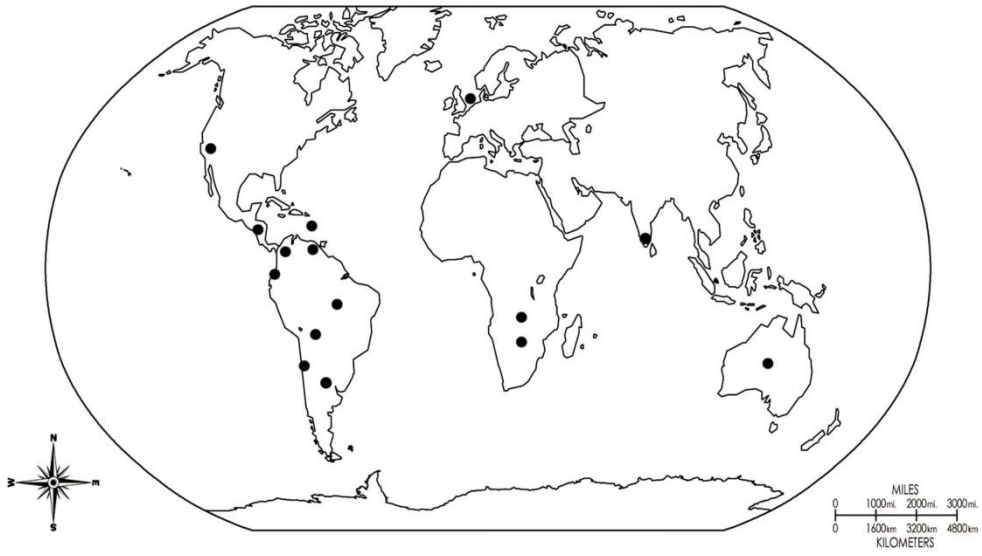
Distribution: India (Karnataka Kerala, Tamil Nadu (Dixon & Potier de la Varde, 1930; Foreau, 1930, 1961; Frahm *et al*., 2013; Gangulee, 1971; Manju *et al*., 2008b; Muller, 1853; Schwarz, 2014b); Canada, Central America, (Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Panama), Mexico, Hungary, South America (Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Paraguay, Peru, Uruguay, Venezuela) (Erzberger, 2016; Pursell 2007). The present report of this species from Kerala is a detailed description of this species from Kerala (Map 24A&24B).

Specimens examined: India, Kerala; Palakkad district (Nelliyampathy, $10^0 53' 55''$ N, $76^0 68' 37''$ E, 900m), 12.07.2014, Manjula, K.M. (ZGC 1098A, 1093A), Malappuram (New Amarambalam, $11^0 34' 34''$ N, $76^0 41'$ E, 1050m), K.P. Rajesh 111863c (CALI).

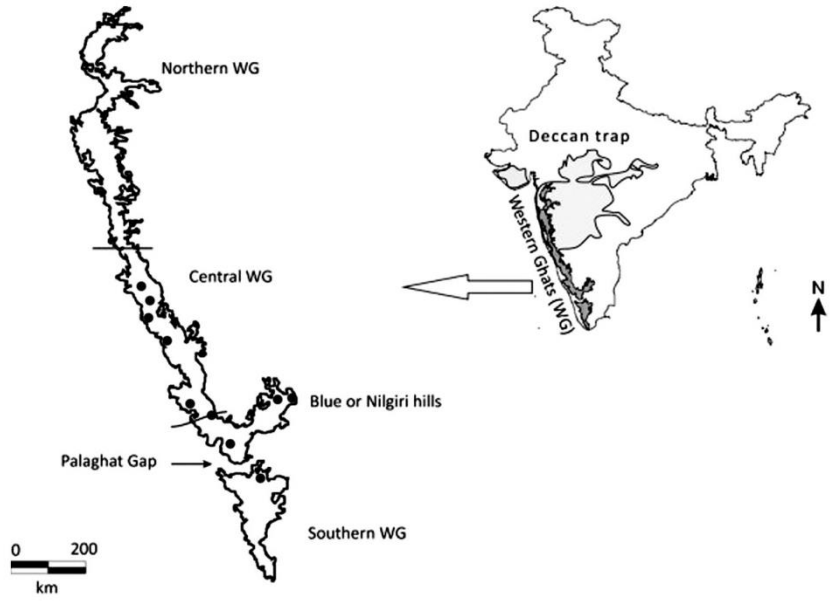
Etymology: The specific epithet *crispus* refers to the strongly crispate leaves in dry condition.

Fissidens curvatus Hornsch., Linnaea 15: 148. 1841.; Gangulee, Moss. E. India & Adj. 2: 475. F. 218. 1971; Beever, New Zealand J. Bot. 37: 661. 1999; Li & Iwatsuki, Moss Fl. China 2: 26. 2001; Pursell, Fissidentaceae Fl. Neotrop. Monogr. 101: 102. 2007; Erzberger, Studia. Bot. Hung. 47(1): 79. 2016.

Type*:* South Africa, An einer Mauer in Mr. Aurets Garten unter dem Löwenreucken, den 24. Octbr. 1827, *Ecklon s.n.* (Lectotype H-BR).



Map. 24A. World distribution of Fissidens crispus Mont.



Map. 24B. Distribution of Fissidens crispus Mont. in Western Ghats

Fissidens laxifolius Hornsch., Linnaea 15: 149. 1841; *F. cuspidatus* Muell. Hal., Linnaea 17: 588. 1843; *F. pungens* Hampe & Muell. Hal., Linnaea 26: 502. 1853[1855]; *Conomitrium gracile* Hampe, Bot. Zeitung (Berlin) 17: 197. 1859;*Fissidens gracilis* (Hampe) A. Jaeger, Enum. Fissident. 12. 1869; *Conomitrium lindigii* Hampe, Linnaea 31: 532. 1862; *Fissidens algarvicus* Solms, Tent. Bryo-Geogr. Algarv. 41. 1868; *F. lindgii* (Hampe) A. Jaeger, Enum. Fissident. 12. 1869; *F. tequendamensis* Mitt., J. Linn. Soc., Bot. 12: 601. 1869; *F. luteo-viridis* Lindb. *ex* Ångstr., Öfvers. Förh. Kongl. Svenska Vetensk.-Akad. 33(4): 48. 1876; *F. indistinctus* Muell. Hal., Linnaea 42: 238. 1879; *F. campyloneurus* Beckett, Trans. & Proc. New Zealand Inst. 25: 295. 44. 1893; *F. capillisetus* Broth., Bih. Kongl., Svenska Vetensk.-Akad. Handl. 21 Afd. 3(3): 17. 1895; *F. perexilis* Broth., Bih. Kongl. Svenska Vetensk.-Akad. Handl. 21 Afd. 3(3): 13. 1895; *F. strictulus* Muell. Hal., Nuovo Giorn. Bot. Ital., n.s. 5: 159. 1898; *F. pycnophyllus* Muell. Hal., Hedwigia 38: 57. 1899; *F. laxereticulatus* Besch., Rev. Bryol. Geh. 28: 63. 1901; *F. minutissimus* Besch. & Geh., Rev. Bryol. 28: 62. 1901; *F. brotheri* Dusén, Ark. Bot.6(8): 3. 2. f. 1–7. 1906; *F. francii* Thér., Bull. Acad. Int. Géogr. Bot. 17: 307. 1907; *F. minusculus* Broth. & Paris, Öfvers. Finska Vetensk.-Soc. Förh. 51A(17): 7. 1909; *F. aberrans* Broth. & Dixon, J. Bot. 53: 261. 540 f. 3. 1915; *F. aristatus* Broth., Proc. Linn. Soc. New South Wales 41: 578. 1916; *F. bockii* Herzog, Biblioth. Bot. 87: 25. 5a–d. 1916; *F. brotherianus* Paris, Revista Chilena Hist. Nat. 25: 290. 1921; *F. brotherianus* var. *longisetus* Thér., Revista Chilena Hist. Nat. 25: 290. 1921; *F, angustinervis* thér., Recueil Publ. Soc. Havraise Études Diverses 90: 80. 1923; *F. valdiviensis* Herzog., Hedwigia 64: 9. 1923; *F. crassicuspis* Broth., Nat. Hist. Juan Fernandez 2: 417. pl. 26: f. 5–8. 1924; *F. diversiformis* Broth., Acta Horti Gothob. 1: 190. 1924; *F. subinclinatulus* Muell. Hal. *ex* Broth., Ergebn. Bot. Exped. Seudbras., Musci 1901 273. 1924; *F. filirameus* R.S. Williams, Publ. Field Mus. Nat. Hist., Bot. Ser. 4(5): 126. pl. 1. 1927; *F. subxiphioides* Broth., Symb. Sin. 4: 9. 1929; *F. lindigii* var. *latifolius* P. de la Varde & Thér., Mem. Soc. Cub. Hist. Nat. "Felipe Poey" 13: 207. 1939; *F. saxatilis* Tuzibe & Nog., J. Jap. Bot. 24: 145. 1. 1949; *F. milobakeri* L.F. Koch, Bryologist 54: 206. A–F. 1951; *F. flavosetus* Pursell, Bryologist 63: 98. 1–16. 1960; *F. rambii* Gangulee, Moss. E. India & Adj. 2: 475. f. 218. 1971.

Plants dimorphic, delicate, unbranched or branched from older parts, Fertile plants mixed with sterile shoots, light green, 0.10-1.96 x 0.55-0.81 mm, central strand present or absent; axillary hyaline nodules present or reduced; rhizoids light reddish, smooth; leaves lanceolate, crispate when dry, 5-10 pairs, 0.47-0.61 x 0.08-0.10 mm, 6 times long as wide, apex acute or acuminate, mostly ending in a single costal cell, margin entire; limbidium present on all laminae, confluent or not at the apex, two or three rowed at vaginant laminae base, 2 rowed at dorsal lamina base, intramarginal in some vaginant laminae base; vaginant laminae 0.32-0.39 mm long, 0.39-0.43 mm wide at base, open unequal, reaching ½ or 3/4 of apical lamina, uniseriate; dorsal lamina 0.19-0.24 mm wide at base, narrows towards leaf insertion and ending much above insertion, base not round, apical lamina and dorsal lamina uniseriate; costa strong, slightly excurrent or ending one or two cells below leaf apex but costal cells extend upto apex, bryoides type; laminal cells irregularly rectangular, slightly bulging, smooth, 13.44-20.12 x 6.10-7.18 µm, laminal cells of vaginant laminae base elongated; gemmae not found.

Fertile parts. Monoicous (rhizoautoicous); perigonia not found; perichaetia terminal, 3 or 4 pairs of leaves, limbidium complete, upto 5 rows at vaginant lamina base, costa slightly excurrent; setae 3-4 mm; capsule 0.3-0.5 x 0.2-0.3 mm, 19-24 columns of exothecial cells, indistinct trigones in upper cells, peristome bryoides type, 0.10-0.16 mm, base 41.26-51.66 µm, perforations in some bases; spores globose, 19.99-21.75 µm (Plate 48-49 & Fig.22).

Diagnostic characters: *F. curvatus* Hornsch. is characterised by dimorphic plant with very small fertile and large sterile plants, limbidium distinct on leaves, confluent at apex, excurrent costa and very long seta. This species is similar to *F. taylorii* Muell. Hal., however which has short costa and poorly developed limbidium.

Note: Gangulee reported this species as *F. rambii* Gangulee in India (Gangulee, 1971) from Darjeeling. This species is synonymised by Pursell (2007) under *F. curvatus.* The earlier report of this species from Western Ghats is based on previous data including collection from Perumalmalai Shola, Manalur, Lower Pulneys and Sirumalai [Dixon & Potier de la Varde 1927: 177]; Upper Palnis: Tiger Shola, Perumalmalai; Lower Palnis: Manalur (Foreau, 1930; Matthew, 1973) in Tamil

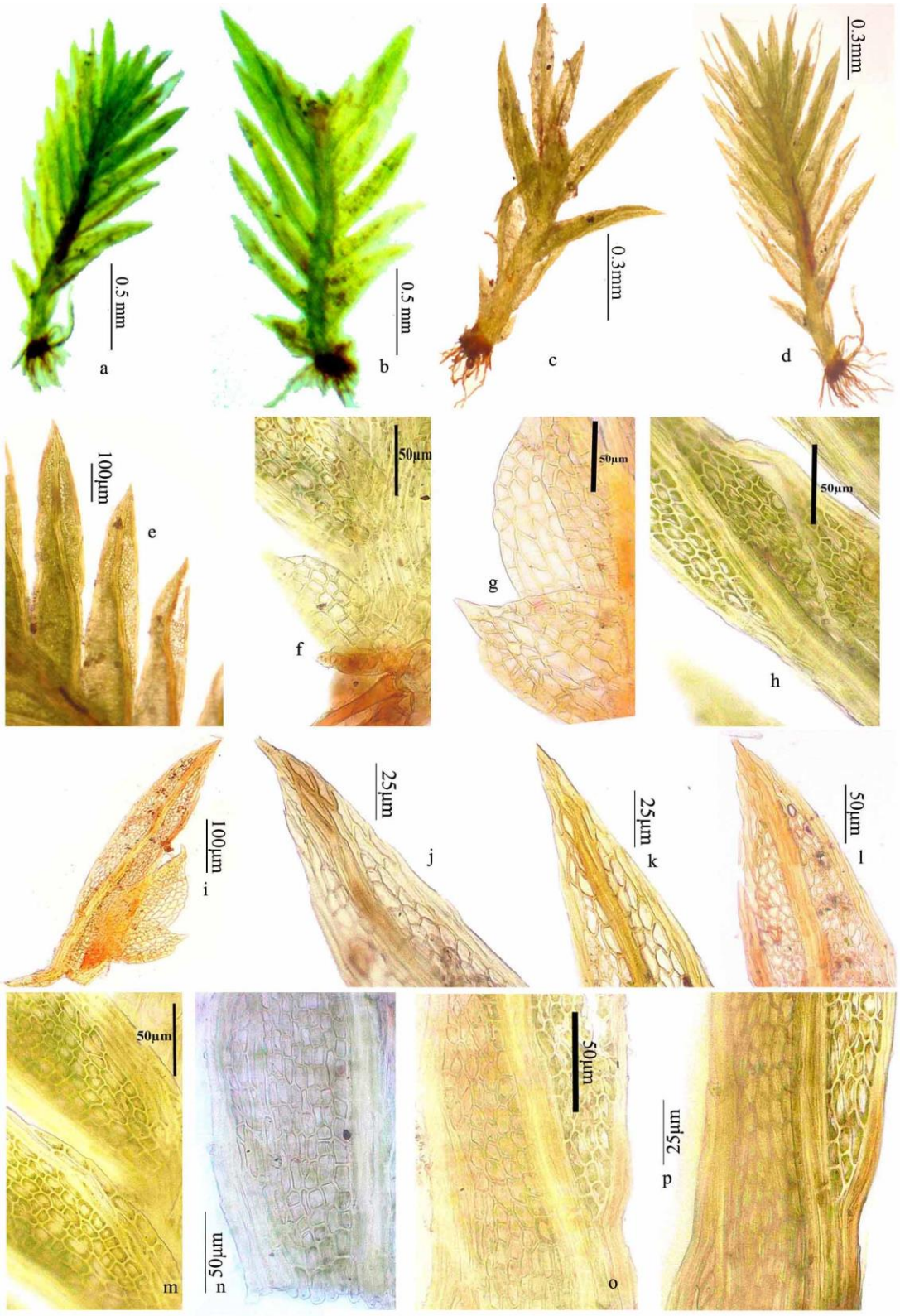


Plate 48. *Fissidens curvatus* Hornsch., a-d. vegetative plant, e. vegetative leaf, f. basal leaf, g. branch initials from leaf midrib, h&o. laminal cells, i. vegetative leaf with branch initial, j-l. leaf apex, m&n. vaginant laminae base, p. dorsal lamina base

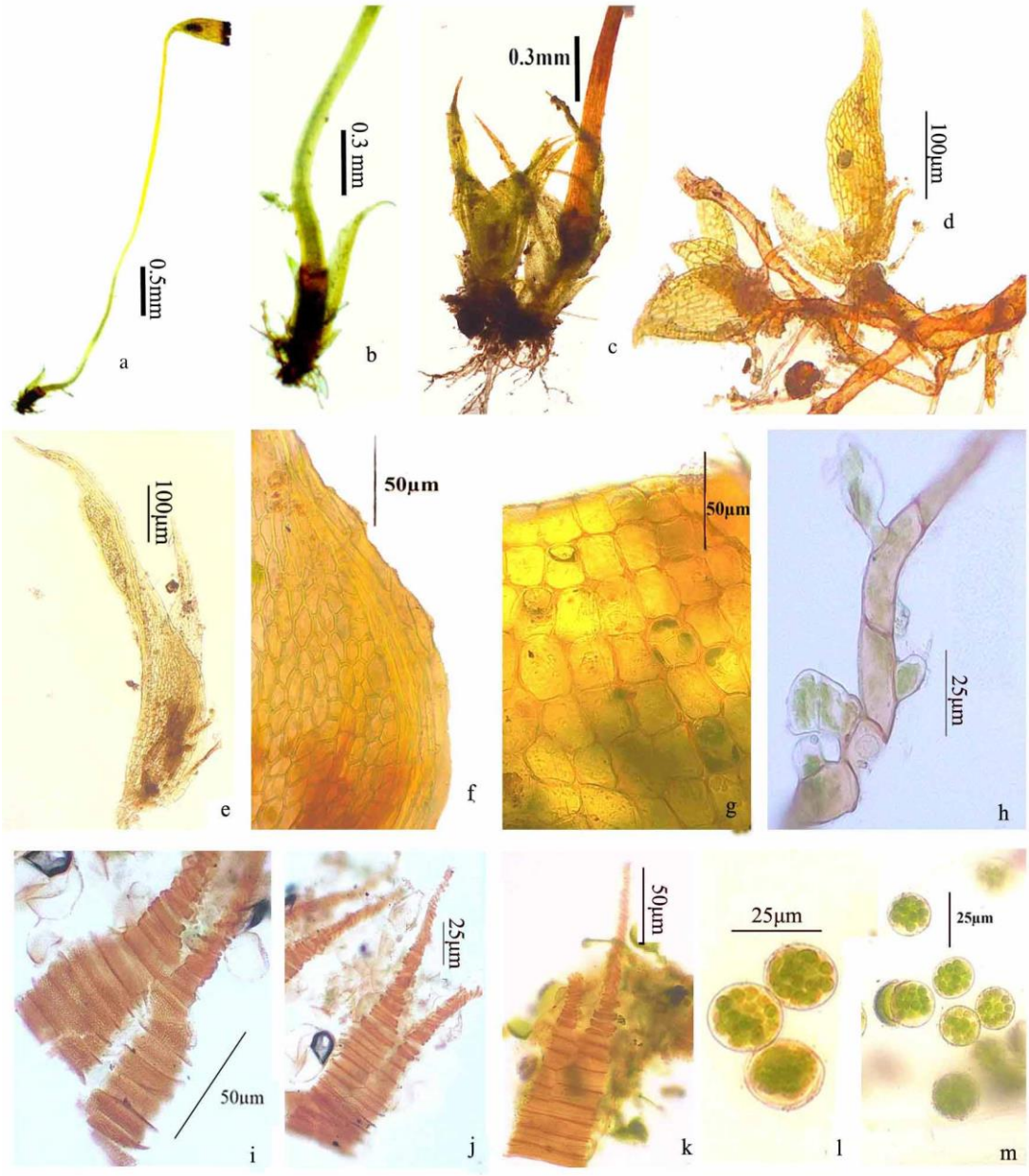


Plate 49. Fissidens curvatus Hornsch., a-d. fertile plants, e. perichaetial leaf, f. vaginant laminae base, g. exothecial cells, h. protonema, i-k. peristome, l&m. spores.

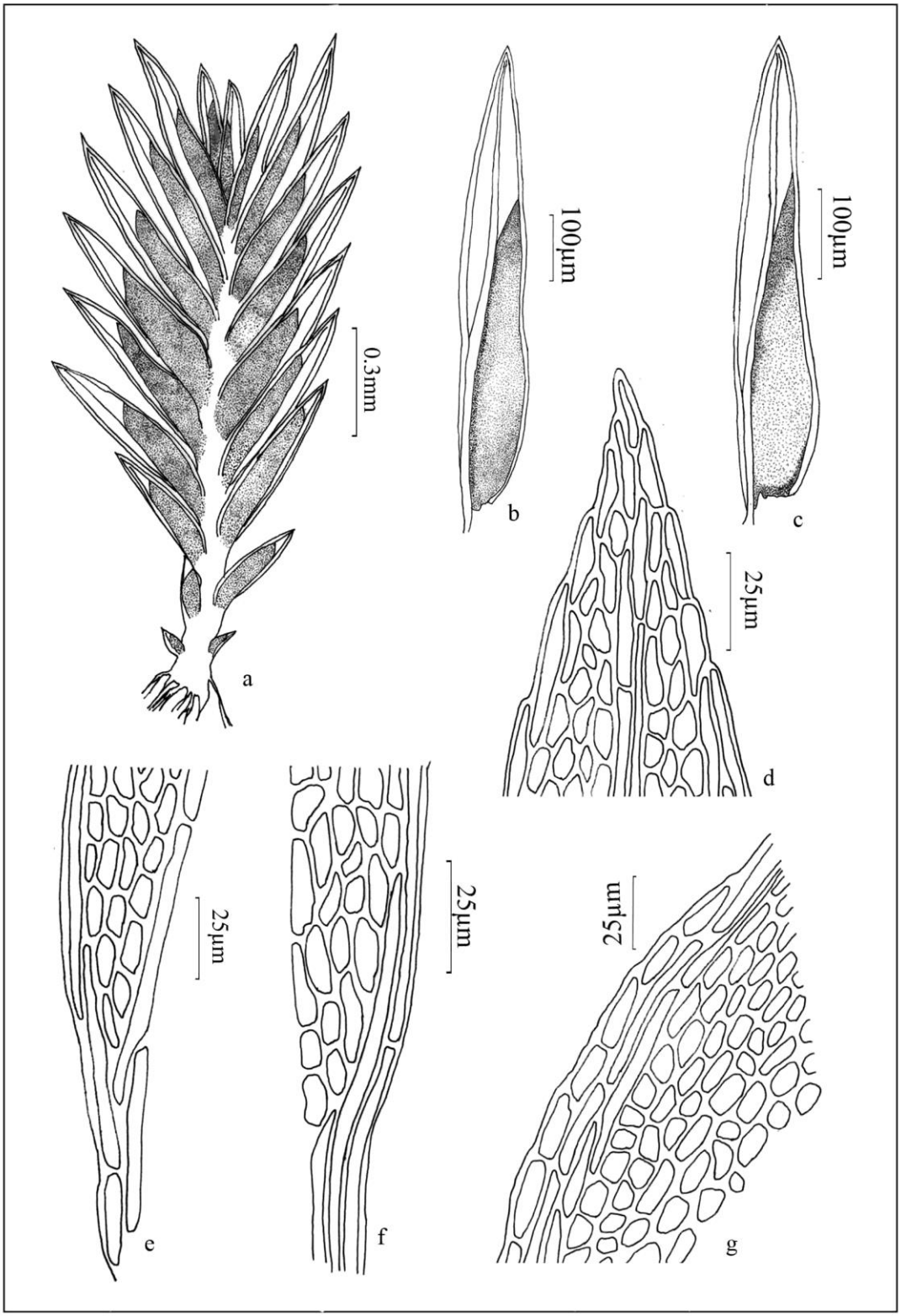


Fig. 22: *Fissidens curvatus* Hornsch., a. vegetative plant, b&c. vagetative leaves, d. leaf apex, e&f. dorsal lamina base with limbidium, g. vaginant laminae base with limbidium

Nadu. Daniels (2010) reported this species based on these collection. During the present study I could collect this species from Tamil Nadu.

Habitat and Ecology: Growing as scattered mass on land cuttings along with other *Fissidens* such as *F. serratus* and *F. crispulus*, *Asterella khasiana* (Griff.) Grolle and *Fossombronia* sp. in semi evergreen forests of high altitude areas.

Distribution: India (Darjeeling, Tamil Nadu) (Dixon & Potier de la Varde 1927; Foreau 1930; Gangulee, 1971; Matthew 1973); Argentina, Australia, Brazil, Bolivia, California, Chile, Colombia, Ecuador, Europe Mexico, Honduras, Pacific Islands (New Caledonia, New Zealand), Venezuela, West Indies, Zimbabwe, Zambia, (Kis, 1984; Pursell, 2007, 1994; Forzza, 2010) (Map 25A&25B).

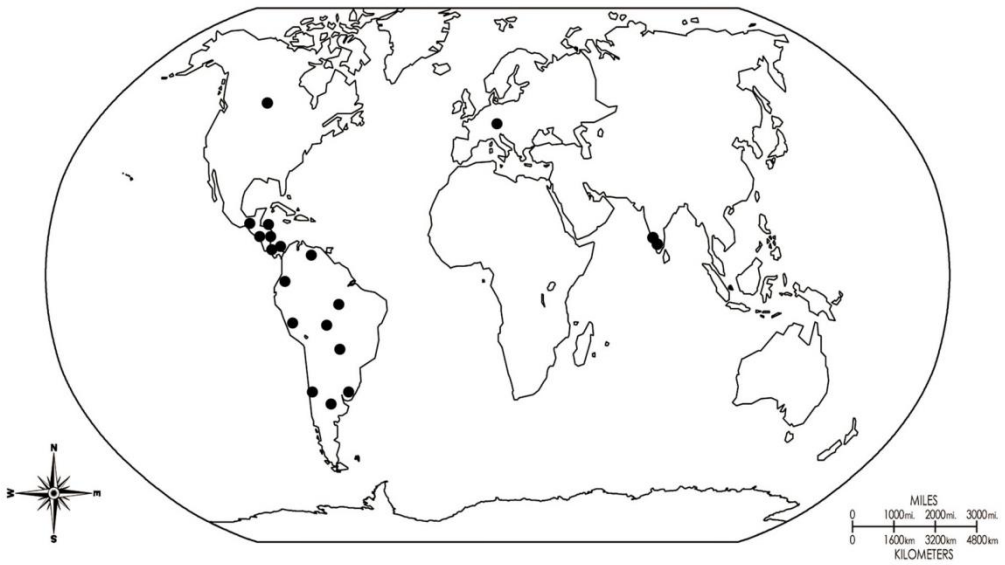
Specimens examined: India, Tamil Nadu, Coonoor (Way to Dolphin's Nose, 1629 m), 23.12.2015, Manjula, K.M. & Deepa, K.M. (ZGC16011C); Uttarakhand, Nainital, 29.09.1970, A.H. Norkett (14488) (BM!).

Fissidens diversifolius Mitt., J. Proc. Linn. Soc., Bot., Suppl. 1:140. 1859; Gangulee, Moss. E. India & Adj. 1(2): 492. 1971; Iwatsuki & Suzuki, J. Hattori Bot. Lab 51: 374. 1982; Chaudhary & Deora. Moss Fl. Rajasthan 36. 1993; Li & Iwatsuki, Moss Fl. of China 2: 28. 2001; Daniels & Kariyappa, Curr. Sci. 93(7): 980. 2007; Daniels, Archive Bryol. 65: 55. 2010.

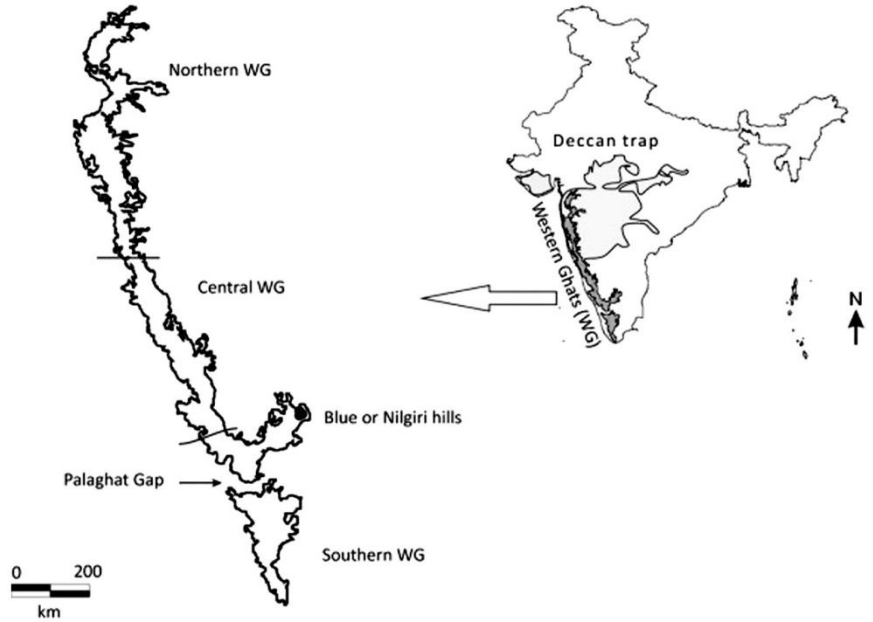
Type. India: North Bihar, J. D. Hooker 633 (Lectotype NY).

F. debilis Wils, Kew J. Bot. 9: 294. 1857; *F. plicatulus* Thér., Monde Pl., sér. 2, 9(45): 21. 1907; *F. jeyporensis* Dixon & P. de la Varde in Varde, Ann. Crypt. Exot. 1: 38. 1928; *F. uii* Broth. *ex* His., Classif. Moss. Japan, 77. 1932; *F. uii* var. *brevifolius* His., Trans Sapporo Nat. Hist. Soc. 13: 395. 1934; *F. doii* Sak., Bot. Mag. Tokyo 47: 736. 1933; *F. laxiusculus* Dixon in Sas., Shokubutsu Shumi 3: 172. 1934; *F. mayebarae* Sak., Bot. Mag. Tokyo 50: 514 *f* 1. 1936; *F. lativaginatus* Bartr., Rev. Bryol. Lichénol. 23: 242. 1954; *F. diversifolioides* Gangulee, Bull. Bot. Soc. Beng. 11: 67. 1957.

Plants small, yellowish green, brownish when old, fertile leafy stems usually simple, *ca*. 3.3 mm long, 1.3 mm wide, proliferations present in some plants; rhizoids smooth, basal, axillary hyaline nodules indistinct; central strand not



Map. 25A. World distribution of ***Fissidens curvatus*** *Hornsch.*



Map. 25B. Distribution of ***Fissidens curvatus*** *Hornsch. in Western Ghats*

differentiated, cortical cells small; leaves in 5–9 pairs, upper leaves much larger and more densely arranged, lower leaves small, scaly, ovate or oblong–lanceolate, 1.2-1.5 mm × 0.2-1.0 mm, acute or obtusely acute at apex, margins almost entire; limbidia distinct on vaginant laminae, 1-2 cells wide on upper half of vaginant laminae, 2-3 cells wide on lower half; vaginant laminae 2/3-4/5 the leaf length, unequal minor lamina apex opens near costa, unistratose, base of dorsal laminae broadly wedge-shaped to rounded, apical lamina and dorsal lamina unistratose; costa stout, ending a few cells below apex; cells of apical and dorsal laminae quadrate to irregularly hexagonal, 5-10 µm long, smooth, moderately thick-walled, cells of vaginant laminae larger than those of apical and dorsal laminae, especially toward the base near costa; gemmae not found.

Fertile parts, autoicous, perigonium terminal on short branches, perichaetium terminal, setae 2.5-3.0 mm long, capsule erect or inclined, symmetrical, peristome teeth 0.4-0.6 mm long, operculam conic, *ca*. 0.2 mm long, spores 22-32 µm in diameter (Plate 50 & Fig.23).

Diagnostic characters: *Fissidens diversifolius* Mitt. is characterised by more or less brownish plants, indistinct axillary hyaline nodules, oblong-ovate leaves with acute or obtusely acute leaf apex, wedge shaped dorsal lamina and smooth laminal cells. *F. diversifolius* is similar to *F. pellucidus* Hornsch. in the smooth cell with clear cell wall but differs in the presence of limbidium on vaginant laminae and guttula in the cells of *F. diversifolius*.

Note: *F. diversifolioides* Gangulee was published as a separate species since Mitten (1859) did not mentioned the semilimbidium of *F. diversifolius* Mitt. in its description. After re-examination of this species Norkett pointed out the semilimbidium of *F. diversifolius* Mitt. and considered *F. diversifolioides* Gangulee as a synonym of *F. diversifolius* Mitt.

Habitat and General Ecology: On soil or small rocks near stream and on wet rocks in open lands.

Distribution: India (Assam, Bihar, Karnataka, Orissa, Nilgiri-Tamil Nadu, Western Himalaya, West Bengal, (Daniels, 2010; Gangulee, 1971; Schwarz (pers.comm); Verma *et al.*, 2011); China, Japan and Myanmar. (Iwatsuki & Suzuki, 1982; Li & Iwatsuki, 2001) (Map 26A&26B).

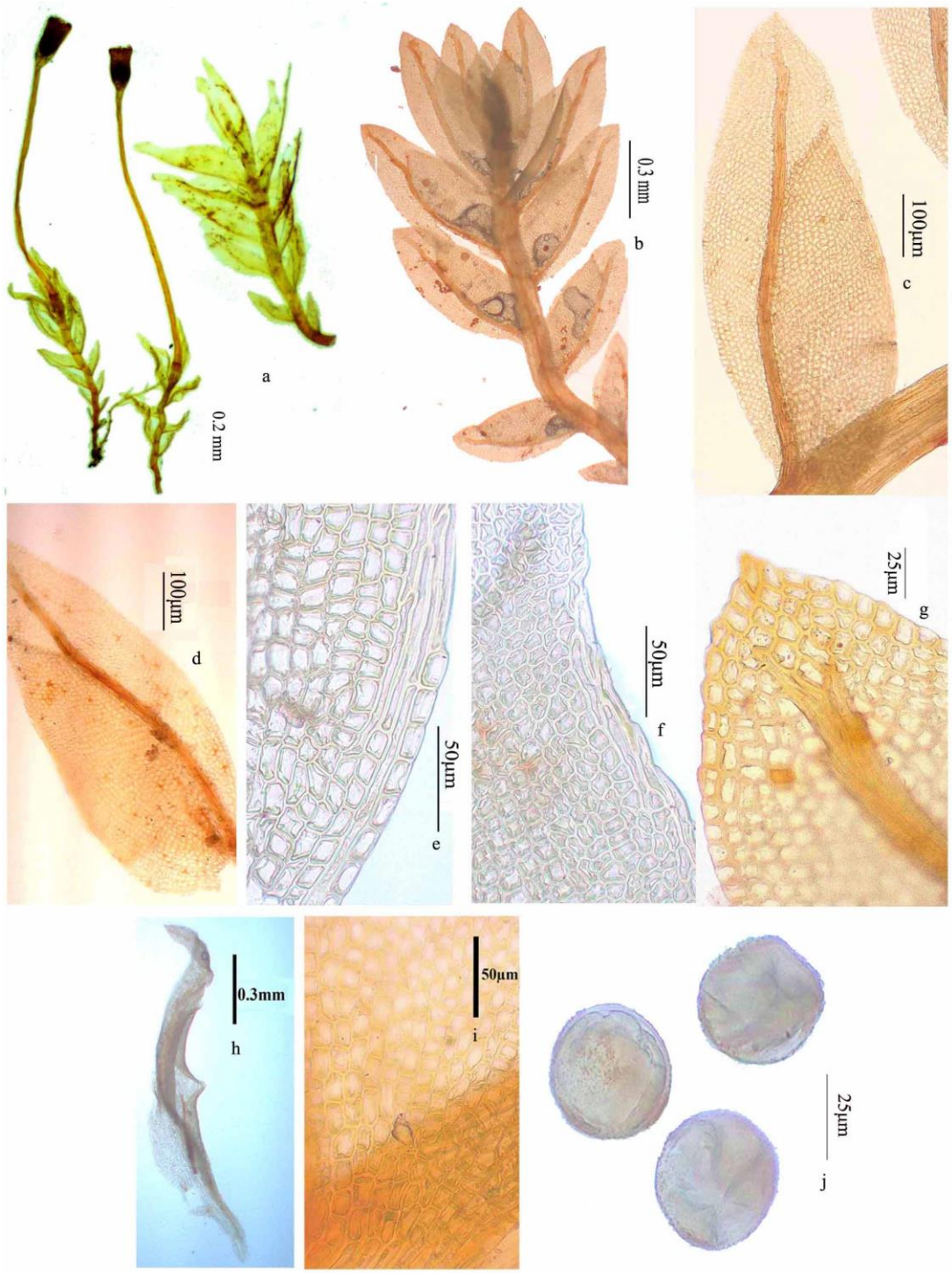


Plate 50. *Fissidens diversifolius* Mitt., a&b. single plant, c. vegetative leaf, d. vaginant laminae, e&i. vaginant laminae base, f. vaginant laminae apex, g. leaf apex, h. perichaetial leaf, j. spores (photo from Norkett 8881 BM!).

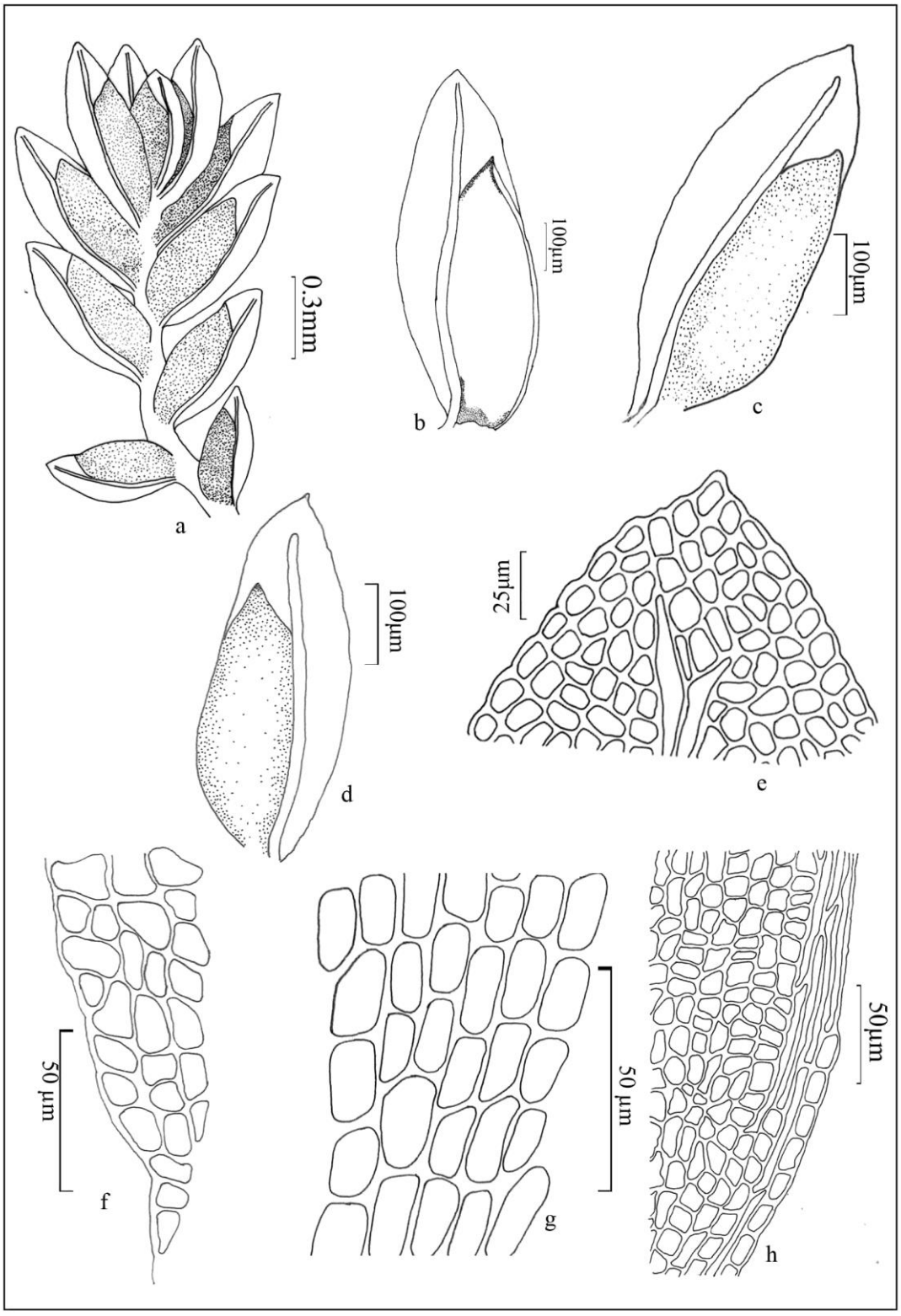
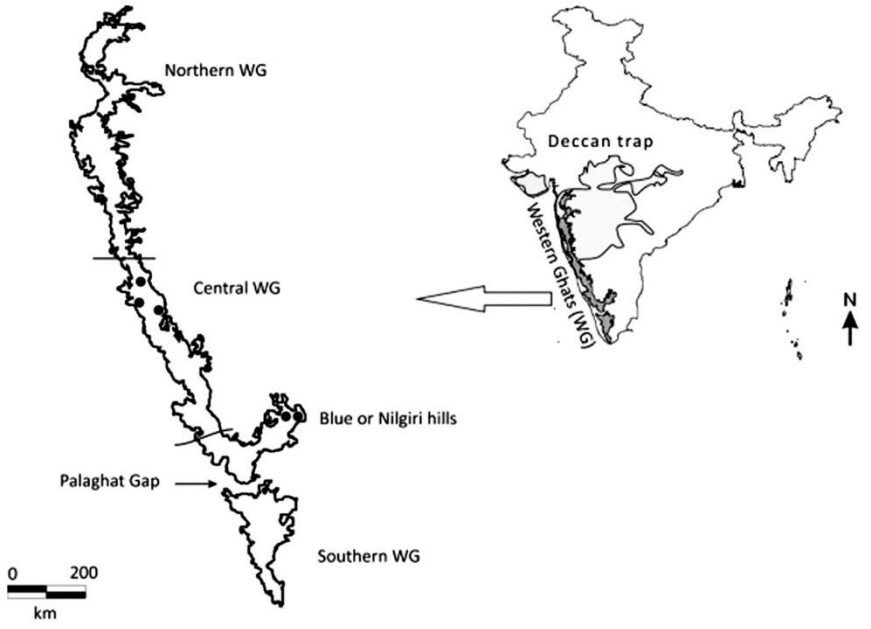


Fig. 23. *Fissidens diversifolius* Mitt., a. vegetative plant b-d. vegetative leaves, e. leaf apex, f. dorsal lamina base near insertion, g. vaginant laminae base, h. vaginant laminae base with limbidium

Map 26A. World distribution of ***Fissidens diversifolius*** *Mitt*



Map 26B. Distribution of ***Fissidens diversifolius*** *Mitt. in Western Ghats*

Specimen examined: Eastern Nepal, Arun R, Tumlingtar 1800 ft, 15.12.1961, A.H. Norkett (8881) (BM!).

Note: Daniels (2010) listed this species from Nilgiri in Tamil Nadu based on Gangulee (1971). But Gangulee (1971) did not mention any collection number for this species. The exact collector and collection locality in Western Ghats is not mentioned in any literatures. During the present study I could not collect this species from Western Ghats. The above description is based on the collection from Nepal, authentically identified specimen procured from Natural History Museum (BM).

Etymology: The specific epithet *diversifolius* (*diverse*= *different* + *folius*= leaves) refers to the large well developed upper leaves and small, reduced scaly lower leaves in the same plant of this species.

Fissidens microdictyon Dixon & P.de la Varde, Arch. Bot. Bull. Mens. 1(8–9): 163. 4 f. 3. 1927.

Type: India, Tiger Shola, Palni Hills, 5600 ft, 31 Mar 1926, no. *Foreau 189* (BM!).

Plants small, rhizoids basal, smooth, stem unbranched, 2.8-3.0 mm long, upto 11 pairs of leaves, leaves linear lanceolate, margin entire, leaf apex narrowly acute, limbidium present on all laminae, 2-4 rows at vaginant laminae base, costa slightly excurrent, ending in short apiculus; vaginant lamina closed, reaching more than half of leaf length, unistratose; dorsal lamina base narrow, not decurrent, joins to leaf insertion, dorsal lamina and apical lamina unistratose; laminal cells smooth, elongated; gemmae not found.

Fertile parts, *perigonia* not found; *perichaetia* terminal, plants small, 0.9 mm long, archegonia not found, sporophyte erect, seta long, 0.8-0.9 mm long without capsule, spores not found (Plate 51 & Fig.24).

Diagnostic characters: *F. microdictyon* is characterised by dimorphic plant with linear lanceolate leaves, complete limbidium on all laminae and smooth laminal

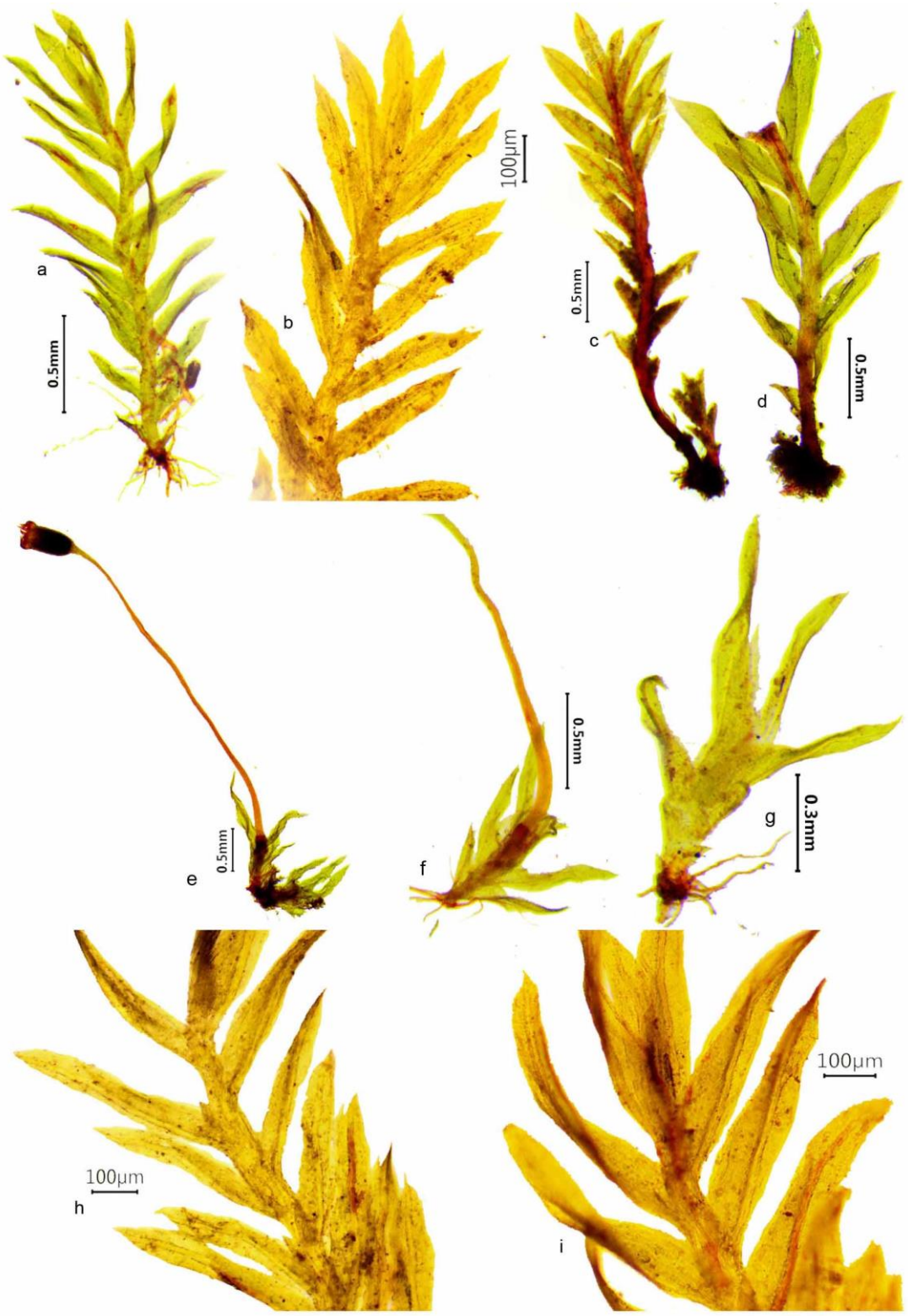


Plate 51. *Fissidens microdictyon* Dixon & P. de la Varde, a&d. vegetative plants, e-g. fertile plants, h&i. vegetative leaves (Photo from Foreau 189 BM!).

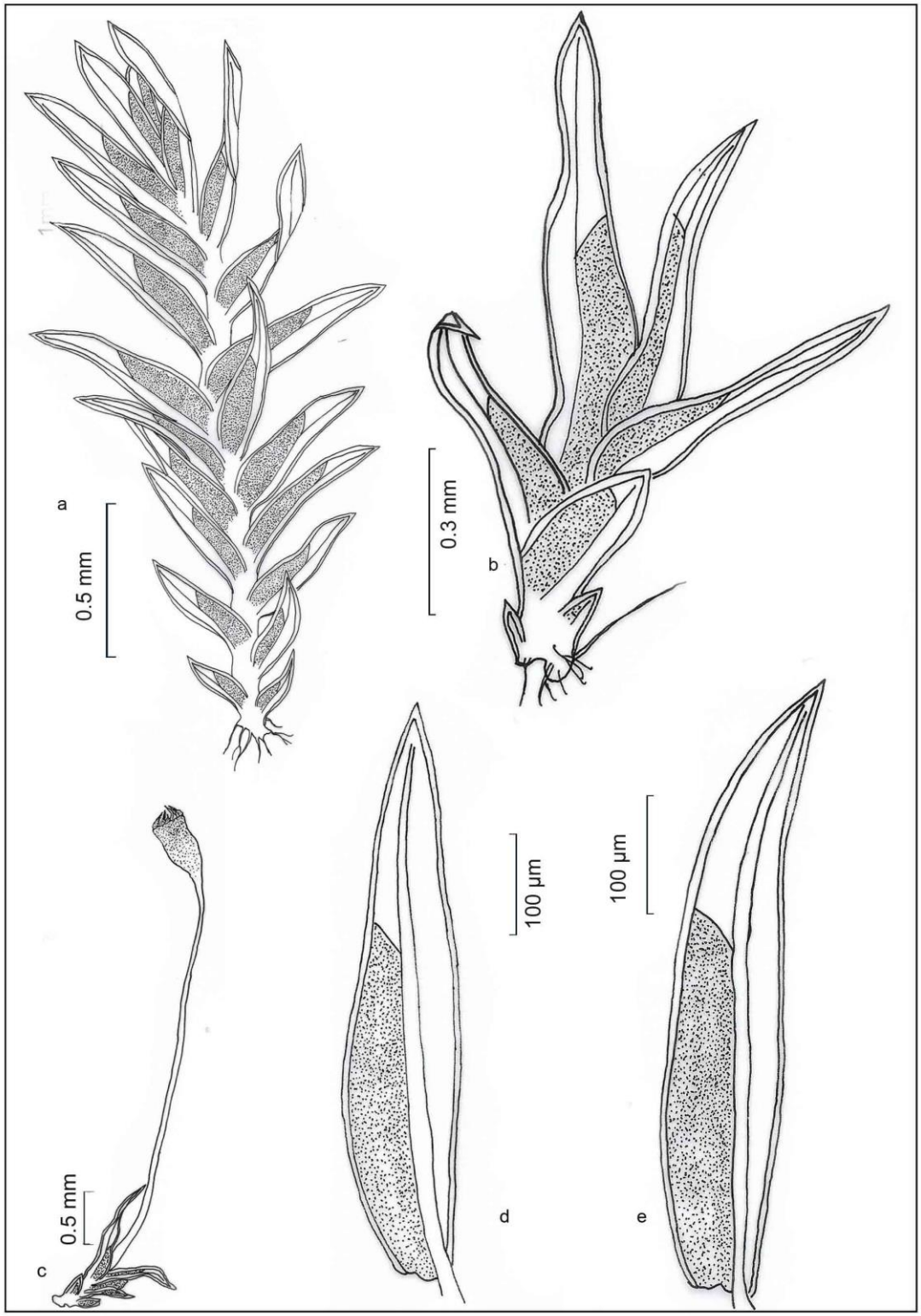


Fig. 24. *Fissidens microdictyon* Dixon & P. de la Varde., a. vegetative plant, b&c. fertile plants, d&e. vegetative leaves.

cells. This species is similar to *F. curvatus* in dimorphic plants and linear lanceolate leaves, while differs in dorsal lamina base of *F. curvatus* which ends mostly far above leaf insertion.

Habitat and General Ecology: On land cuttings in shola region.

Distribution: Endemic to Palni hills (Bruhl, 1931; Daniels, 2010; Dixon & Potier de la Varde, 1927; Foreau, 1930, 1961; Lal, 2005) (Map 27A&27B).

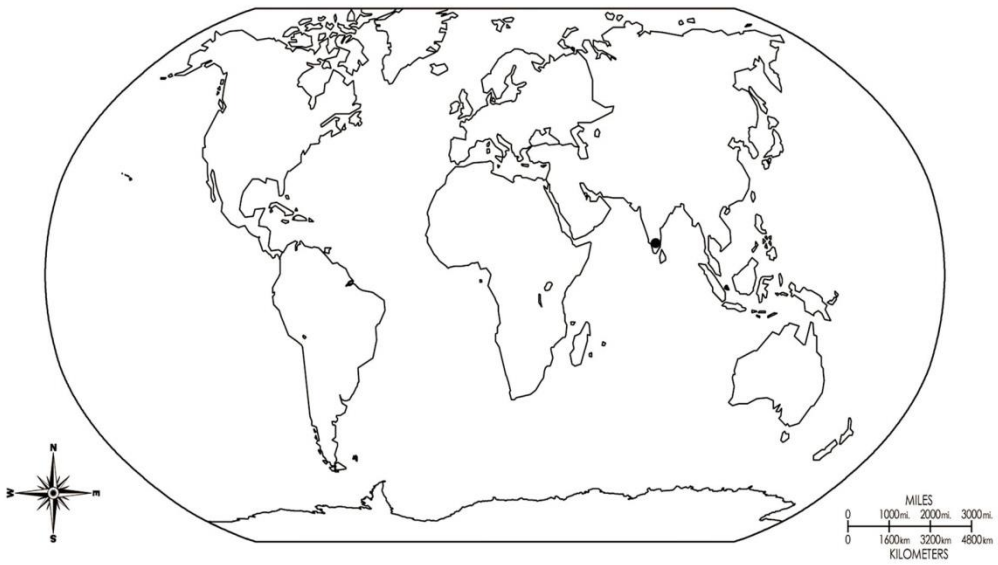
Specimen examined: India, Tiger Shola, Palni Hills, along Kodaikanal, 5600 ft, 31 Mar 1926, no. Foreau 189. (BM!).

Fissidens viridulus (Sw.) Wahlenb., Fl. Lapp. 334. 1812; Gangulee, Moss. E. India & Adj. 2: 462. 1971. Suzuki & Iwatsuki, Hattoria 3: 10. 2012; Erzberger, Studia. Bot. Hung. 47(1): 131. 2016.

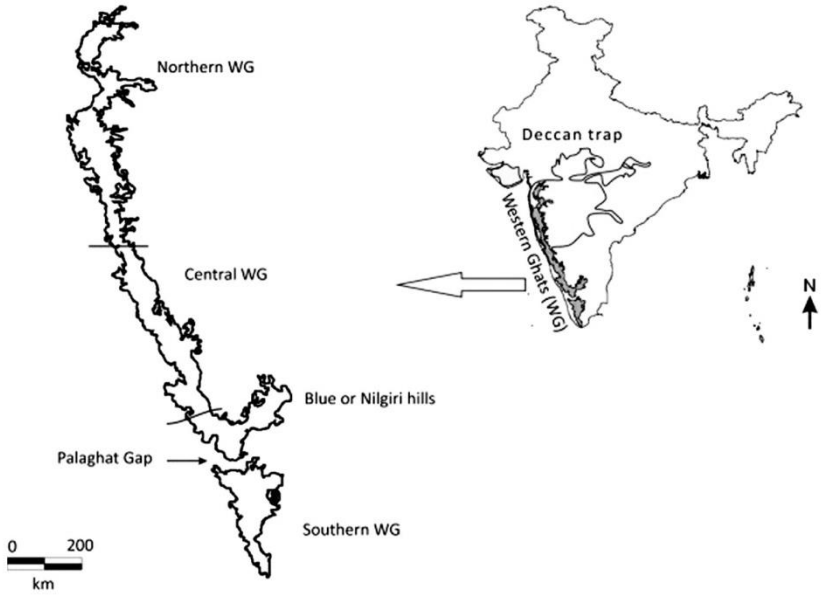
Type: Lapponica, Berlin

Dicranum viridulum Sw., Monthl. Rev. 34: 538. 1801; *Fissidens bryoides* var. *intermedius* R. Ruthe., Bryoth. Eur. 24: n. 1160. 1872; *F.impar* Mitt., J. Linn. Soc. Bot. 21: 554. 1885; *F. bryoides* var. *hedwigii* Limpr., Laubm. Deutschl. 1: 429. 1887; *F. bryoides* subsp. *viridulus* (Sw.) Kindb., eur. N. Amer. Bryin. 2: 170. 1897; *F. bryoides* var. *viridulus* (Sw.) Broth., Laubm. Fennoskand. 18. 3A. B. 1923.

Plants small, bright green, usually unbranched, rhizoids smooth, basal and axillary, reddish; axillary hyaline nodules not differentiated; stem central strand weakly differentiated or absent; stem light green, 4.0-6.0 x 1.0-1.3 mm; leaves 7-13 pairs, older leaves yellow to reddish, small, 0.97-1.0x 0.28 mm, oblong lanceolate, widest at middle and tapering towards apex, apex apiculate or mucronate, limbidium not continuous, broken patches on all laminae, limbidial cells becomes rectangular near leaf insertion and leaf apex, one or two rows of slightly elongated cells on vaginant laminae; costa excurrent in short apiculus, bryoides type, light green;



Map 27A. World distribution of ***Fissidens microdictyon*** *Dixon & de la Varde*



Map 27B. Distribution of ***Fissidens microdictyon*** *Dixon & P.de la Varde in Western Ghats*

vaginant laminae reaching half of leaf length, slightly open, minor lamina unequal, unistratose; dorsal lamina not decurrent, rounded or wedge shaped near insertion, dorsal lamina and apical lamina unistratose; laminal cells quadrangular to irregularly polygonal, smooth, thin walled, 4.2-6.0 µm long, cells at vaginant laminae base near costa large as double as upper cells; gemmae not found.

Fertile plants, autoicous, perigonia and perichaetial clusters in terminal or axillary with paraphysis, antheridum less in number than archegonia; one or two sporophytes per perichaetium, seta 3-4 mm long, capsule erect, exothecial cellsrounded quadrate, operculum rostrate, peristome 32-37 µm wide at base, fissidens type, spores smooth, 10-13 µm (Plate 52 & Fig.25).

Diagnostic characters: *F. viridulus* (Sw.) Wahlenb. is characterised by oblong lanceolate leaves with obtuse to mucronate apex, long peristome and broken simple, single rowed limbidia on all leaves. This species is similar to *F. bryoides* in smooth laminal cells, dorsal lamina base, slightly excurrent costa,but differs in obtuse to mucronate leaf apex, broken limbidia on all leaves and long peristome of *F. viridulus.*

Note: Many authors like Anderson (1963) and Kindberg (1897) considered this species as a subgeneric taxa of *F. bryoides* complex, due to enormous range of variations within *F. bryoides* complex. Gangulee (1971) and Erzberger (2016) considered this as a separate species. Bruggeman-Nannenga (Hill *et al.,* 2006) also commented on this species that most of the North American authors are treating this species as an expression of *F. bryoides* complex. But in the present study, this taxa is considering as a distinct species because of the variation in limbidium, perigonia and perichaetia in single cluster, obtuse to mucronate leaf apex which greatly varies from *F. bryoides.*

Habitat and General Ecology: On rocky patch along with *Oreoweisia* sp. in evergreen forest at high altitude areas.

Distribution: India (Karnataka (present collection), Western Himalaya) (Gangulee, 1971); Austria, China, Caucasus, Europe, Hungary, Japan, Nepal, New Zealand, North & Central Africa, North America, Siberia, Slovenia, Slovakia (Suzuki & Iwatsuki,

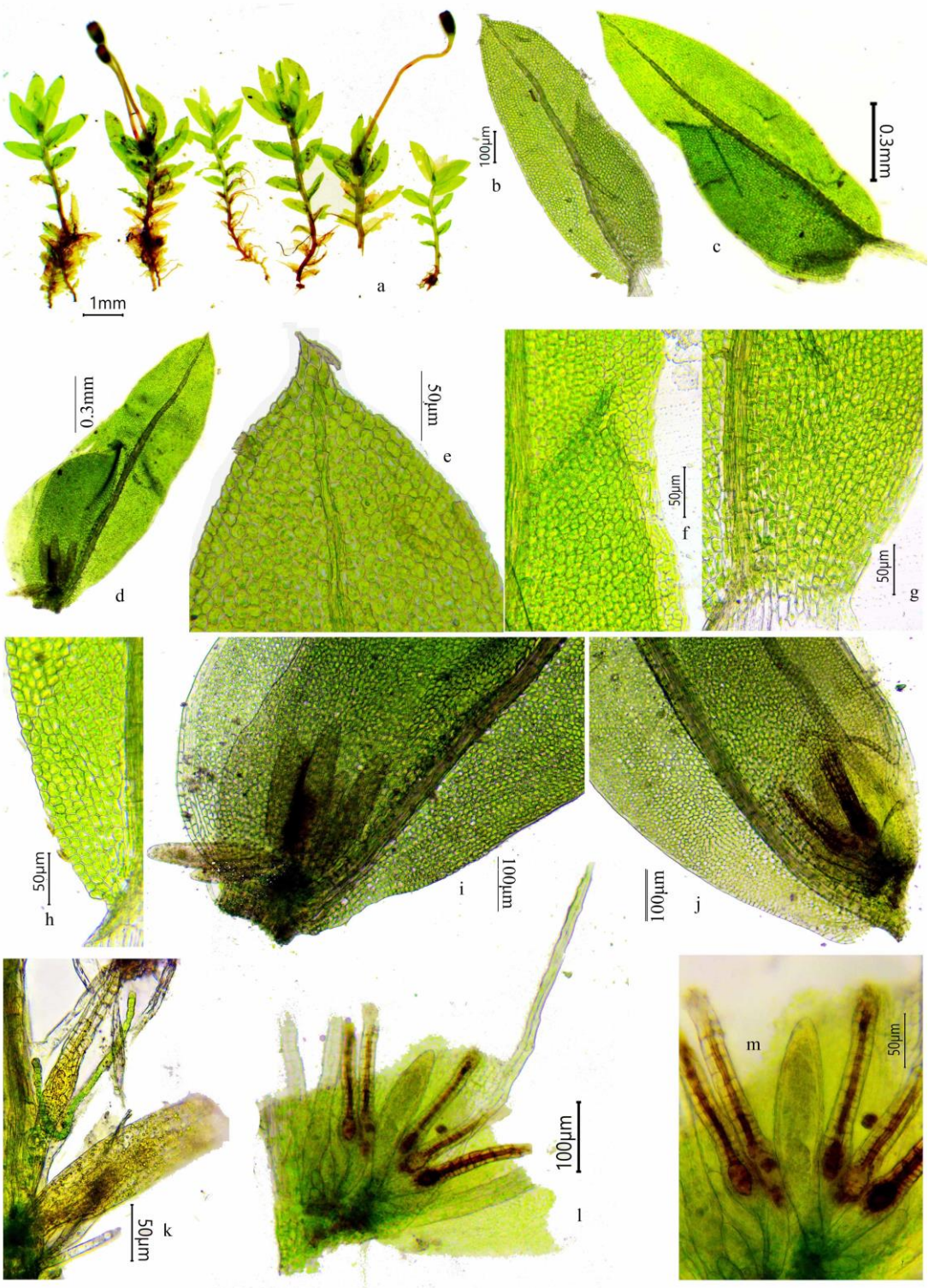


Plate 52. *Fissidens viridulus* (Sw.) Wahlenb., a. vegetative and sporophytic plants, b&c. vegetative leaves, d. perichaetial leaf, e. leaf apex, f. vaginant laminae apex, g. vaginant laminae base, h. dorsal lamina base, i. perigonial leaf, j. perichaetial leaf, k. axis showing male and female structure, l&m. archegonial cluster

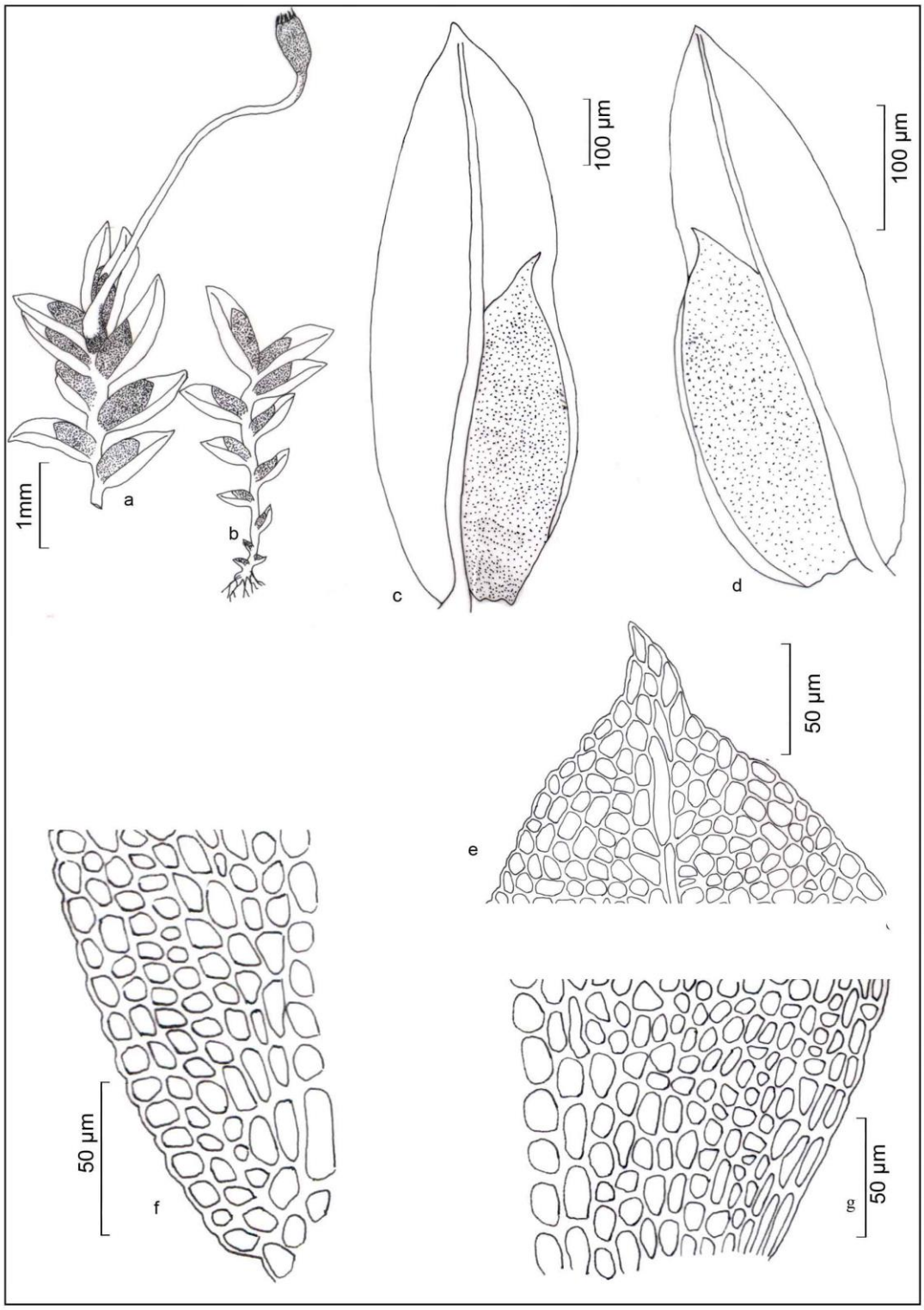
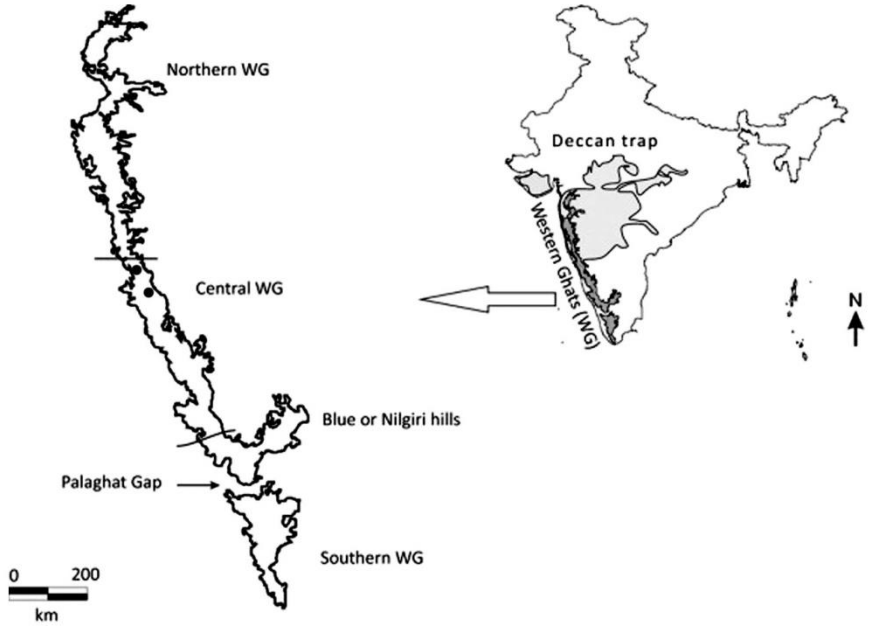


Fig. 25. *Fissidens viridulus* (Sw.) Wahlenb., a. fertile plant, b. vegetative plant, c&d. vegetative leaves, e. leaf apex, f. dorsal lamina base near insertion, g. vaginant laminae base.

Map. 28A. World distribution of Fissidens viridulus (Sw.) Wahlenb.



Map. 28B. Distribution of Fissidens viridulus (Sw.) Wahlenb. in Western Ghats

2012, Erzberger, 2016). The present collection is a new record for Western Ghats and Karnataka (Map 28A&28B).

Specimens examined: India, Karnataka, Nandhi Hills (1400-1478m), 09.17.2018, Sabhareesh (ZGC 4098, 4018).

b. Fissidens* Hedw. subgenus *Fissidens* section *Sarawakia (Muell. Hal.) Pursell & Bruggeman-Nannenga, Bryologist 107(1): 14. 2004.

Plants sordid to black-green, aquatic, submerged, to 10 cm or more long, branched profusely, with a pleurocarpous-like habit, branches tightly attached, without basal rhizoids. Stem with basal and axillary, smooth, reddish rhizoids; axillary hyaline nodules differentiated; epidermis and outer 1–4 tiers of cortical cells small, thick-walled, pigmented; inner cortical cells larger, thin-walled, hyaline; central strand differentiated. Leaves imbricate, numerous pairs pinnately arranged, lanceolate to ovate, acute to obtuse, sometimes apiculate; margin 6 entire, limbate on proximal 4/5 or less of vaginant laminae, limbidial cells uni- to pluristratose; costa bryoides-type; dorsal lamina ending at insertion or above, or short-decurrent; vaginant laminae 4/5 length of leaf, acute, 6 equal; laminal cells unistratose or irregularly bistratose, firm-walled, smooth, irregularly quadrate to hexagonal, eguttulate. Monoicous (gonioautoicous). Sporophytes one per perichaetium; seta short; theca immersed to emergent, ovoid, erect, radially symmetric, stomatose or estomatose, exothecial cells oblong, vertical walls thicker than horizontal walls; peristome undivided, poorly developed, bryoides-type; operculum conic, long-rostrate. Spores smooth, large for the genus. Calyptra smooth, mitrate.

There is no report of the species in this section from Western Ghats.

3. *Fissidens* Hedw. subgenus *Aloma* Kindb., Eur. N. Amer. Bryin. 2: 165. 1897.

Plants small to medium, light to sordid green, often reddish, particularly in stems and costa, terrestrial, saxicolous, lignicolous, corticolous, rarely epiphyllous, rarely epizoic, typically in humid places, or infrequently aquatic; unbranched or branched; branches with basal rhizoids; persistent protonemata infrequent. Stems

with axillary and basal, smooth, mostly reddish, but sometimes bright red, tan or colorless rhizoids; axillary hyaline nodules differentiated or not; epidermis and outer 1–2 tiers of cortical cells, thick-walled, or large, thinwalled and collapsed when dry; inner cortical cells large, thin-walled, hyaline; central strand differentiated or not, hyaline or, infrequently red; axillary and subterranean, irregularly globose, multicellular gemmae infrequent; axillary, fiilamentous, multicellular, rhizoidal gemmae infrequent; axillary stalked, clavate, multicellular gemmae frequent; filamentous, multicellular gemmae at stem apices infrequent; epiphyllous, branched, multicellular gemmae rare. Leaves imbricate to distant, few to several pairs pinnately arranged or frondiform, elimbate or, more often, limbate, limbidium, when present, on all laminae, or more frequently more or less confined to vaginant laminae, marginal or intralaminal, sometimes inconspicuous, limbidial cells mostly unistratose, rarely pluristratose; costa variable in length, sometimes lacking or nearly so, bryoides type; dorsal lamina mostly ending at insertion; vaginant laminae variable, minor lamina acute, ending near margin or between costa and margin, or infrequently rounded and free distally; laminal cells unistratose to irregularly or regularly bistratose, small to large with firm walls or large, thin walls, collapsed when dry, smooth, mammillose, uni- or pluripapillose, guttulate or eguttulate. Monoicous; perigonia variable in position; perichaetia terminal on main stem and branches, naked antheridia and archegonia infrequent in leaf axils. Sporophytes 1–several per perichaetium, yellow, darkening with age; seta mostly elongate; theca usually erect, radially symmetric, stomatose, exothecial cells frequently 6 quadrate, usually collenchymatous, vertical walls often thicker than horizontal walls; peristome scariosus-type, infrequently reduced, rarely none; operculum conic, usually short-rostrate. Spores finely papillose to smooth, calyptra cucullate, rarely mitrate, smooth or prorate.

This subgenus includes the largest number of species in the genus. Most species are tropical and subtropical in distribution. On the whole, the subgenus is characterized by a scariosus-type peristome, a bryoides-type costa, and fewer than 40 files of exothecial cells. Gametophytically, the subgenus is heterogeneous and at first glance seems to be incongruous. However, when considered with a worldwide

perspective no sharp breaks among the sections recognized by Brotherus are apparent. In a given character there is intergradation from one end of the spectrum to the other. Thus it is impractical to make infrageneric separations on cell size, laminal cell wall ornamentation, or costa structure (e.g., from a typical bryoides-type costa to the absence of a costa). Groups of species with smooth laminal cells, elimbate leaves (e.g., F. pellucidus Hornsch.) grade into those groups with elimbate and limbate leaves, and mammillose and unipapillose laminal cells [e.g., *F. pellucidus* var. *papilliferus* (Broth.) Pursell and *F. saeulensis* W. R. Buck & Pursell] which, in turn grade into those groups that are limbate and have pluripapillose laminal cells [eg., *F. elegans* Brid.). There are many more species with mammillose, unipapillose, and pluripapillose laminal cells than there are species with smooth-walled laminal cells.

Subgenus Aloma of *Fissidens* contain 38 species in Western Ghats

Key to the species of the Subgenus Aloma

1a. Costa present ……..…. 2

1b. Costa completely absent ……..…… *Fissidens enervis*

2a. Costa excurrent or percurrent ……...……..….. 3

2b. Costa reaching up to middle ……..…….. *F. flaccidus*

3a. Limbidium present on all laminae ……...…….…… 4

3b. Limbidium restricted to vaginat laminae only or completely absent ……..….. 7

4a. Laminal cells papillose ……..…….. *F. biformis*

4b Laminal cells smooth …….…..... 5

5a. Plants more than 4 mm, laminal cells irregularly polygonal ……...…...…….… 6

5b. Plants less than 4 mm, laminal cells elongated rectangular ….…. *F. subbryoides*

6a. Axillary hyaline nodules present ……..…… *F. zollingeri*

6b. Axillary nodule absent ……..…… *F. subpalmatus*

7a. Limbidium distinct or weakly developed on vaginant laminae ……..…… 8

7b. Limbidium completely absent ……...…… 26

8a. Limbidium present on both vegetative and fertile leaves …… 9

8b. Limbidium restricted to fertile leaves only ……..….. 23

9a. Laminal cells smooth or with 1distinct mamilla ……..... 10

9b. Laminal cells papillose or more than 1 mamillae ……..… 15

10a. Laminal cells smooth ……..……...……..…… 11

10b. Laminal cells mamillose …….……..... 12

11a. Plants epiphytic, stem central strand not differentiated, laminal cells unistratose ……..…….*F. neomagofukui*

11b. Plants aquatic, stem central strand differentiated; laminal cells bistratose ..... …..…..……..... *F. sedgwickii*

12a. limbidium only at vaginant laminae base …….……...…… 13

12b. limbidium covers the vaginant laminae completely ……...…… 14

13a. Leaves oblong lingulate, 6-9 pairs of leaves, costa ending below apex ….....… ……..… *F. orishae*

13b. Leaves lanceolate, 8-15 pairs of leaves, costa slightly excurrent or reaching the apex …….……...…. *F. walkeri*

14a. Leaves lanceolate …….... *F. crenulatus*

14b. Leaves ovate lingulate ……... *F. ranchiensis*

15a. Laminal cells unipapillose ……...……...……. 16

15b. Laminal cells pluripappillose …….... 19

16a. Costa excurrent ……...……...……. 17

16b. Costa ending below apex …… 18

17a. Plants 2-3 mm long; limbidium interrupted; dorsal lamina base boat shaped..... ……..……..… *F. arunii*

17b. Plants 5-7 mm long, limbidium continuous; dorsal lamina base not boat shaped ….. .....……..……..……...*Fissidens sp.* 1

18a. plant 4-5 mm, mid vaginant laminal cells slightly convex …….. *F. firmus*

18b. plant 6-9 mm, mid vaginant laminal cells plane …… *F. kammadensis*

19a. stem central strand differentiated ……..… *F. ceylonensis*

19b. stem central strand weakly differentiated or absent ……..……..… 20

20a. leaves lanceolate, elongated oval or oblong lanceolate, papillae towards cell wall ……..…..……... 21

20b. leaves oblong lingulate, papillae at centre ……..… *F. incognitus*

21a. limbidium marginal with highly elongated cells, laminal cells pluripapillose (3-7) …….……..….. *F. speluncae*

21b. limbidium intramarginal or intermitting with slightly elongated cells, laminal cells 2-4 papillose ……..……...……. 22

22a. Limbidium slightly developed only at the base of vaginant laminae, costa ending 8- 14 cells below apex ……..…. *F. brevinervis*

22b. Limbidium distinct on vaginant laminae, costa excurrent in short apiculus ……... ……...…*F. hollianus*

23a. Plants medium size, more than 2.5 mm, leaves oblong …….…….. 24

23b. plants very small, less than 2.5 mm, leaves not oblong ……..….. *F. pokhrensis*

24a. Plants epiphytic, leaves small, costa ending 5-10 cells below apex …..…….. …….…..*F. pallidinervis*

24b. Plants growing on soil, costa ending 2 or 3 cells below apex 25

25a. Leaf apex acuminate to mucronate, costa ends 2 or 3 cells below apex ……. ……. *F. kurzii*

25b. Leaf apex acute to mucronate, costa ends 5-7 cells below apex ..……....….. ……...…… *F. macrosporoides*

26a. Laminal cells smooth, mamillose or guttulate …..... 27

26b. Laminal cells papillose …..... 32

27a. Laminal cells guttulate …..... *F. pellucidus*

27b. Laminal cells smooth or mamillose …..... 28

28a. Plants with axillary hyaline nodules, central strand absent, vaginant laminae Closed; laminal cells mamillose ……..…… *F. polysetulus*

28b. Plants without axillary hyaline nodule, central strand weakly differentiated; vaginant laminae open; laminal cells smooth ….....…… 29

29a. Costa excurrent ..... *F. longtonianus*

29b. Costa not excurrent ……....… 30

30a. Plants less than 2 mm long; leaf apex broadly acute; laminal cells elongated ……..…... *F. manilalia*

30b. Plants with more than 2 mm long; leaf apex acute, laminal cells not elongated ……. …. 31

31a. Plants with 3-5 pairs of cells; leaf margin serrulate ……..… *F. ganguleei*

31b. Plants with 7-9 pairs of leaves; leaf margin smooth ……..….. *F. laxitextus*

32a. laminal cells single papillose ……..……. 33

32b. laminal cells pluripapillose …….……. 34

33a. Setae very short less than 0.2 mm long, leaf margin slightly crenate, laminal cells with small central papilla ……....……...…. *F. macrosporus*

33b. Setae 1.0-2.0 mm long, leaf margin highly serrate, laminal cell with large conical papilla …..…….....……. *F. serratus*

34a. Axillary hyaline nodules present ……..……..……. *F. kalimpongenesis*

34b. Axillary hyaline nodules absent ……..…….…… 35

35a. Leaf margin denticulate with sharp cells, 1 or 2 papillae in each cells …… 36

35b. Leaf margin corrugate, more than 2 papillae from each cell …….…..….... 37

36a. More than 10 pairs of leaves, dorsal laminae base not decurrent ….…….. ……..…. *Fissidens sp. 2*

36b. Less than 10 pairs of leaves; dorsal lamina base decurrent …...…. *F. pulchellus*

37a. Leaves 10-15 pairs of pairs; leaf margin serrate ……..…. *F. gardneri*

37b. Leaves 7-9 pairs of leaves; leaf margin corrugate …….. *F. griffithii*

Fissidens arunii J.P. Srivast. & Nork., Proc. Bot. Soc. Kanpur 1: 55-57. 1988.

Type: Mahabaleshwar, central India, on soil at the base of cliffs along wayside near Lingmala fall, Oct 1962 Leg. J.P. Srivastava Br. Sri . JPS 102; Isotypes: Section Cryptogames Brit. Nat. Hist. Museum, London. Now recorded from N.W. Himalayas

Plants small, erect, rhizoids reddish; stem brwnish, 2-3 mm long, leaves upto 1 mm long, lower ones minute, distichous, upper ones especially the terminal ones narrowly lanceolate, generally curved and inrolled when dry, spreding on moistening, (3)-4-6(7) pairs of leaves, apex acute ending into a pellucid cell, margin serrulate near apex, sides of lamina unequal; limbidium interrupted, border nearly upto apex, border cells long narrow, thick walled; costa running into apex or slightly excurrent, shining lemon yellow; vaginant laminae base boat shaped, from a little less than half; dorsal lamina narrowed at base; leaf cells quadrate to irregularly hexagonal, about 10x8µm, with a single large papilla in each occupying the whole of cell lumen, cells at base of vaginant laminae elongated, upto 20x10 µm.

Fertile plants, perigonial plants not found; perichaetium, archegonium not found; seta terminal, red or reddish- orange, twisted when dry, 0.5-1.0 cm long, theca obovoid, assymetrical with a large curved portion on one side, dark brown but yellowish when empty, about 1 mm long mouth slightly contracted when dry, widens on moistening, exothecial cells large and relatively thin walled, middle ones considerably thick and mostly large trigones at corners, peristome single, teeth 16, each bifurcated to the base into filiform processes, red below and yellowish at distal end, spirally ridged, papillose, spores yellowish green, smooth, round with markings, 12-16 µm across (Fig.26).

Diagnostic characters: *F. arunii* is characterised by its single large papilla, presence of limbidium and costa ending up to apex or slightly excurrent costa.

Distribution: Endemic to Western Ghats of Maharashtra (Map 29A&29B).

Note: This description is based on the protologue, need further modification on the species and Dr. Bruggeman-Nannenga (pers.comm) commented that this is a perfect species and she has procured the isotype of the *F. arunii* from BM and she has rewritten the description and communicated the paper as neotypification of *F. arunii* along with some new synonyms (*inedit*).

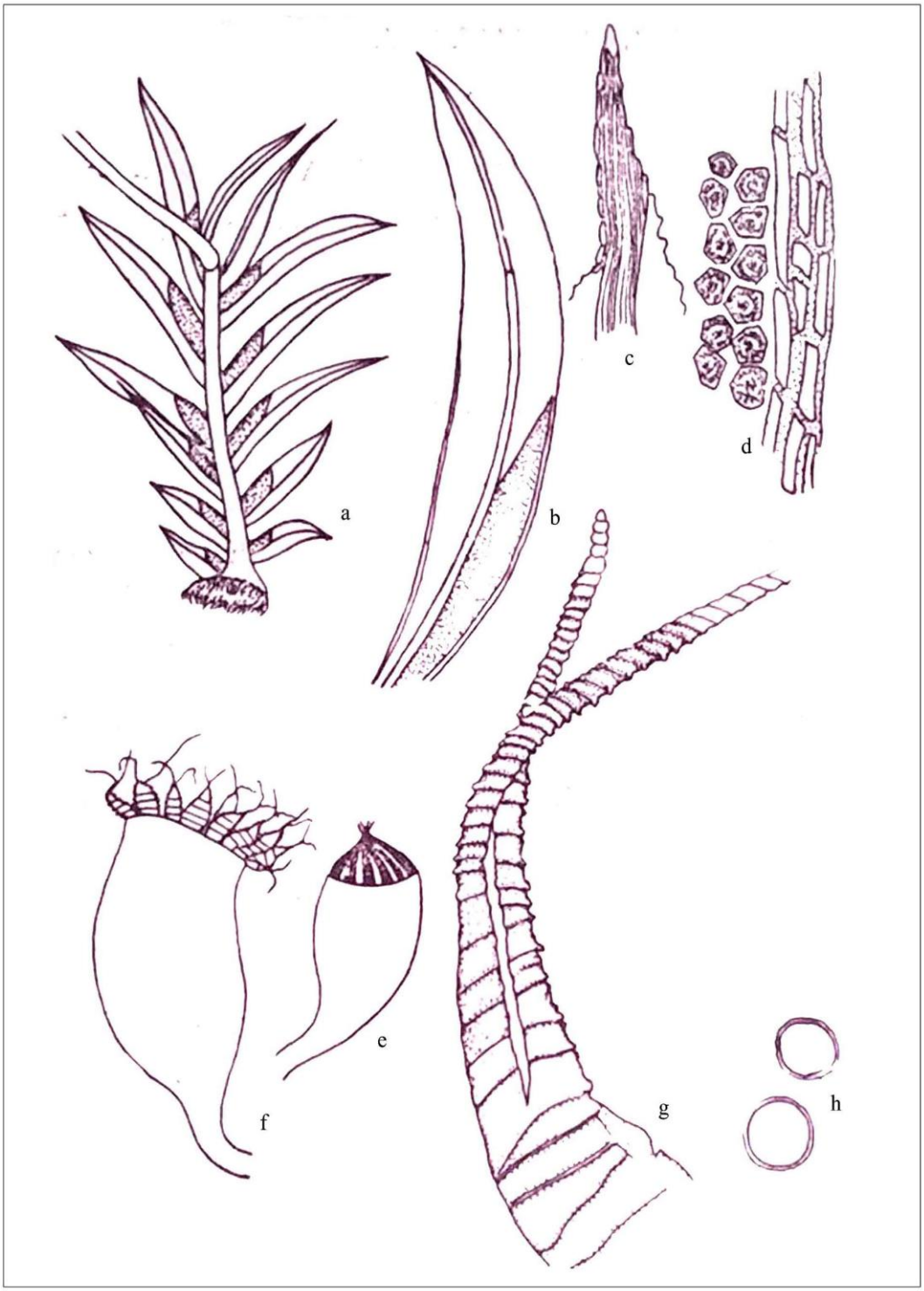
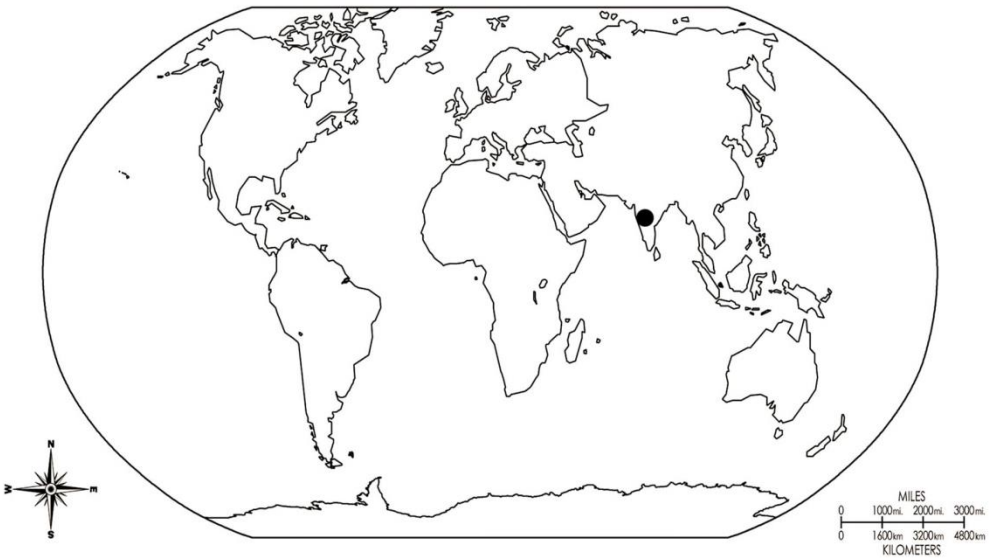
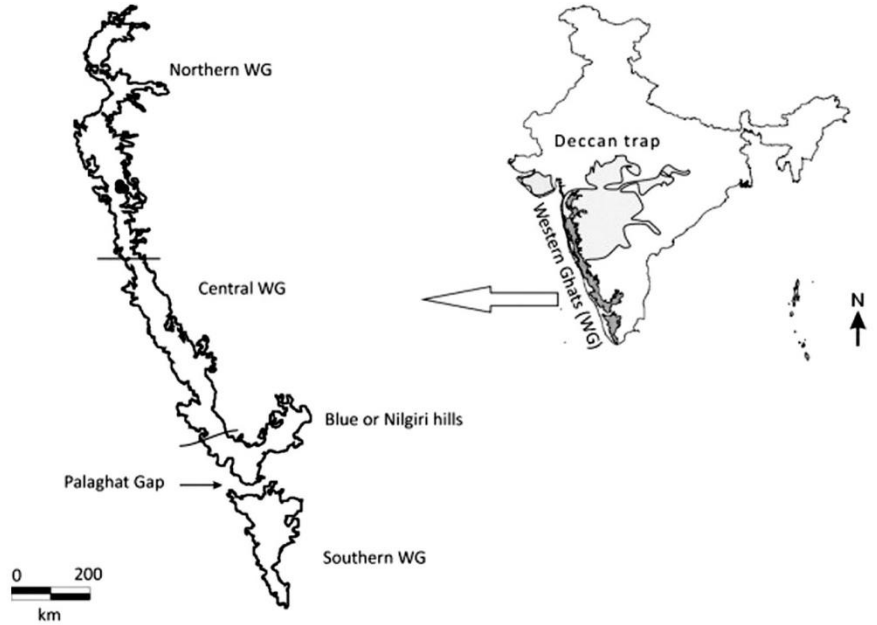


Fig. 26. *Fissidens arunii* J.P. Srivast. & Nork., a. plant (x25), b. single leaf (x50), c. leaf apex (x400), d. leaf border and mid cells each with single papilla (x400), e. capsule (x 25), f. capsule when dry (x50), g. peristome, h. spores (x400) (plate scanned from protologue).



Map. 29A. Distribution of ***Fissidens arunii*** *J.P. Srivast. & Nork.*



Map. 29B. Distribution of ***Fissidens arunii*** *J.P. Srivast. & Nork. in Western Ghats*

Fissidens biformis Mitt., J. Proc. Linn. Soc., Bot.2: 141. 1859; Eddy, Hand. Malay. Mosses 1: 90. 1988; Bruggeman-Nannenga, Lindbergia 39: 33. 2016; Nair *et al*., Bryo. Wayanad W. Ghats. 107. 2005 (as *F. subbryoides*).

Type: Sri Lanka, ad Matale, Gardner 55 (626) (Lectotype NY)

Fissidens angustifolius Sull., Proc. Amer. Acad. Arts & Sci. 5: 275. 1861.

Plants growing in loose tufts, light green; stem unbranched, monomorphic, 2-4 x 1.3-1.8 mm, 4-6 pairs of leaves, rhizoids reddish brown, smooth, axillary hyaline nodules present, central strand slightly differentiated; leaves linear lanceolate, 1.22-1.52 x 0.30-0.35 mm, usually palmately arranged, leaf apex acute, leaf margin entire, limbidium present on all laminae, three or four rowed at vaginant laminae base, one or two rowed in apical lamina and dorsal lamina which gradually merges to normal cells at apex, distally confluent; vaginant laminae reaching ½ of leaf length, closed, 0.76-0.90 mm long, 0.16-0.21 mm wide at base, uniseriate, dorsal lamina narrowing towards base, base slightly rounded or not, not decurrent, apical and dorsal lamina unistratose; costa extending upto leaf apex, bryoides type; laminal cells irregularly quadrangular to polygonal, mammillose, more or less obscure, apical cells 20.33-33.02 x 9.05-9.85 µm, juxta costal cells 25.47-47.87 x 11.98-19.25 µm; mid dorsal laminal cells plane, 9.43-11.39 x 7.90-9.46 µm, mid vaginant laminal cells plane, 7.25-15.81 x 6.60-8.97 µm; gemmae not found (Plate 53-54 & Fig.27).

Fertile parts not found.

Diagnostic characters: *F. biformis* Mitt. is characterised by its small size, palmately arranged leaves, limbidium present on all laminae and confluent at apex, mammillose and obscure laminal cells, large juxta costal cells and presence of axillary hyaline nodules. The characters such as leaf shape, presence of limbidium on all laminae and closed vaginant laminae are similar to *F. subbryoides* Gangulee, which has smooth laminal cells compared to *F. biformis* Mitt.

Note: Gangulee (1971) and Eddy (1988) reported *F. biformis* Mitt. as plant with smooth laminal cells and *F. coorgensis* Broth. as its synonym since it also has

smooth laminal cells. According to the protologue of *F. biformis* Mitt. the laminal cells are obscure with a single papilla and *F. biformis* is the only papillose species in the bryoides complex reported from Asia. So the species reported as *F. biformis* Mitt. by Gangulee (1971) and Eddy (1988) is probably *F. zollingeri* Mont. and *F. coorgrnsis* Broth. is the synonym of *F. zollingeri* Mont. rather than *F. biformis* Mitt. since it has smooth laminal cells (Bruggeman-Nannenga, 2016). Nair *et al.* (2005) reported this species as *F. subbryoides* Gangulee from Wayanad district of Kerala. According to the description the species reported has cell inclusions which cause obscurity to the cell. *F. subbryoides* Gangulee has smooth, clear laminal cells. Hence *F. subbryoides* Gangulee sensu Nair *et al*. (2005) is *F. biformis* Mitt.

Habitat and General Ecology: On land cuttings and small rocky patch found on low land semi evergreen sacred grove and moist deciduous forest along with *Garckea flexuosa* (Griff.) Margad. & Nork., *Fossombronia sp*. and *Philonotis hastata* (Duby) Wijk & Margad at an altitude range of sea level to 900 m.

Distribution: This species is Pantropical in distribution. Reported from India (Kerala, Karnataka, Tamil Nadu (Dandotiya *et al.*, 2011; Frahm *et al*., 2013; Lal, 2005; Nair *et al.*, 2005 (as *F. subbryoides*); Schwarz, 2014b); Africa, Central America (Belize, Costa Rica, Fiji, Guatemala, Honduras, Nicaragua, Panama), China, Malaysia, Mexico, New Caledonia. Samoa, South America (Argentina, Bolivia, Brazil, Colombia, French Guiana, Paraguay, Peru, Tobago, Trinidad, Venezuela), West Indies (Eddy, 1988; Iwatsuki, 1982). The present collection is a new record to Kerala. (Map 30A&30B).

Specimens examined: India, Kerala, Wayanad district (Muthanga Range, 867 m), Manju C.N. (ZGC 84395), Ernakulam district (sea level), Vilangannoor kavu, Aluva), 09.07.2017, Vinjusha (ZGC 16377); Kannur district, Aralam WLS (near Pookkundu, 70 m), 10.01.2015, Manjula (ZGC 4020B), Way to waterfall from Meenmutty tower, 800m, 17.09.2015, Manjula (ZGC 15643B), Kozhikode district, Pokkunnu (ZG college campus, 81 m), 18.07.2014, Manjula (ZGC 4375, ZCC 15655); Tamil Nadu, Kulasekharam, 24.06.1999. Kanya kumari (SCCN 503B).

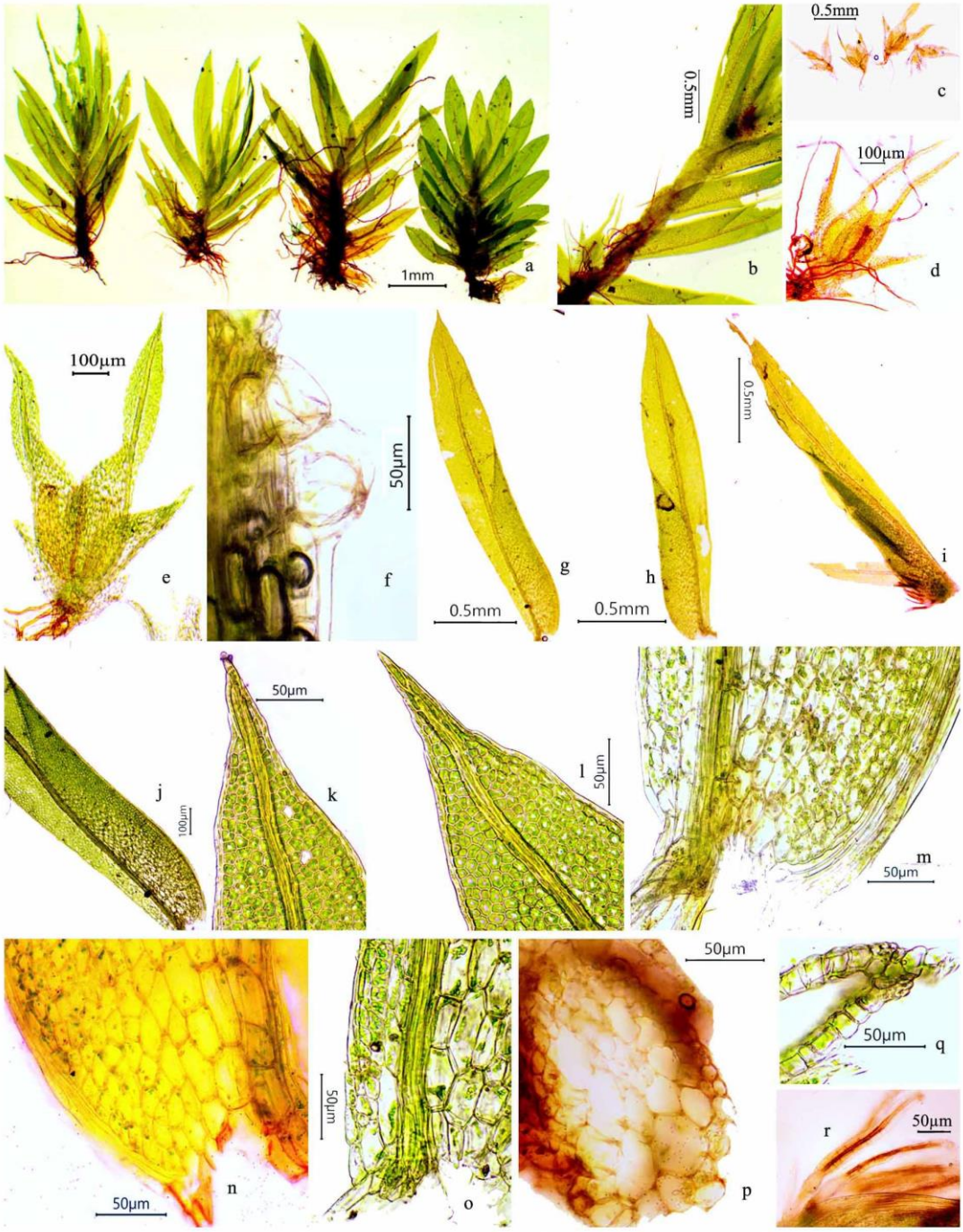


Plate 53. *Fissidens biformis* Mitt., a. vegetative plants-different forms, b. fertile plant with axillary perigonial branch, c-e. perigonial plants in different magnifications, f. stem axillary hyaline nodule, g&h. vegitative leaves, i. perichaetial leaf, j. vaginant laminae, k&l. leaf apices, m&n. vaginant laminae base, o. dorsal lamina base near insertion, p. stem T.S., q. leaf T.S., r. archegonia

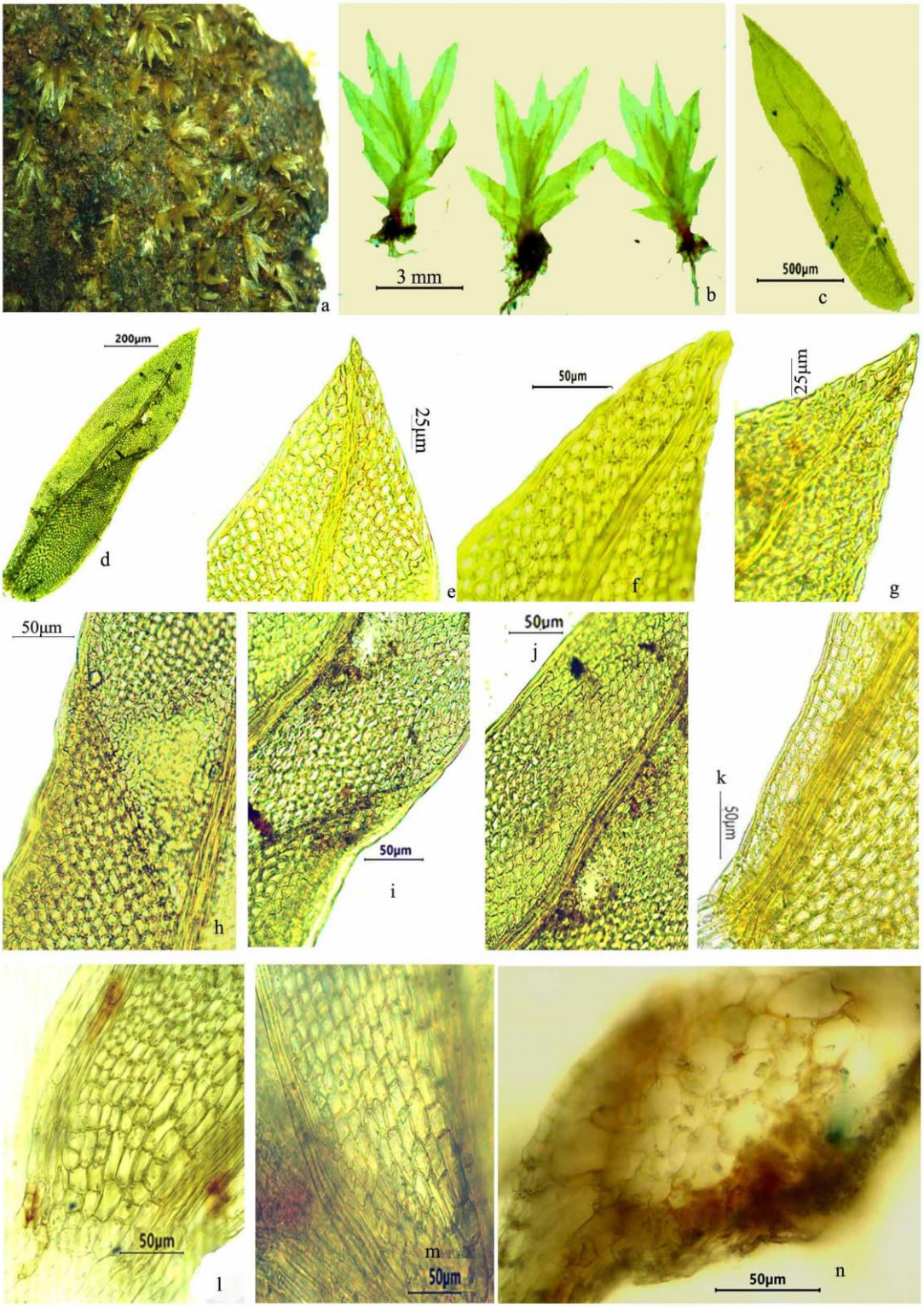


Plate 54. *Fissidens biformis* Mitt., a. habit, b. single plants, c&d. vegetative leaves, e-g. leaf apex, h&i. vaginant laminae apex, j. mid laminal cells, k. dorsal lamina base near insertion, l&m. vaginant laminae base, n. stem T.S. (photo from 84395 (CALI!)).

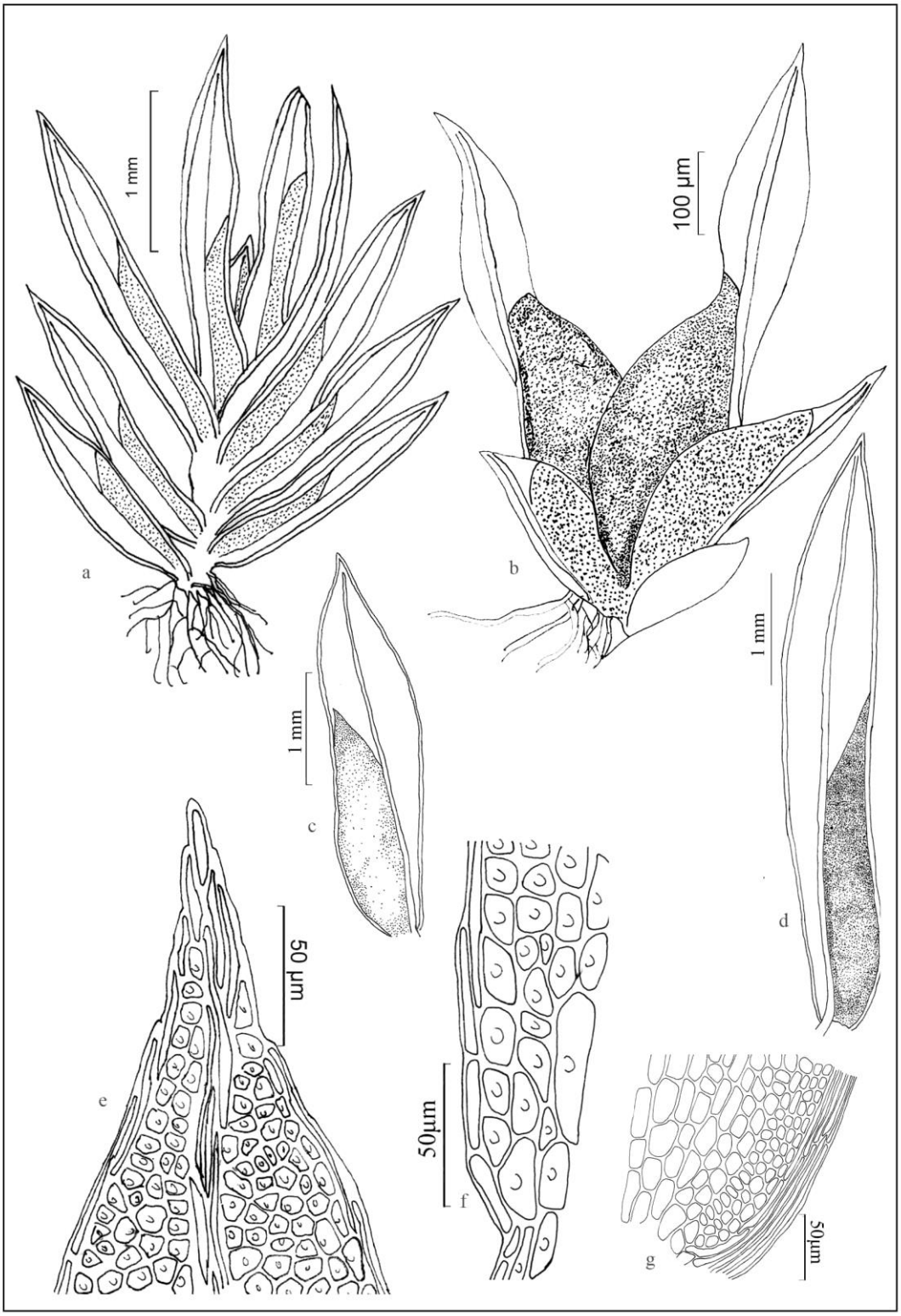
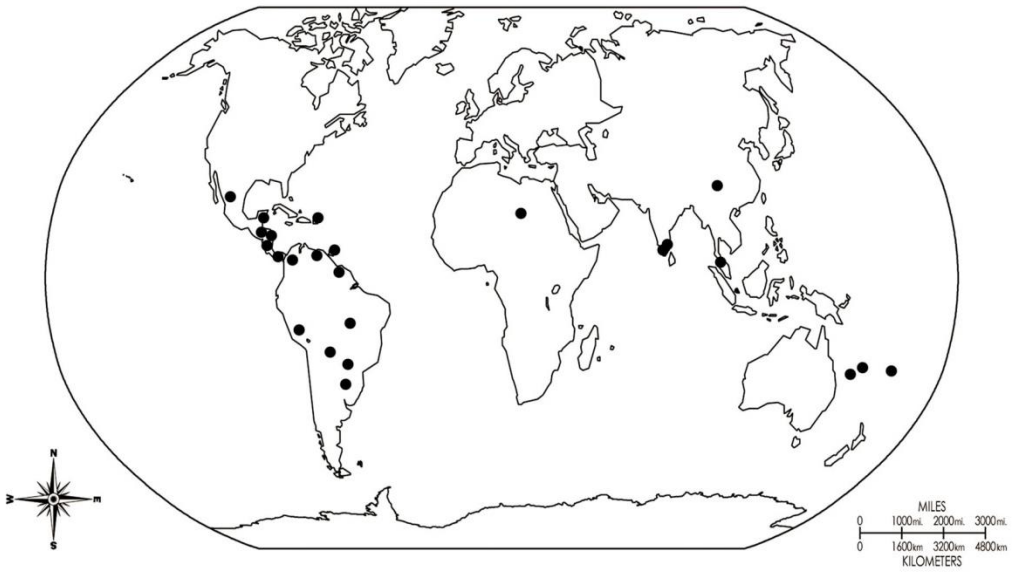
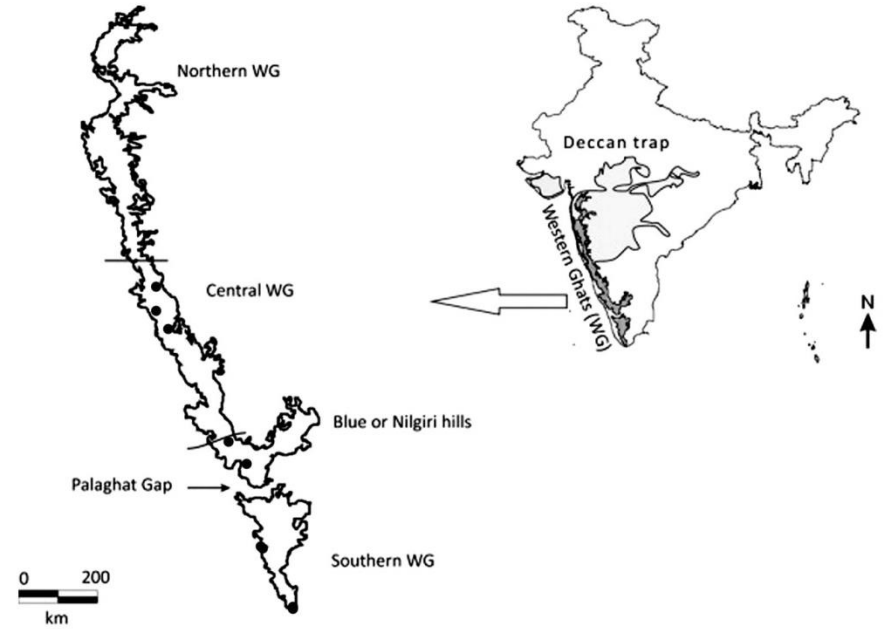


Fig. 27. *Fissidens biformis* Mitt., a. vegetative plant, b. fertile plant, c&d. vegetative leaves, e. leaf apex, f. dorsal lamina base near insertion, g. vaginant laminae base.



Map. 30A. World distribution of ***Fissidens biformis*** *Mitt.*



Map. 30B. Distribution of ***Fissidens biformis*** *Mitt. in Western Ghats*

Fissidens brevinervis Broth., Sitzungsber. Kaiserl. Akad. Wiss. Math.-Naturwiss. Cl. 133: 559. 1924; Schwarz, Frahmia 3: 3-5. 2014b.

Type: China, Sichuan province

Plants small, yellowish green, 1.8–2.9 mm long, 7-9 pairs of leaves, stem simple, cortical stem cells thick walled, 6–8 x 6–15 μm, inner cells thin walled 9–17 x 10–19 μm, central strand absent or very weakly developed, slightly developed hyaline nodules present; leaves elongated oval, margin slightly serrulate, leaf apex acute, limbidia absent to slightly developed as 1 2 intermitting rows of short rectangular cells, costaending 8–14 cells below leaf apex, costa covered by 4, lamina-like cells on both sides from the leaf base to the apex, bryoides type costa, vaginant laminaequal, reaching 2/3 of the leaf length, dorsal lamina wedge shaped at base, slightly obtuse to widely acute, not decurrent, margin finely serrulate, dorsal lamina and apical lamina unistratose; cells at leaf base quadrate to rectangular 4–7 x 5–7 μm, at mid leaf quadrate to polygonal 5–8 x 5–8 μm, leaf apex 6–8 x 6–9 μm, leaf cells with 3–4 papillae on both sides (Plate 55 & Fig.28).

Fertile parts not observed

Diagnostic characters: *F. brevinervis* is characterised by the nature of the costa like costa ends 8-14 cells below apex, central strand absent or weakly developed, presence of axillary hyaline nodules on stem, limbidia absent or slightly developed as intermitting rows and the cells are pluripapillose. This species is related to*F. gardneri* Mitt. in its costa ending far below apex and minutely pluripapillose laminal cells, but differs in the nature of the costa in Indian species of *F. gardneri*, like costa ends slightly beyond the distal end of the vaginant lamina and dorsal lamina ends above or close to the leaf base. This species also related with *F. pallidinervis* Mitt. in its pluripapillose laminal cells and nature of costa. But differs from *F. pallidinervis* in broad vaginant lamina base and completely absence of limbidia on sterile plants.

Note: Some authors like Pursell *et al*. (1993) synonimised *F. brevinervis* under *F. gardneri*, but Suzuki and Iwatsuki (2010) erected *F. brevinervis* as a distinct species. Schwarz (2014b) also commented that Indian species of *F. gardneri* and *F. brevinervis* are different. In the present study I could not locate the species from the area and the above description is based on Schwarz (2014b).

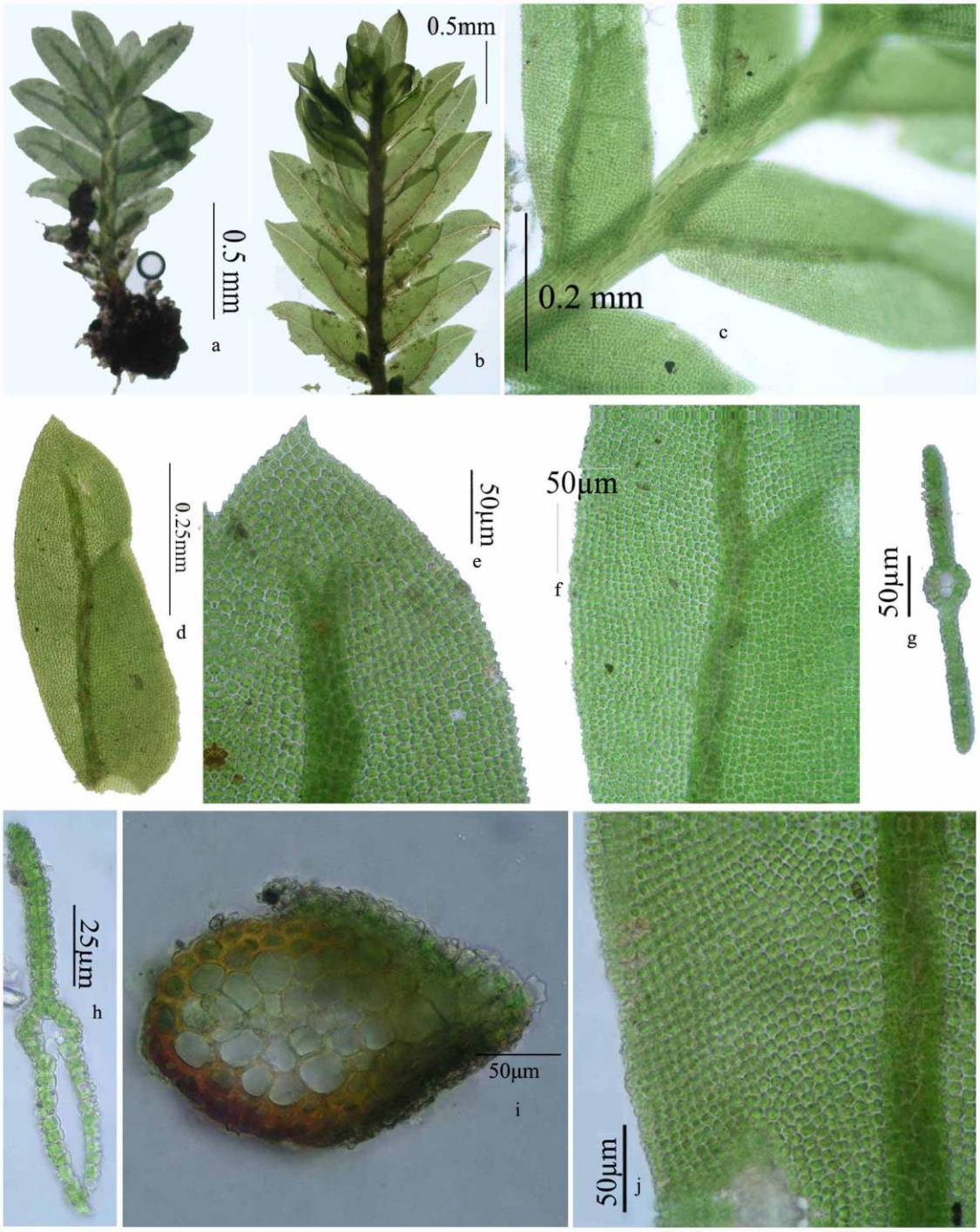


Plate 55. *Fissidens brevinervis* Broth., a&b. habit, c. branch enlarged, d. leaf, e. leaf tip with costa, f. vaginant lamina, g. leaf T.S. near apical lamina, h. leaf T.S. near vaginant laminae, i. stem T.S., j. vaginant laminae base (Photo courtesi Dr. Uwe Schwarz)

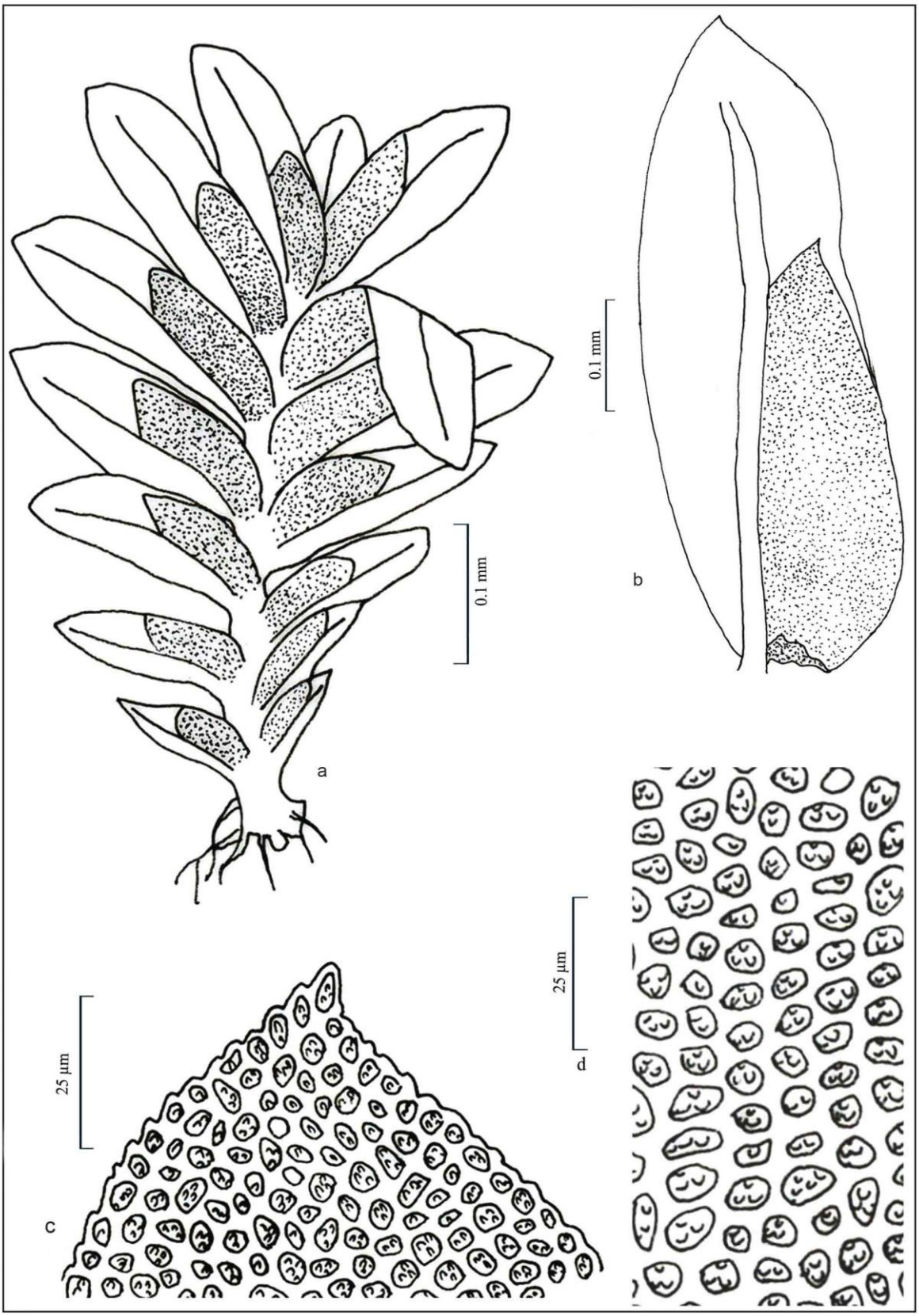


Fig. 28. *Fissidens brevinervis* Broth., a. vegetative plant, b. vegetative leaf, c. leaf apex, d. laminal cells.

Habitat and General Ecology: On bark of tall trees in urban areas at an altitude of 900 m.

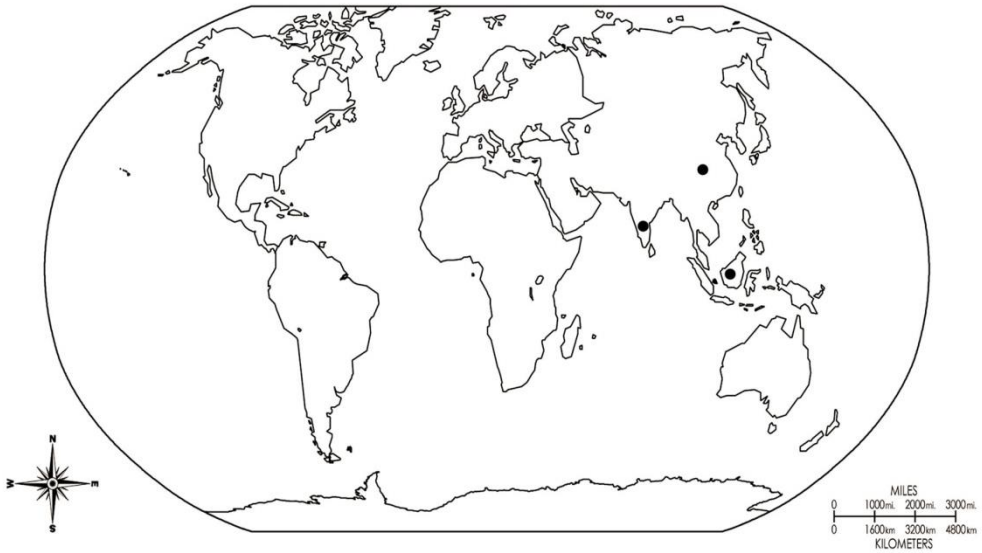
Distribution: India (Karnataka-Bangalore) (Schwarz, 2014b, Schwarz (present coll., pers.comm); China and Indonesia (Iwatsuki, 1982; Li, 1985; Suzuki & Iwatsuki, 2010) (Map 31A&31B).

Fissidens ceylonensis Dozy & Molk., Ann. Sci. Nat. Bot. ser. 3, 2: 304. 1844; Bruehl, Rec. Bot. Surv. India 13(1): 17.1931; Wadhwa, M.V.M. Patrika 4: 90. 1969; Gangulee, Moss. E. India & Adj. 1: 511. 1971; Mohamed *et al.,* J. Bombay Nat. Hist. Soc. 83: 689. 1986; Iwatsuki & Mohammed, J. Hattoori Bot. Lab. 62: 345. 1987; Ellis a&b, Bull. Brit. Mus. (Nat. Hist.), Bot. 22: 153. 1992; Li & Iwatzuki, Moss Fl. China. 2: 19. 2001; Nair & Madhus., J. Econ. Taxon. Bot. 25: 571. 2001; Lal, Checklist of Indian moss: 60.2005; Nair *et al.*, Bryo. Wayanad W. Ghats. 104. 2005; Daniels & Kariyappa, Curr. Sci. 93(7): 980. 2007; Manju *et al.,* Tropical Bryol. Res. Rep. 7: 12. 2008b; Daniels & Daniel, Bryo. South. W. Ghat. 37. 2013.

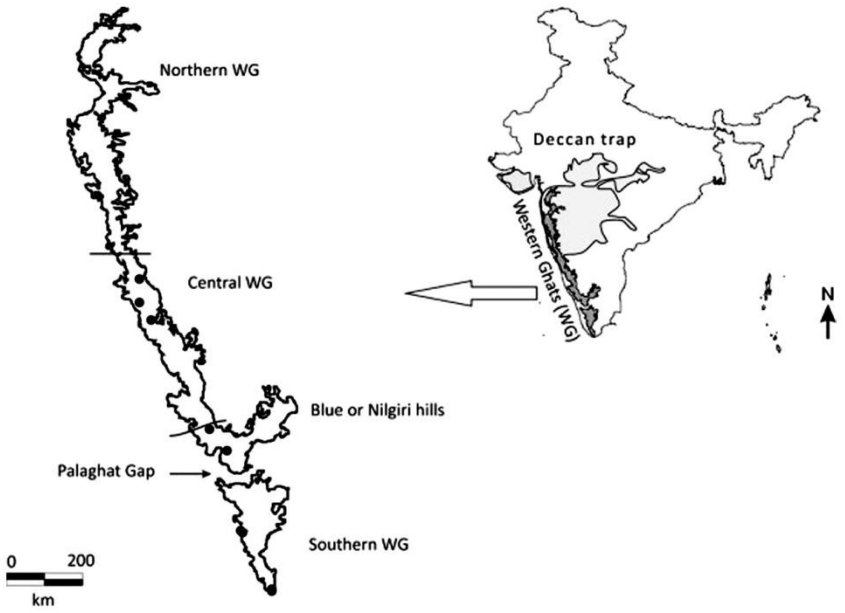
Type: Sri Lanka (Ceylon), König 910. Herb. van Royen. (L).

F. perpusillus Wilson *ex* Mitt., J. Proc. Linn. Soc., Bot. 1 (Suppl.): 141. 1859; *F. bicolor* Thwaites & Mitt., J. Linn. Soc. Bot. 13: 322. 1873; *F. pennatulus* Thwaites & Mitt., J. Linn. Soc. Bot. 13: 325. 1873; *F.intromarginatulus* Bartr., Rev. Bryol. Lichénol. 23: 242. 1954; *F. ceylonensis* var. *jhargramii* Gangulee, Bull. Bot. Soc.Bengal 11: 72. 1957; *F. intromarginatulus* var. *kalimpongensis* Gangulee, Bull. Bot. Soc. Bengal 11: 73. 1957.

Stem with central strand, mostly unbranched, small, 3-6 x 1.50-2.00 mm, hardly heterocaulous, pinnate; vegetative stem yellowish green with 8-14 pairs of leaves, rhizoids reddish brown, axillary hyaline nodules absent; leaves distant to crowded, more crowed towards tip, oblong lingulate, 0.96-2.10 x 0.27-0.60 mm, 5 times long as wide, leaf tip acute to mucronate, margin serrate where elimbate, limbidium intramarginal by 1-5 rows, not reaching the insertion, present on vaginant



Map. 31A. World distribution of ***Fissidens brevinervis*** *Broth.*



Map. 31B. Distribution of ***Fissidens brevinervis*** *Broth. in Western Ghats*

laminae of all leaves of both perichaetial and vegetative stems, extending ± half the length of the vaginant laminae, upto 24 µm wide; vaginant laminae reaching 3/5-4/5 of total leaf length, closed or slightly open, unistratose; dorsal lamina narrowing towards base, 3-5 cells wide, slightly rounded and slightly decurrent at insertion, dorsal and apical lamina unistratose; costa pale green, excurrent, bryoides type; vaginant laminae cells 10.85-11.45 x 5.74-7.37 µm, dorsal lamina cells 9.59-12.21 x 6.23-10.24 µm, mid dorsal laminal cells irregularly hexagonal, slightly convex, 2-5 papillose, 12.80-13.60 x 7.29-8.60 µm; mid vaginant laminal cells 10.13-11.68 x 7.00-9.10 µm, convex, 2-4 papillose; gemmae not found.

Fertile parts; perigonia not seen, perichaetia terminal, perichaetial leaves lanceolate, limbidium prominent on vaginant laminae up to 0.31-0.44 mm; setae 2.00-2.50 mm long, smooth, capsule symmetrical, erect, 0.90-1.00 mm, exothecial cells quadrate with thickened corners, peristome scariosus type, tooth base 46.90–53.60 µm wide, orange-brown, spirally thickened, calyptra 0.35-0.49 mm long, scabrose; spores 15.25-17.38 µm, translucent (Plate 56-60 & Fig.29).

Diagnostic characters: *F. ceylonensis* Dozy & Molk. is characterised by short excurrent costa, rarely ending below apex, vaginant laminae 3/5-4/5 of total leaf length, 4-6 (or 2-5) papillose laminal cells and intramarginal limbidia on part of vaginant laminae of mid and upper leaves. It can be confused with *F. hollianus* Dozy & Molk. which however, has scabrous setae and shorter, strongly intra-marginal limbidium on vaginant laminae.

Note: Gangulee (1971) reported that the limbidium on vaginant laminae of sterile leaves are much reduced or rarely absent in some forms. *F. ceylonensis* var. *jhargramii* Gangulee proposed by Gangulee (1957) had variation only in the acute leaf apex which is within the variation of type variety and hence considered as a synonym of *F. ceylonensis* Dozy & Molk. The present collections from different microhabitats of Western Ghats shows variations of morphological characters within the species. In some specimens the limbidia on vaginant laminae of fertile stem are very weak or sometimes lacking. Epiphytic specimen shows weakly developed limbidium and costa ends below apex which is a variation from usual character of this species. The extreme tip of leaves also shows variations in morphological nature.

Habitat and General Ecology: This species prefers wide range of habitats such as, land cuttings, large rocky patch, small pebbles, on exposed roots, termite mount and also seen as epiphytes on tree trunk and on rhizome of ferns in almost all altitudinal range upto 2000m. This species is not found as submerged one. It is found in open lands in urban areas, laterite hillocks, scrub jungles, evergreen, semi evergreen, moist and dry deciduous forests, plantations in forest land and in homestead areas. But this species is not found in shola forest. Usually there is no association observed within the species. It is mostly growing as singly or in cluster of the same species. In some collections in the present study this species is found growing in association with the exposed rootlets of higher plants like *Areca in* plantations.

Distribution: India (Dehra Dun, Darjeeling, Himalaya, Karnataka, Kerala, Tamil Nadu, Goa, Sikkim, Uttar Pradesh, West Bengal, (Dixon & Potier de la Varde 1927; Foreau 1930, 1961; Gangulee, 1971; Lal, 2005; Nair *et al.*, 2005); Borneo, China (Yunnan), Indonesia, Iran, Japan, Java, Malaysia, Moluccas, Nepal, New Zealand, Philippines, Sri Lanka, Sumatra, Thailand, Vietnam (Li & Iwatzuki,2001). The present collection is a new record to Goa. (Map 32A&32B).

Specimens examined: India; Karnataka, Way to Kalathagiri (), 20.09.2014, Manjula & Deepa (ZGC 3640); Charmadi Ghat (860m), 02.05.2015, Mufeed (ZGC 4267); Kerala, Kannur district, Aralam WLS, Kannadivecha kunnu (99m), 22.08.2017, Vijisha (ZGC 10161), Ernakulam district, Kothamangalam (Pooyamkutty, $10^0$09’13” N, $76^0$47’40” E, ca. 250m), 23.07.2015, Manjula (ZGC 15056), Ernakulam district, Kothamangalam, Thalakkod, Pattayam kudi, Padavu (83m), 25.07.2015, Manjula (ZGC 15103); Idukki district (Vagamon, $9^0$39’48” N, $76^0$54’27” E, 1300m), 11.01.2004, Shaji, E.K. (120756 (CALI!); Kannur district, Aralam WLS, Valayamchal, $11^0$55’24.1” N, $75^0$47’54” E, 50m) Manju 106695 (CALI!), 10.01.2015, Manjula (ZGC 4021), (Near Pookundu, $11^0$55’81.5” N, 75^0 48’12.5” E, 70m), 10.01.2015, Manjula (ZGC 4020), way to waterfall from Meenmutty tower, $11^0$56’65.5” N, $75^0$52’90” E, 800m), 17.09.2015, Manjula (ZGC 15643), (Mavankal, 100m), 05.10.2002, K.P. Rajesh (87029 (CALI!); Kozhikode district (Maripuzha, $11^0$44’98” N, $76^0$09’80” E, 637m), 18.07.2013, Manjula (ZGC 612a), (Mavoor, $11^0$15’35” N, $75^0$56’43” E, 33m), 18.07.2013, Manjula (ZGC 692), Janakikadu (67m), 28.07.2017, Vinjusha (ZGC 16386), Kakkayam (Urakuzhi, $11^0$33’01” N, $75^0$56’28” E, 911m), 20.09.2014, Manjula & Prajitha (ZGC 3702),

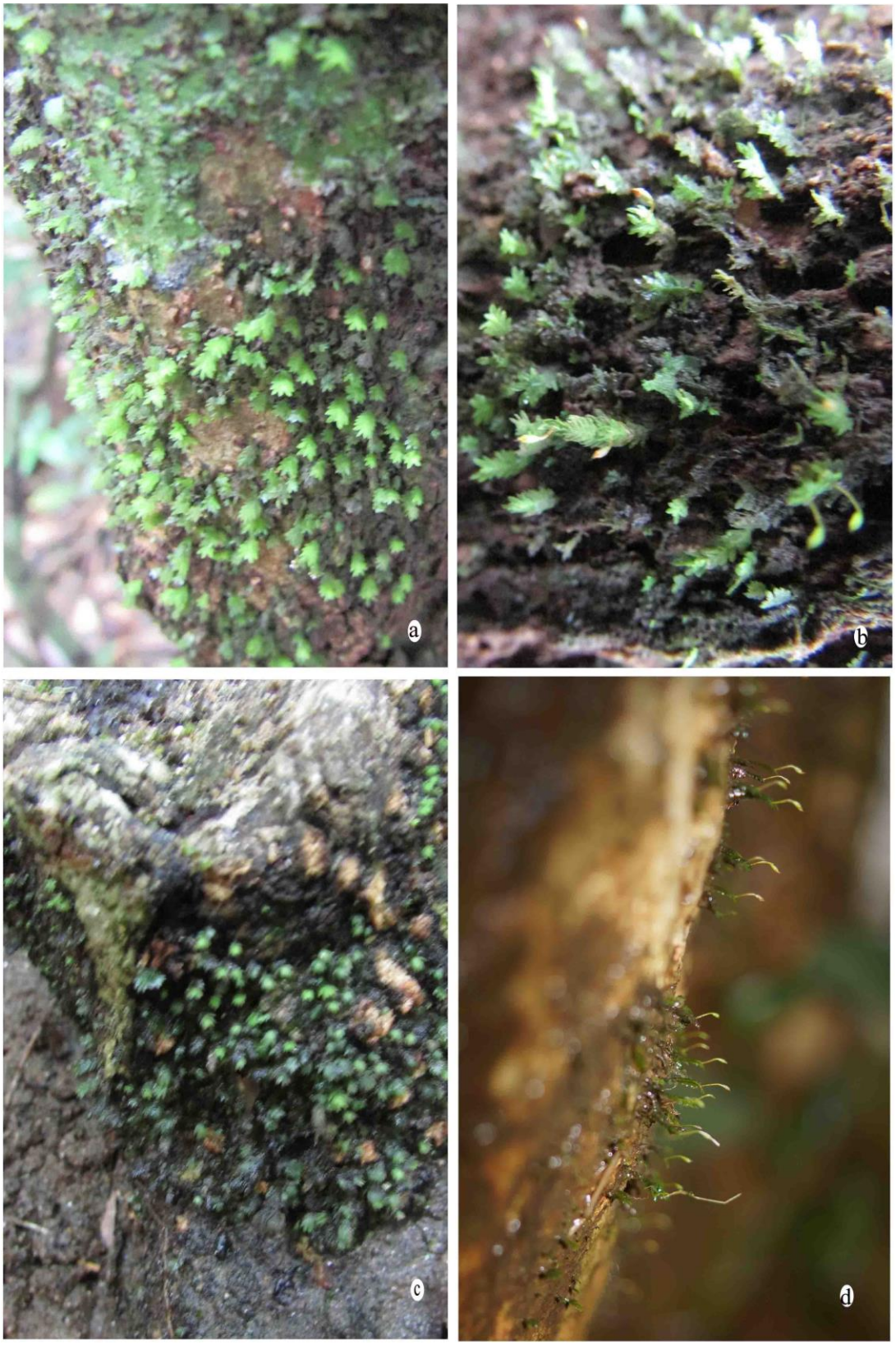


Plate 56. *Fissidens ceylonensis* Dozy & Molk., habit & habitats (epiphytic forms); a&b. on bark, c. on exposed roots of higher plants, d. on lianas

Plate 57. *Fissidens ceylonensis* Dozy & Molk., habit & habitats; a-c&f. on land cuttings, d. on rotten log, e. laterite stone

Plate 58. *Fissidens ceylonensis* Dozy & Molk., habit & habitats; a-d. on land cuttings, e. on termite mount, f. enlarged view of species on termite mount

Plate 59. *Fissidens ceylonensis* Dozy & Molk., a. habit, b. vegetative & sporophytic plant, c&d. vegetative leaves, e&f. leaf apex, g-k. intramarginal limbidial cells at vaginant laminae, l-n. vaginant laminae base, p&q base of dorsal lamina.

Plate 60. *Fissidens ceylonensis* Dozy & Molk., a. sporophytic plant habit, b&f.capsule, c. fertile plant, d&e. perichaetial leaves, g. leaf T.S., h-j. stem T.S., k. archegonia, l. spores, m. calyptra (h,i,j same size).

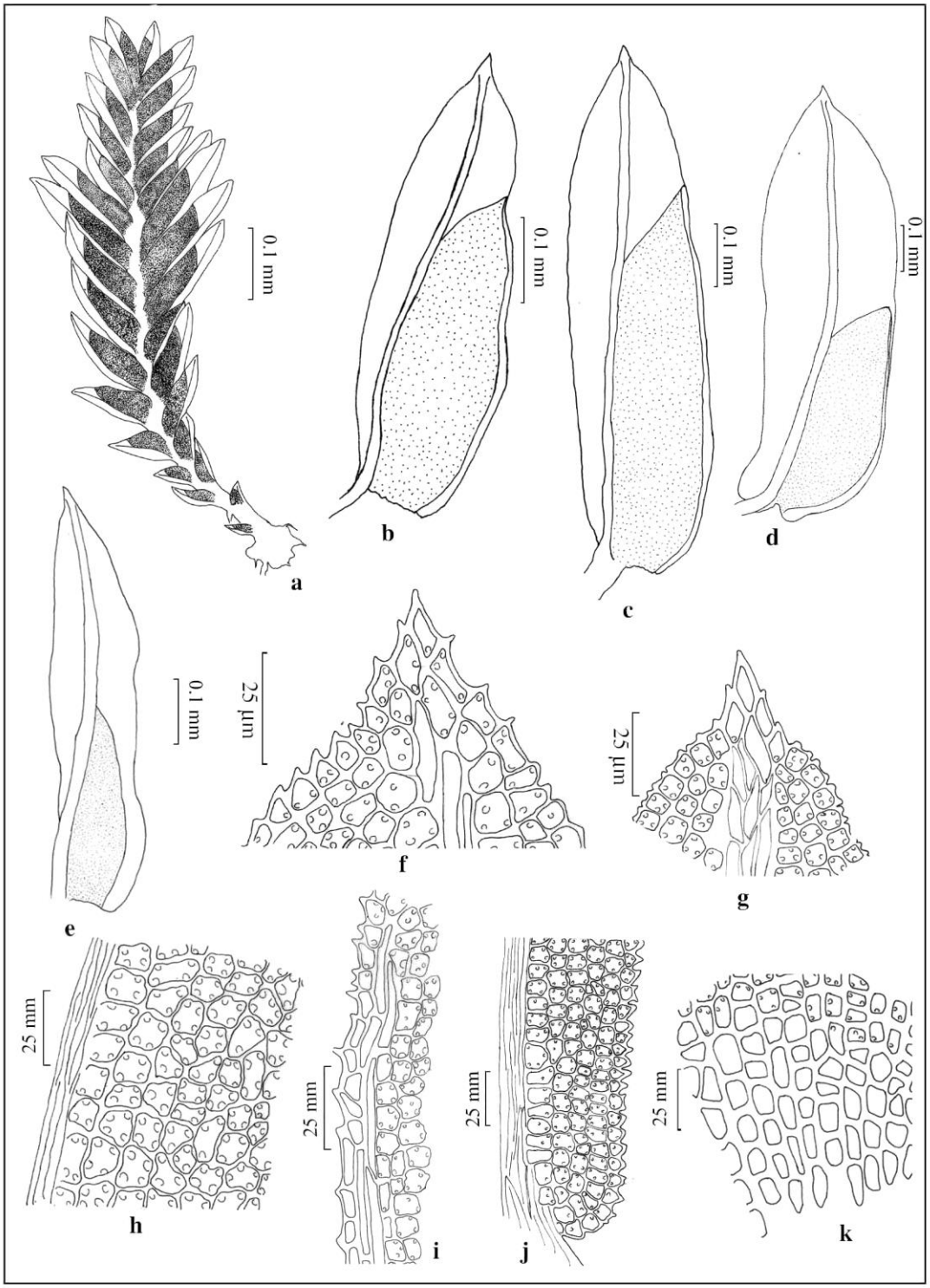
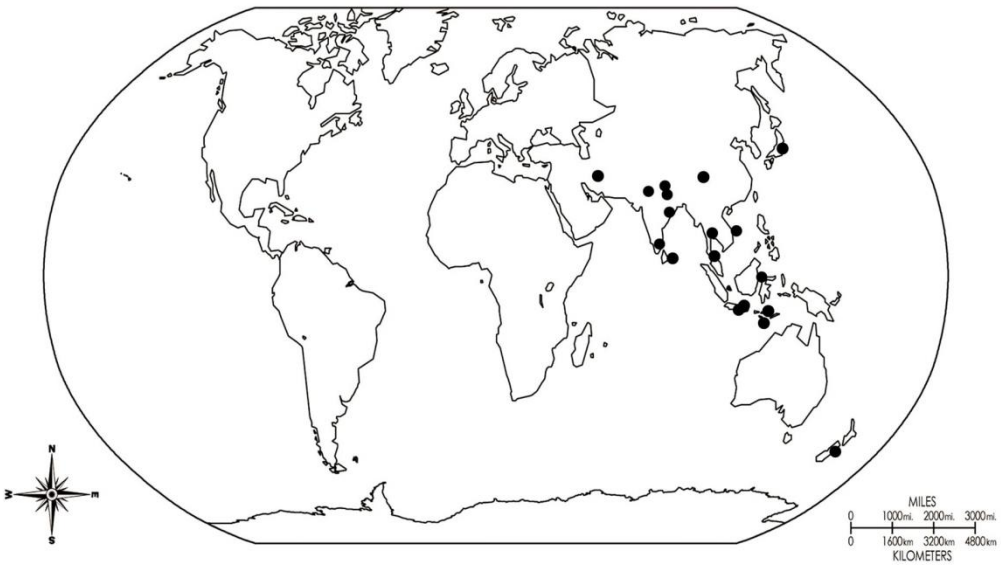
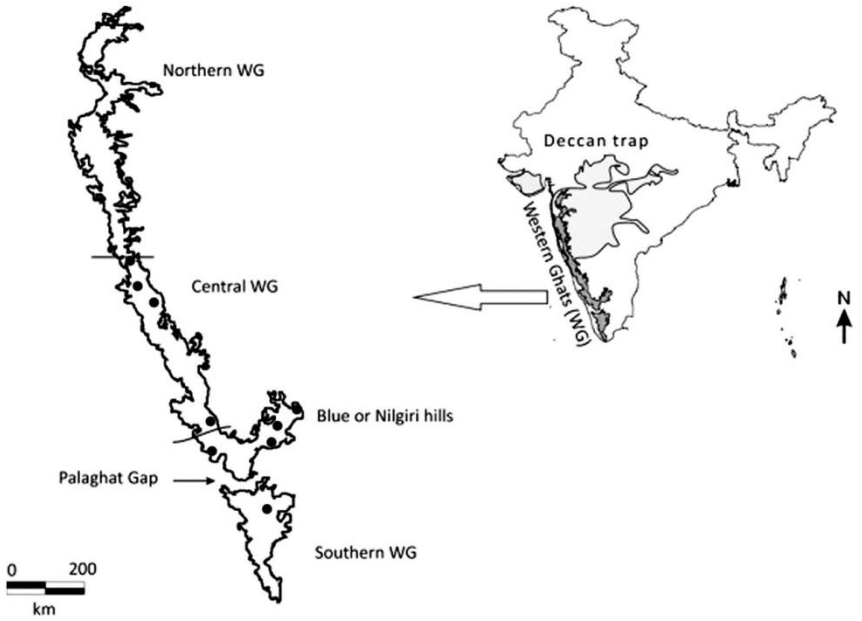


Fig. 29. Fissidens ceylonensis Dozy & Molk., a. vegetative plant, b-d. vegetative leaves, e. perichaetial leaf, f&g. leaf apex, h. vaginant laminae cells with marginal limbidium, i. intramarginal limbidium of vaginant laminae, j. dorsal lamina base near insertion, k. vaginant laminae base.



Map. 32A. World distribution of ***Fissidens ceylonensis*** *Dozy & Molk.*



Map. 32B. Distribution of ***Fissidens ceylonensis*** *Dozy & Molk. in Western Ghats*

Pokkunnu (ZG college, $11^0$14’26” N, $75^0$49’19” E, 81m), 12.09.2017, Akhila (ZGC 6909); Malappuram district (Manoor, $10^0$49’02” N, $76^0$01’04” E, 16m), Chandini (ZGC 801), (Kakkancheri, $11^0$09’22” N, $75^0$53’23” E, 68m), 05.09.2013, Manjula (ZGC 516), (Civil station, $11^0$14’26” N, $75^0$49’19” E, 62m), 21.09.2013, Manjula (ZGC 820, ZGC 821), Near Kondotty (way to Puthiyedathu Paramba, $11^0$13’03” N, $75^0$56’37” E, 39m), 13.08.2016, Manjula & Deepa (ZGC 16128), (Villunniyal, $11^0$07’49” N, $75^0$53’21” E, 65m), 05.09.2013, Manjula (ZGC 539), Vazhikadavu (Palad, $11^0$21’56” N, $76^0$19’54” E, 68m), 16.09.2016, Manjula & Deepa (ZGC 16156), Chelari (Koyappa, 40m), 16.09.2007, P.V.M (106353 (CALI!); Palakkad district, Palakkad district, Silent valley NP, Way to Sairandri, near welcome board (746m), 26.08.2015, Manjula & Deepa (ZGC 15544); Way to Pathrakadavu from Arikan para (854m), 26.08.2015, Manjula & Deepa (ZGC 15532), Sairandhri (Near Watch Tower, $11^0$03’54” N, $76^0$31’53” E, 650m), 26.08.2015, Manjula & Deepa (ZGC 15196), Sairandhri (Way to Paathrakadavu from Arikan para, $11^0$03’46” N, $76^0$31’54” E, 679m), 26.08.2015, Manjula & Deepa (ZGC 15530, ZGC 15541); Pathanamthitta district (Gavi, $9^0$20’06” N, $77^0$09’54” E, 1186m), 17.11.2014, Rajilesh (ZGC 3932, ZGC 3934, ZGC 3942); Wayanad district (Periya, $11^0$50’8.3” N, $75^0$51’22.7” E, 780m) 06.10.2013, Manju (ZGC 885, ZGC 886, ZGC 887), Kuruva dweep, $11^0$82’184” N, $76^0$08’792” E, 900m, 25.09.2013, Manjula (ZGC 864); Goa, Cancona, (Cotigao Wildlife Sanctuary, 88 m), 15.08.2015 Manjula & Deepa (ZGC 15121), Baghavan Mahavir NP (180m), 16.08.2015, Manjula & Deepa (ZGC 15153 (2)); Tamil Nadu, Nagercoil (Maramalai, 340m) 14.01.2014, Manjula (ZGC 975, ZGC 977, ZGC 978 A, ZGC 982), Tirunelveli (Mundanthurai), 30.07.1999, A.E.D. Daniels 556 (SCCN); Maharashtra, Nashik, Hathghat, Burgavu hill (1016m), 17.09.2017, Manjula (ZGC 7760); Trambakeshwar, Dhara (854m), 16.09.2017, Manjula (ZGC 7744), Brahmagiri (1076m), 16.09.2017, Manjula (ZGC 7754)

Etymology: The specific epithet *ceylonensis* is derived from ‘Ceylon’ (older name for Sri Lanka), the type locality of this species.

Fissidens crenulatus Mitt., J. Proc. Linn. Soc., Bot. 1 (Suppl.): 140. 1859; Sedgw., J. Bombay Nat. Hist. Soc. 19: 940. 1910; Blatt., J. Bombay Nat. Hist. Soc. 33: 872. 1929; Bruel, Rec. Bot. Surv. India 13(1): 17. 1931; Gangulee. Moss. E. India 1: 504. 1971; Eddy, Handb. Malay. Mosses 1: 77-79. 1988; Bruggeman-Nannenga &

Berendsen, J. Hattori Bot. Lab. 68: 201. 1990; Dabhade, Moss. Khandala: 139. 1998; Li & Iwatzuki, Moss Fl. China 2: 24. 2001; Lal, Checklist Indian Moss.: 61. 2005; Nair *et al.,* Bryo. Wayanad W. Ghats. 105. 2005 (as *F. virens*); Manju *et al.,* Geophytology 36(1&2): 11. 2006; Chaudhary *et al.,* Bryoph. Fl. N. Konkan: 252. 2008; Daniels & Kariyappa, Curr. Sci. 93(7): 980. 2007 (as *F. crenulatus* and *F. virens*); Manju *et al.,* Tropical Bryol. Res. Rep. 7. 12. 2008b (as *F. crenulatus* and *F. virens*); Daniels, Archive Bryol. 65: 54. 2010; Daniels & Daniel, Bryo. South. W. Ghat.: 38. 2013; Rani *et al.,* Bryo. Andhra Pradesh. 126. 2014

Type: Burma, Prome, *Wallich* 1170 (BM!).

Conomitrium sinense Rabenh., Bryol. Eur. 25: no. 1202. 1873; *Fissidens axilifolius* Thwaites & Mitt., J. Linn. Soc., Bot. 13: 325. 1873; *F. sinensis* (Rabenh.) Broth., Nat. Pflanzenfam. 1(3): 356. 1901; *F. elmeri* Broth., Leafl. Philipp. Bot. 2: 652. 1909; *F. crenulatus* var. *elmeri* (Broth.) Z. Iwats. & Tad. Suzuki, J. Hattori Bot. Lab. 51: 386. 1982; *F. hueckii* P.de la Varde, Rev. Bryol. Lichénol. 15: 145. 1946; *F. semperfalcatus* Dixon, J. Siam Soc., Nat. Hist. Suppl. 10: 2. 1935; *F. titalyanus* Muell. Hal. Linnaea 37: 165. 1871-1873[1872]; *F.virens* Thwaites & Mitt., J. Linn. Soc., Bot. 13: 324. 1873.

Light green, small plants of 2-3 x 1-2 mm, 6-8 pairs of alternate leaves, stem central strand not differentiated, rhizoids brownish, smooth, axillary hyaline nodules absent; leaves lanceolate or oblong lanceolate, leaf tip curls in herbarium; 0.50-0.55 x 0.18-0.20 mm, 3 times long as wide, margin crenulate, apex acute, shows variation in nature of leaf apex; limbidium on the vaginant laminae, two or three rows at vaginant laminae base and single row at tip, vaginant laminae closed, 0.10-0.13 mm wide at base, unistratose, dorsal lamina base round, not decurrent, reaching insertion, dorsal lamina and apical lamina unistratose; costa strong, ending 2-4 cells below apex; laminal cells mamillose, vaginant laminae basal cells 9.82-10.57 x 3.8-6.65 µm, dorsal laminal cells 8.67-9.51 x 4.09-5.83 µm, mid dorsal laminal cells plane, 9.98-11.23 x 6.51-7.52 µm; mid vaginant laminal cells slightly convex, 8.24-10.09 x 6.28-7.01 µm; gemmae not found (Plate 61-64 & Fig.30).

Fertile plants not found.

Diagnostic characters: *Fissidens crenulatus* Mitt. is characterised by oblong lanceolate leaves with acute apex, limbidium usually on the entire length of vaginant laminae of both vegetative and fertile leaves, laminal cells mamillose, round but not decurrent dorsal lamina and serrate margin. Laminal cells and leaf margin is similar to *F. crispulus* Brid. but *F. crispulus* Brid. is elimbate with linear lanceolate leaves and well developed axillary hyaline nodules.

Note: Some plants in the type specimen of *F. crenulatus* Mitt. shows variations such as the limbidium on sheathing laminae is shorter but reaching more than half of sheathing laminae length while in some plants limbidium reaching up to the base of apical lamina and the dorsal lamina base is round or tapering gradually towards the leaf insertion. But in the present species the limbidium usually found on the entire length of vaginant laminae of both vegetative and fertile leaves. This may be due to the habitat variation. Nair *et al*. (2005) and reported this species from Kerala as *F. virens.* Daniels (2003) reported *F. crenulatus* and *F. virens* from Tamil Nadu as separate species.

Habitat and General Ecology: Epiphytic on bark of trees in evergreen forest and on land cuttings, soil and small and large rocks in open lands in moist deciduous forests and semi evergreen forests.

Distribution: India (Assam, Orissa, Western Ghats of Karnataka, Kerala, Maharashtra, Goa, Tamil Nadu (as *F. crenulatus* and *F. virens*) and West Bengal) (Chaudhary *et al.*, 2008; Dabhade, 1998; Daniels, 2003a & 2010; Daniels & Daniel, 2013; Gangulee, 1971; Magdum *et al*., 2017; Nair *et al.*, 2005; Sedgwick, 1910); China, East Nepal, Myanmar, Sri Lanka, Vietnam, Philippines, Italy (Redfearn & Wu, 1986; Tan & Iwatsuki, 1991). The present collection is a new record to Goa. (Map 33A&33B).

Specimens examined: India, Kerala; Wayanad district (Kuruva dweep, 11° 49' 18.48" N 76° 5' 23.28" E, 900m), 26.09.2013, Manjula (ZGC 866), (Periya, $11^0$50’8.3” N, $75^0$51’22.7” E, 744m), 26.09.2013, Manjula (ZGC 878) 16.10.2013, Manju (ZGC 889) (Sulthan Batheri, $11^0$39’56.2” N, $76^0$15’45.6” E, 907 m) Manju 84356 (CALI!), (Thirunelli RF, 11^0 54’12.5” N, 75^0 59’40.3” E, 880 m) MCN 84603 (CALI!), Kannur district, Aralam WLS (Meenmutty fall, $11^0$56’65.5” N,$75^0$52’90” E, 800m), 04.02.2003, Manju 87498 (CALI!), 05.02.2003, Manju

Plate 61. *Fissidens crenulatus* Mitt., habit & habitats; a-f. on land cuttings, b. enlarged view of the plant

Plate 62. *Fissidens crenulatus* Mitt., habit & habitats; a. on large rock, b-e. on land cuttings, f. on roots and small stones

Plate 63. *Fissidens crenulatus* Mitt., habit & habitats; a. on large rock crevice, b-d. on land cuttings (mix of rock and muddy wall), e. on bark, f. on wet exposed root.

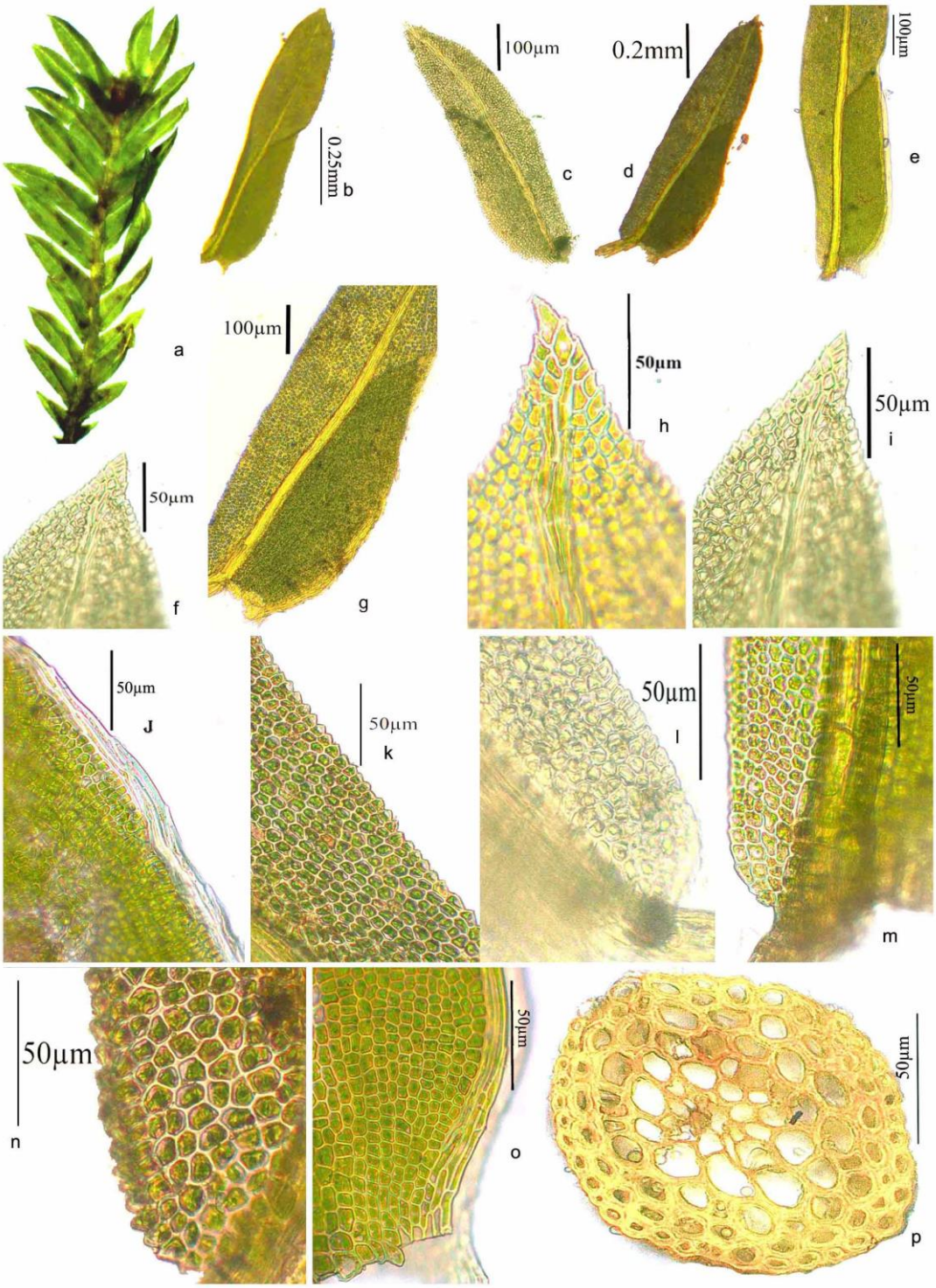


Plate 64. *Fissidens crenulatus* Mitt., a. fertile plant, b-d. vegetative leaves, e&g. vaginant laminae, f,h&i. leaf apex, j. vaginant laminae margin, k. dorsal lamina margin, l-n. dorsal lamina base near insertion, o. vaginant laminae base, p. stem T.S. (a,b,e,h,j,m,o from ZGC 866; c, f, i, l,p from CALI 87516; d,g,k,n from ZGC 889).

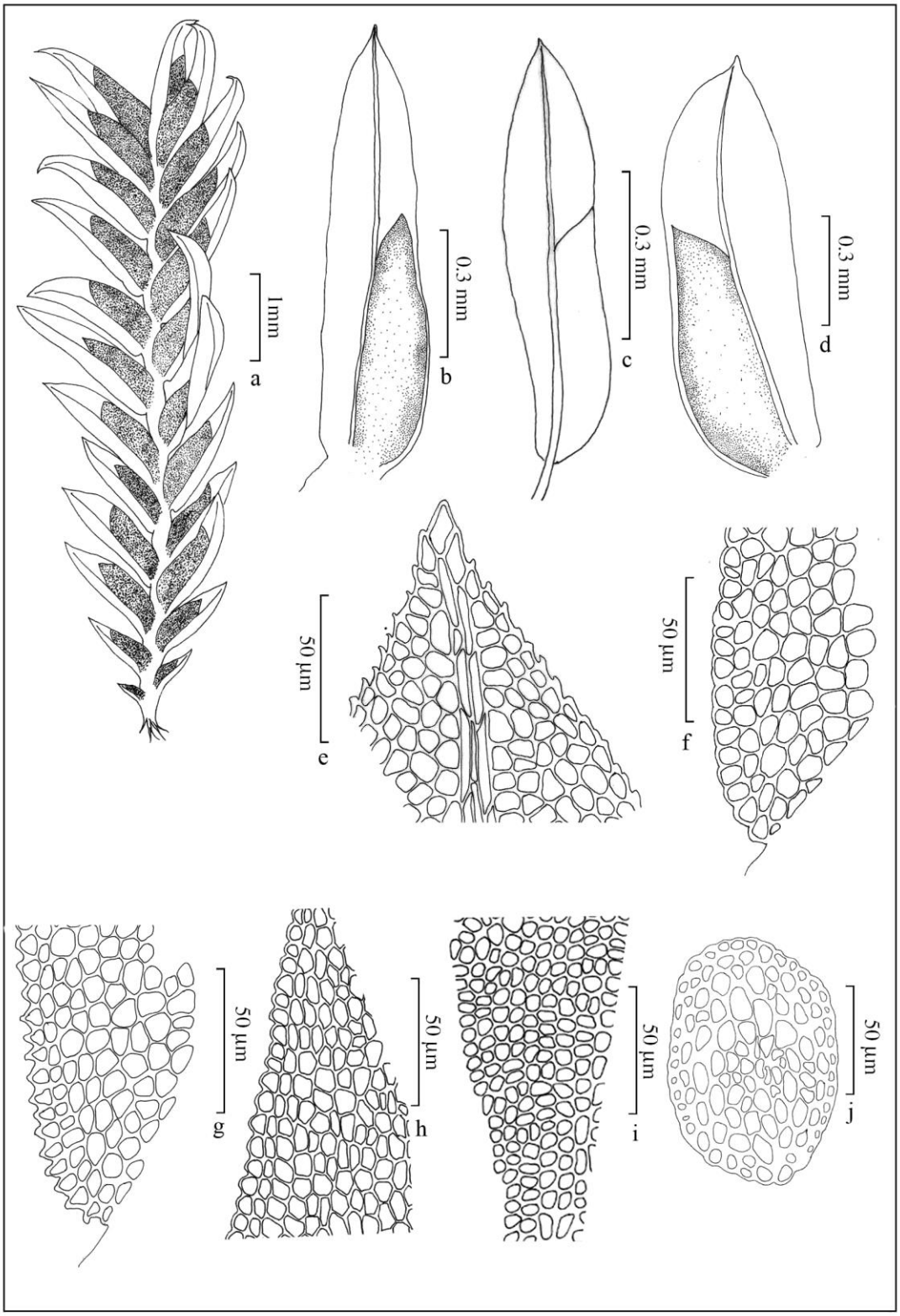
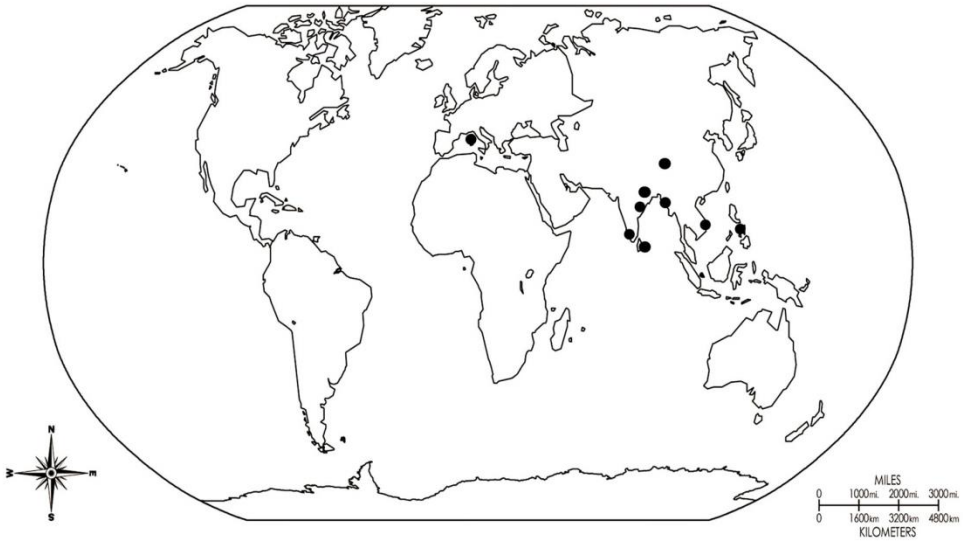
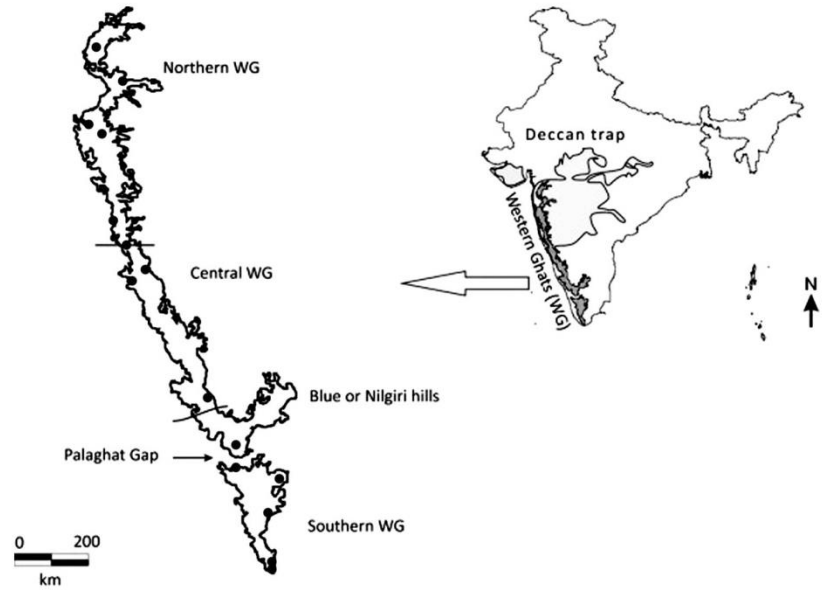


Fig. 30: *Fissidens crenulatus* Mitt., a. vegetative plant, b-d. vegetative leaves, e. leaf apex, f&g. dorsal lamina base near insertion, h. leaf margin, i. vaginant laminae base, j. stem T.S.



Map. 33A. World distribution of ***Fissidens crenulatus*** *Mitt.*



Map. 33B. Distribution of ***Fissidens crenulatus*** *Mitt. in Western Ghats*

87516 (CALI!), Kozhikode district (Thusharagiri, 11° 28' 33.168" N, 76° 0' 47.592" E, 464m), 22.07.2013, Rajilesh (ZGC 633, ZGC 635, ZGC 636b), Palakkad district, Silent Valley NP, Way to Sairandri, near welcome board (749m), 26.08.2015, Manjula & Deepa (ZGC 15545), Pathanamthitta district, Ranni, Way to Erimeli from Plapally (29.01.2017), Manjula (ZGC 16364); Goa, Cancona, (Cotigao Wildlife Sanctuary, 88 m), 15.08.2015 Manjula & Deepa (ZGC 15123); Maharashtra, Choukul (730 m), 14. 09. 2017, Manjula (ZGC 7728), Amboli (800 m), 12.11.2016, Manjula (ZGC 11327B), Burgavu hills (1016 m), 17.09.2017, Manjula (ZGC 7761), Kolhapur, Way to Mahabaleshwar (868m), 10.11.2016, Manjula (ZGC 16198); Rajghat (), 15.09.2017, Manjula (ZGC 7742); Nashik, Hathghat, Burgavu hill (1016m), 17.09.2017, Manjula (ZGC 7761); Amboli Ghat (768m), 12.11.2016, Manjula (ZGC 16327b); Uttar Pradesh, Pilibhit (Near Gajraula, $28^0$46'11.1" N, 79^0 46'50.3" E, 173m), 12.09.2014, Vinay Sahu (LWG 258215A!); West Bengal (Darjeeling, $27^0$1'57.8" N, $88^0$15'1.9" E, 1981m), 23.09.2002, Vinay Sahu (LWG 224015C!); Tamil Nadu, Kanyakumari (Maramalai, 750m), 25.02.1999, A.E.D. Daniels 413 (SCCN!) (as *F. virens* Thwaites & Mitt.); Sikkim, Melli (450m), 02.10.1982, B.D.Kar (57412) (CAL!) (as *F. virens*); Andaman & Nicobar, Campbell Bay, 10.03.94, B.D. Kar (63601) (CAL!); NEFA (Dharibati), Nov. 1934, N.L. Ber (Ber 208) (CAL!), (as *F. semperfulcatus*); Burma, Prome, *Wallich* 1170 (BM!); Islands of Negros, Province of Negros Oriental, 11.04.1911, A.D.E. Elmer (10320) (BM!); Philippines; Province of Negros oriental, Island of Negros, 11.04.1911, A.D.E. Elmer (10320) (BM!); Thailand: Prachinburi, Klug Mai (Orchid) Water fall, A. Touw (12395 BM!).

Etymology: The specific epithet *crenulatus* defines the marginal crenulated (toothed) appearance of lamina.

Fissidens enervis Sim, Trans. Roy. Soc. South Africa 15: 187, 1926; Bruggeman-Nannenga *et al.*, Lindbergia 39: 29. 2016; Bruggeman-Nannenga, Polish Bot. Journ. 62(2): 139-168. 2017.

Type: Natal, Pietermaritzburg, Town Bush Valley, *Sim 9899* (lectotype (designated by Magill, 1981) PRE!)

Plants growing scattered; rhizoids basal, from lower stem cortex and some from the lamina, hyaline or brown, smooth; stem unbranched, 13 µm wide cortical

cells, 1.5- 5.0 x 1.0- 2.5 mm, pinnate; leaves pale green, distant, 4-7 pairs, crispate when dry, elliptical with cuspidate tip, 0.65-0.95 - 1.25 x 0.25 mm, L/W 3.2-5, limbate; limbidium reaching the leaf apex, confluent or not, confluent at the apex of the vaginant laminae, reaching the insertion of the dorsal lamina and reaching the insertion of the vaginant lamina or not, in mid of dorsal lamina11-16 µm wide probably bistratose (no cross-sections seen), on vaginant laminae to 11 µm wide, bistratose, marginal throughout; vaginant lamina ± 1/2 the leaf length, at the base narrower than the stem, slightly rounded at insertion, unistratose, subequal; dorsal lamina slightly rounded to ± straight at toward the insertion base, reaching the insertion, not decurrent, unistratose; costa lacking (vestigial in perichaetial leaves of type (surface view); mid laminal cells large, plane, 32-67 x 16-25 µm; mid vaginant laminal cells large, plane, 31.5 - 54 x 16 – 25.5 µm; gemmae not seen.

Fertile parts. Perigonia terminal on small, *ca*. 1.5 mm long plants; antheridia 230 µm long; perichaetia terminal, perichaetial leaves 1.1-1. 3 mm long, vaginant laminae wide in the proximal part; archegonia 0.14-0.16 mm long; sporophyte: seta ± 4 mm long, smooth; capsule symmetrical, 0.5 X 0.25 mm, ± 32 columns of quadratic-oblong exothecial cells; peristome scariosus-type, teeth ± 33.5 µm wide at base; spores not seen (Plate 65 & Fig.31).

Diagnostic characters: *Fissidens enervis* is characterised by its cuspidate leaf apices, ecostate leaves, large laminal cells and rhizoids growing frequently from the lamina. It may be confused with *F. hyalinus* Wilson & Hook. (= *F. nymannii* Fleisch.) and *F. dealbatus* Hook. f. & Wilson in its ecostate, limbate character. It differs from both by its cuspidate leaf apex and rhizoids growing from laminal cells. *F. hyalinus* is further distinct by its unistratose limbidia and *F. dealbatus* Hook. f. & Wilson in typically having 40 or more columns of exothecial cells.

Habitat and General Ecology: On land cuttings, exposed roots and soil in evergreen forest, associated with *F. crispus* Mont., *F. crispulus* Brid. and *Philonotis hastata* (Duby) Wijk & Margad. between 900 and 1200 m.

Distribution: It is a rare species reported from South India and Africa (Bruggeman-Nannenga *et al.*, 2016; Magill, 1981). Bruggeman-Nannenga *et.al*., (2016) reported this species as new record for Asia collected from the Western Ghats of Palakkad district in Kerala (Map 34A&34B).

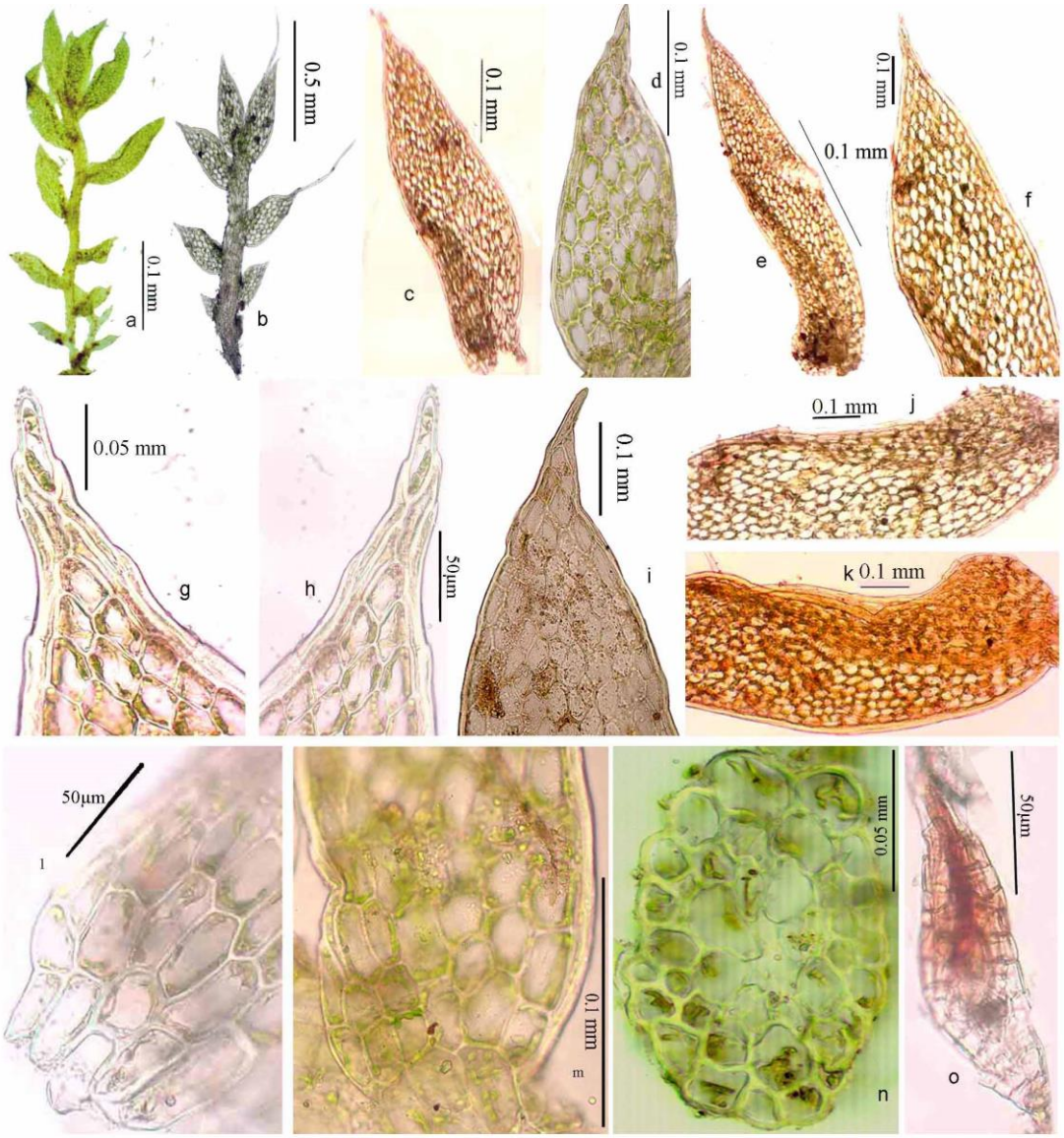


Plate 65. *Fissidens enervis* Sim, a. perichaetial plant, b. small vegetative plant with rhizoids growing from leaves, c&d. vegetative leaves, e. perichaetial leaf, f-i. leaf apex, j&k. base of perichaetial leaves, l&m. leaf insertion, n. stem T.S., o. archegonium (a,c,e-g,j,k,n from 1093c; b,d,m from1138B; i from type specimen, h,l,o from ZGC1098B).

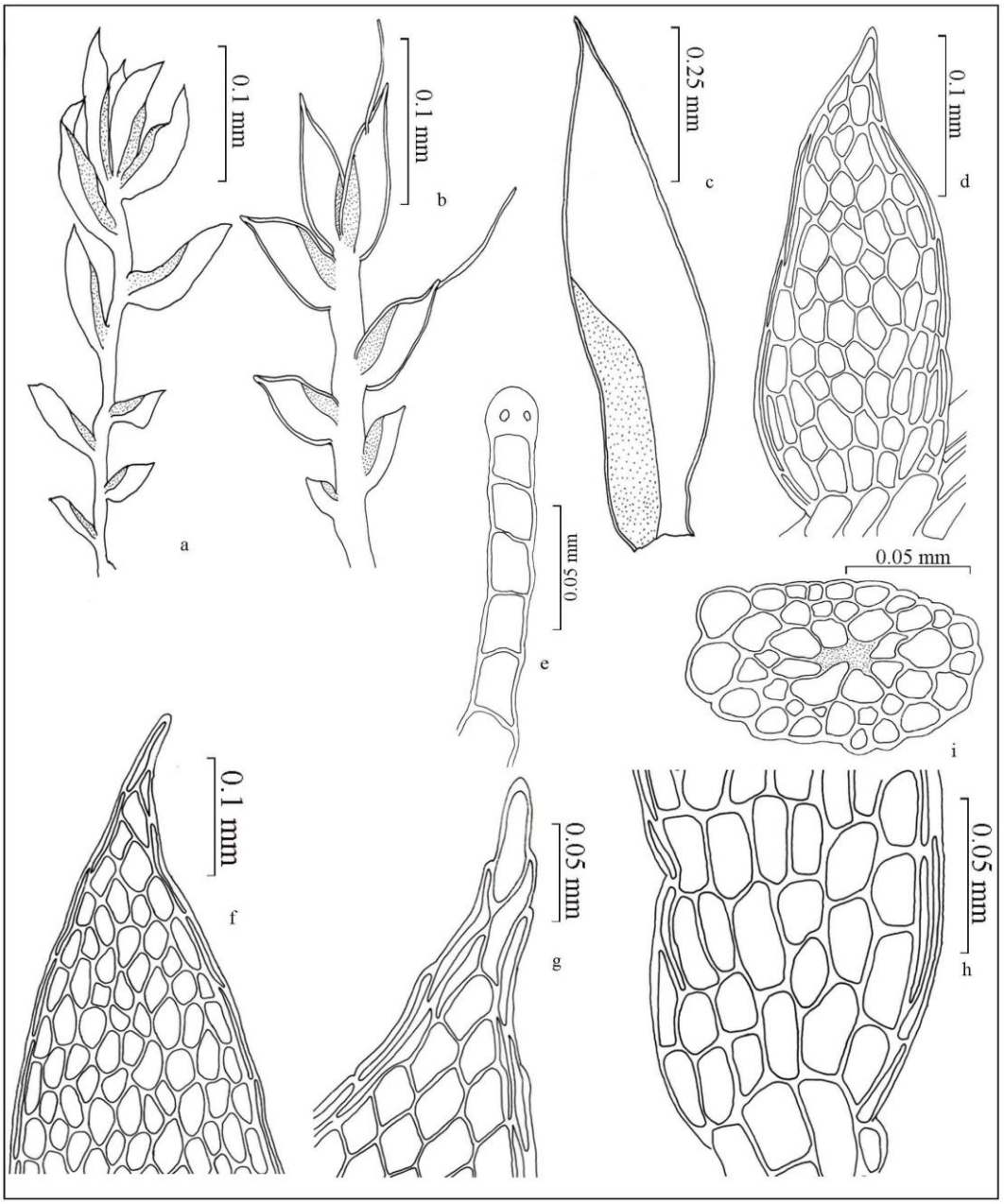
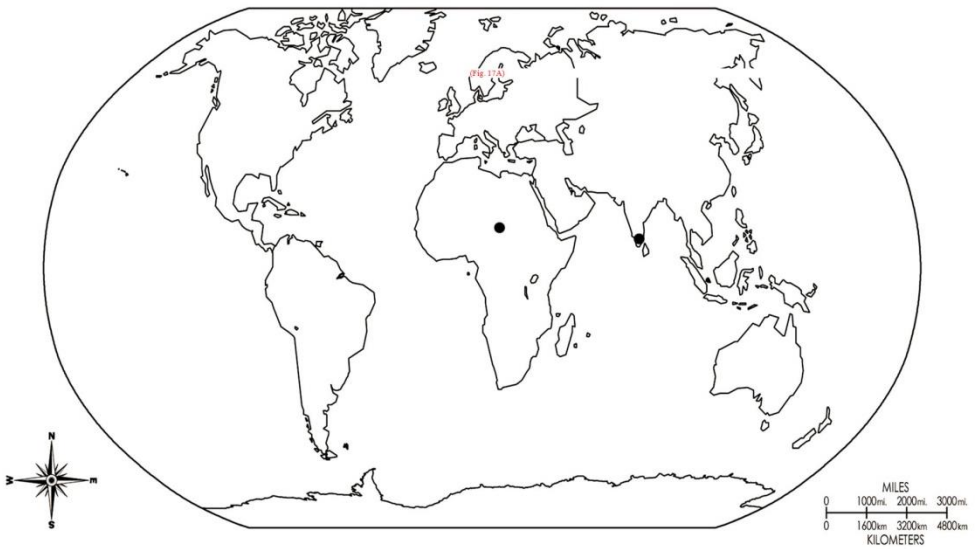
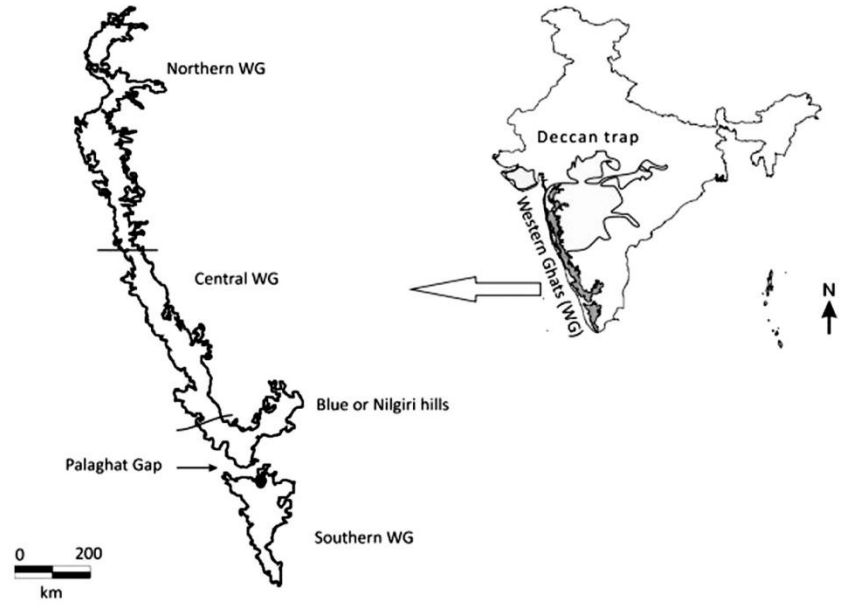


Fig. 31. *Fissidens enervis* Sim, a. perichaetial plant, b. small vegetative plant with rhizoids growing from the leaves, c&d. vegetative leaves, e. transection showing the limbidium of the vaginant laminae, f&g. vegetative leaf apex, h. dorsal lamina base near leaf insertion, i. Stem T.S.



Map 34A. World distribution of ***Fissidens enervis*** *Sim*



Map 34B. Distribution of ***Fissidens enervis*** *Sim in Western Ghats*

Specimens examined: India, Kerala, Palakkad district (Nelliyampathi, $10^{0}53'55''$ N, $76^{0}68'37''$ E, 900–1200 m) 12.07.2015, Manjula K.M. (ZGC 1093C, 1098B, 1138B).

Etymology: The term *enervis* states the ecostate (costa absent) leaves of this species.

Fissidens firmus Mitt., J. Proc. Linn. Soc., Bot., Suppl. 2: 139. 1859; Dixon, J. Indian Bot. 2: 178. 1921 (as *F. subfirmus*); Manju *et al.,* Tropical Bryol. Res. Rep. 7: 12. 2008b; Bruggeman-Nannenga *et al*., J. Bryol. 37 (3): 178-183. 2015

Fissidens subfirmus Dixon J. Indian Bot. 2: 178. 1921.

Type: Ceylon, Adam's Peak.

Plants dark green, slender, 4-15 x 1-2 mm, stem brownish green, central strand not differentiated, 3-5 tiers of thin walled large inner and 2 or 3 tiers of small thick walled outer cortical cells; rhizoids brown, smooth; axillary hyaline nodules absent; main stem branched or unbranched, branching by proliferation with distantly arranged leaves, 10-19 pairs of leaves; leaves slightly crispate when dry; leaves lanceolate with acute apex, but sub-acute in some leaves, margin sub-entire, leaf margin eroded in some leaves due to the submerged habitat, papillae like projections present in some marginal cells especially in apical cells, 1.2-1.4 x 0.3-0.4 mm; limbidium marginal or intramarginal, reaching the vaginant laminae apex or shorter, also at apical lamina base, 3-5 rows at base and 1 or 2 rows above; vaginant laminae slightly open and reaches 1/2 to 3/4 the length of apical lamina, unistratose; dorsal lamina base narrow, slightly round, dorsal lamina and apical lamina unistratose; costa prominent, yellowish green, bryoides type, reaching the apex or 3-5 cells below; laminal cells irregularly polygonal, apical cells 8.78-16.65 x 5.05-10.08 µm, middle cells 9.31-13.02 x 7.53-8.63 µm, dorsal lamina basal cells 8.31-13.76 x 7.65-9.21 µm and vaginant laminae basal cells 14.96-24.25 x 9.03-9.84 µm, mid dorsal laminal cells irregularly rectangular, plane, 8.27-12.44 x 8.71-11.39 µm, mid vaginant laminal cells slightly convex, 9.90-10.07 x 7.59-9.50 µm; branched gemmae are common from axils.

Fertile parts; perigonial branch small, 2-3 mm long, attached to the main stem by rhizoids, 5-7 pairs of leaves, leaves 1.1-1.2 x 0.11-0.13 mm , 0.2-0.28 mm

wide at vaginant laminae base, perigonia terminal, 10-12 antheridia 0.28-0.3 mm long; perichaetia terminal, perichaetial branch more or less similar to vegetative branch, 12-20 pairs of leaves, 8-15 mm long, 15-20 pairs of archegonia of 0.31-0.33 mm long; sporophyte not found (Plate 66-67 & Fig.32).

Diagnostic characters: *Fissidens firmus* Mitt. is characterised by its marginal or slightly intramarginal limbidium, stem central strand not differentiated, costa reaching apex or 3-5 cells below apex, smooth laminal cells, slightly convex mid vaginant laminal cells and plane mid dorsal laminal cells. Limbidium and costa similar to *F. hollianus* Dozy & Molk. but cells are pluripapillose in *F. hollianus*.

Habitat and General Ecology: On wet land cuttings along with *F. hollianus*, water flowing rocks and also as submerged on rocky patches in evergreen, semi evergreen and moist deciduous forests in aquatic habitat.

Distribution: India (Tamil Nadu, Kerala), Sri Lanka and Thailand (Bruggeman-Nannenga *et al*., 2015; Lal, 2005: Manju *et al*., 2008b*;* Vohra *et al*.,1982) (Map 35A&35B).

Specimens examined: India, Kerala, Palakkad district (Nellyampathi, Vellarimedu, 400m), 17.08.2014, Maya, C.N. (ZGC 1192); Wayanad district (Noolpuzha, 1200m), 19.06.2014, Dhanya (ZGC 1053b); Kozhikode district (Peruvannamuzhi, 800m), 16.03.2013, Prajitha, B. (8645) (MBG!); Ceylon, Central Province, Thwaites (1346p.p.) (BM!).

Etymology: The specific epithet *firmus* reflects the rigidity of the leaves and toughness of the plant in appearance.

Fissidens flaccidus Mitt., Trans. Linn. Soc. London 23: 56. 6 f. 18. 1860; Sedgw., J. Bombay Nat. Hist. Soc. 19: 939. 1910; Blatter, J. Bombay Nat. Hist. Soc. 33: 872. 1929; Bruehl, Rec. Bot. Surv. India 13(1): 16. 1931; Wadhwa, M.V.M. Patrika 4: 91. 1969-1971; Gangulee, Moss. E. India & Adj. 1(2): 462. 1971 (as *F. splachnobryoides* Broth.); Iwatsuki & Suzuki, J. Hattori Bot. Lab. 51 : 353. 1982 (as *F. splachnobryoides* Broth.); Iwatsuki & Mohamed, J. Hattori Bot. Lab. 62 : 342. 1987; Pursell, Bryologist 100: 194. 1997; Lal, Checklist Ind. Moss. 63. 2005; Nair *et al.*, Bryo. Wayanad, W. Ghats 107. 2005; Chaudhary *et al.*, Bryoph. Fl. Gujarat: 69. 2006 & Bryoph. Fl. N. Konkan: 252. 2008; Daniels & Kariyappa, Curr. Sci.

Plate 66. *Fissidens firmus* Mitt., habit & habitats; a. on rocky patch where small pebbles of rocks are seen, b. on cliffs of rocks, c&d. on rocky patch

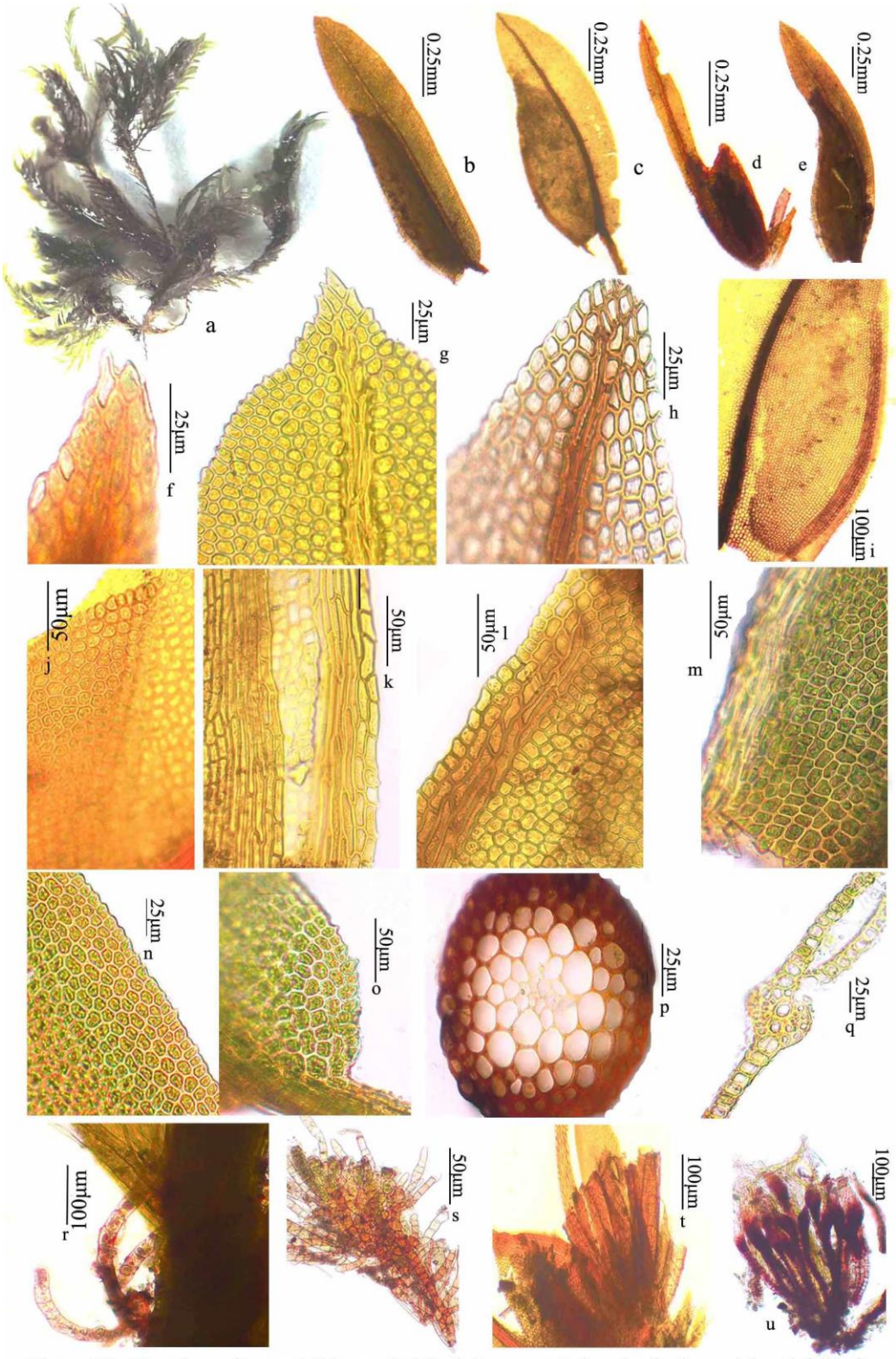


Plate 67. *Fissidens firmus* Mitt., a. habit, b&c. vegetative leaf, d. perichaetial leaf, e. perigonial leaf, f,g&h. leaf apex, i. vaginant laminae base, j. vaginant laminae apex, k&l. limbidium on vaginant laminae, m. vaginant laminae base, n. dorsal lamina margin, o. dorsal lamina base, p. stem T.S., q. leaf T.S., r&s. gemmae from leaf axils, t. perigonium, u. perichaetium.

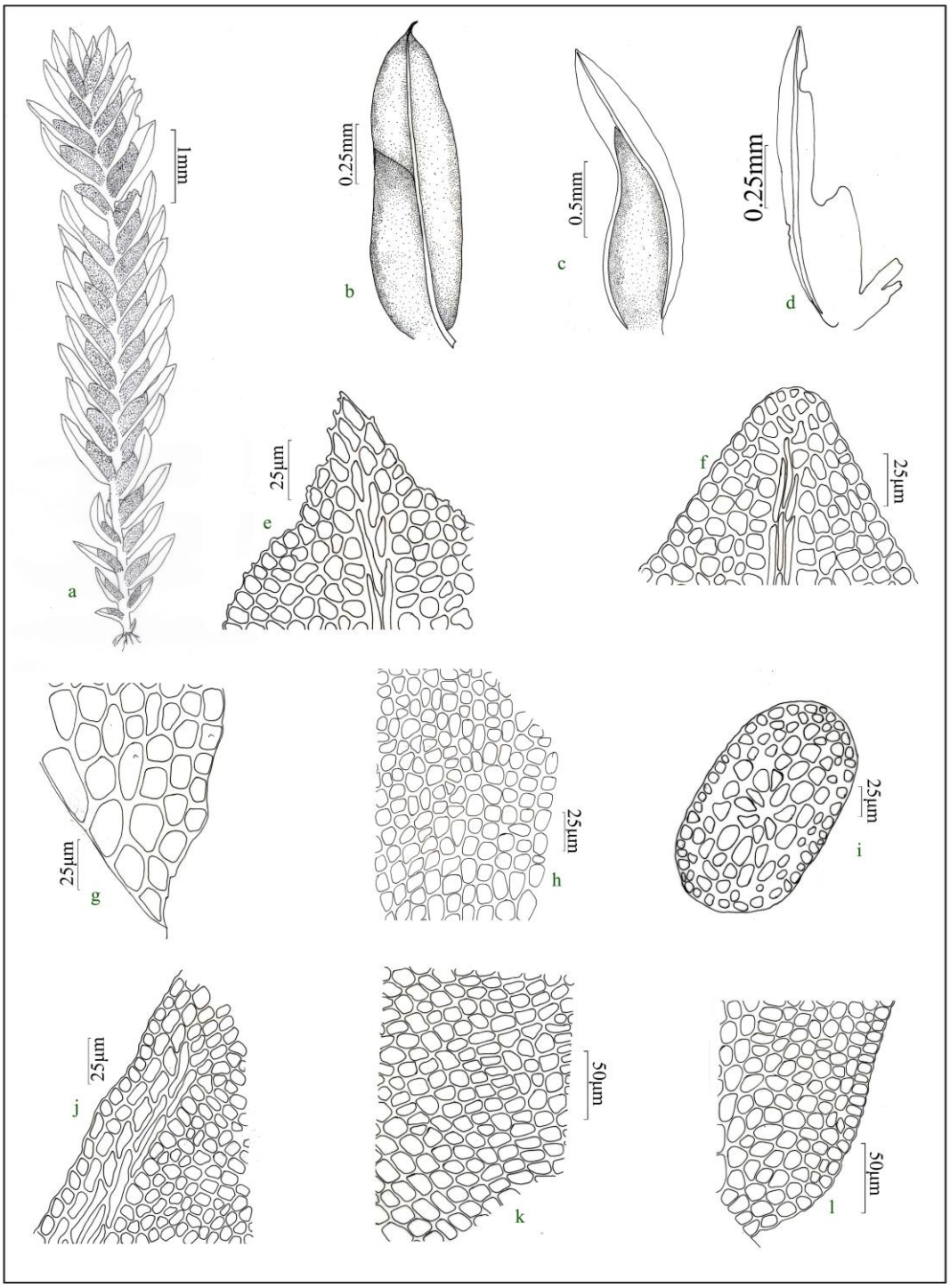
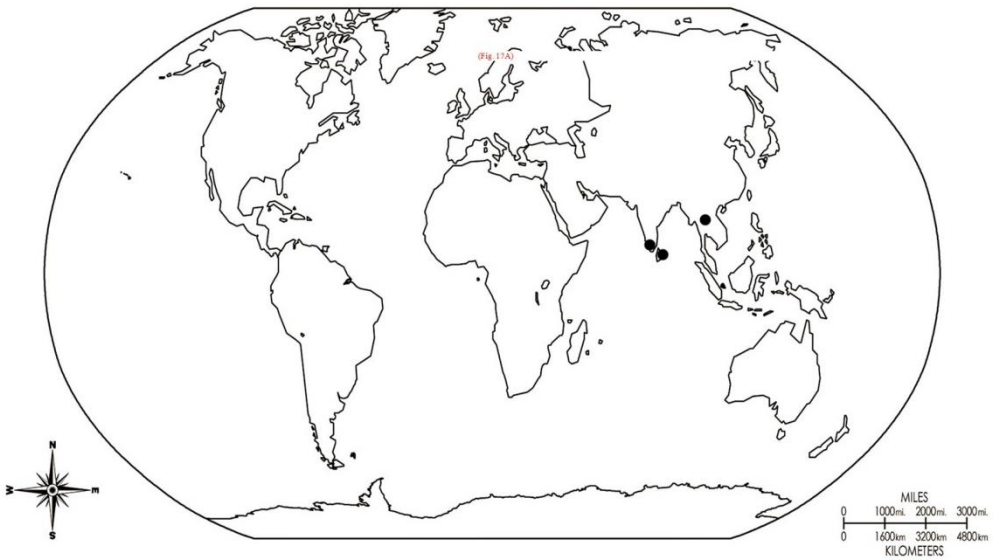
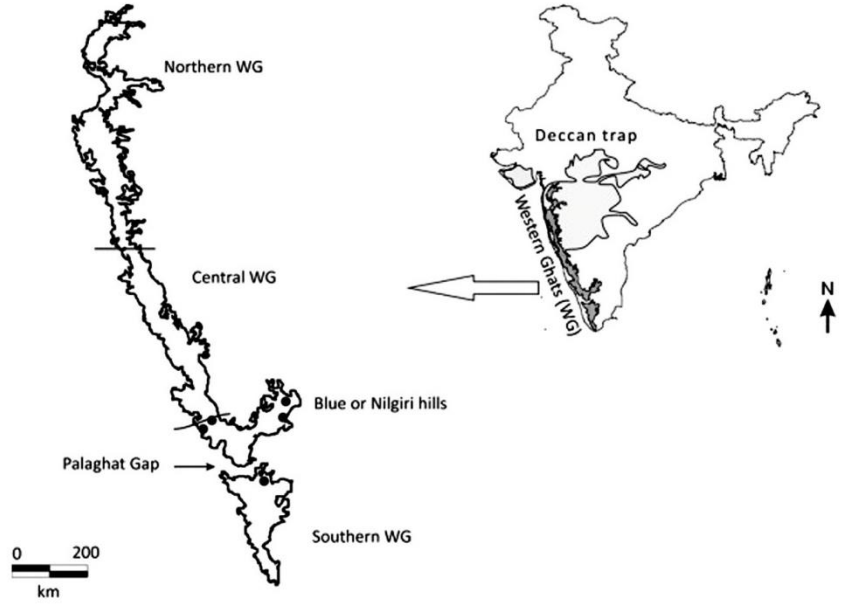


Fig. 32. *Fissidens firmus* Mitt., a. habit, b. leaf, c. perichaetial leaf, d. perigonial leaf, e&f. leaf apex, g&l. dorsal lamina base near insertion, h. laminal cells, i. stem T.S., j. vaginant laminae with limdium, k. vaginant laminae base.



Map. 35A. World distribution of ***Fissidens firmus*** *Mitt.*



Map. 35B. Distribution of ***Fissidens firmus*** *Mitt. in Western Ghats*

93(7): 980. 2007; Manju *et al.,* Tropical Bryol. Res. Rep. 7: 12. 2008b; Daniels, Arch. Bryol. 65: 54. 2010; Daniels & Daniel, Bryo. South. W. Ghat. 36. 2013; Rani *et al.,* Bryo. Andhra Pradesh. 129. 2014 (as *F. splacnobryoides*)

Type: Niger Expedition, Vogel s.n. (Holotype, NY) Isotype (BM!).

Fissidens mollis Mitt., J. Linn. Soc., Bot. 12: 600. 1869; *F. macrophyllus* Mitt., J. Linn. Soc. Bot. 12: 600. 1869; *F. uncinatus* Ăngstr., Őfvers. Förh. Kongl. Svenska Vetensk.-Akad. 33(4): 48. 1876; *Conomitrium bryodictyon* Besch., Rev. Bryol. 18: 50. 1891; *Fissidens flexifrons* Besch., Rev. Bryol. 18: 50. 1891; *Conomitrium palmatulum* Besch., Rev. Bryol. 18: 50. 1891; *Fissidens catumbensis* Broth., Bih. Kongl. Svenksa Vetensk. –Akad. Handl. 21. III(3): 13. 1895; *F. schwackeanus* Broth., Hedwigia 34: 119. 1895; *F. megacistis* Pursell, Cryptog. Bryol. Lichénol. 7: 39. 1986; *F. splachnobryoides* Broth. Fl. Schutzgeb. Seudsee 81. 1900; *F. brachyneuron* Broth. & Fleisch. in Fleisch., Musci Fl. Buitenz. 1: 20. 1904: *F. subbrachyneuron* Thér. & P. de la Varde, Rev. Gen. de Bot. 29: 292. 1917.

Plants light greenish, delicate, leaves curls when dry and green coloured in herbarium; axillary hyaline nodule absent, rhizoids reddish, smooth; vegetative stem 4-7 mm long with 9-14 pairs of leaves, central strand lacking, 1.00-1.50 mm wide at base and 2.00-2.50 mm wide above including leaves; leaves linear-lanceolate to slightly oblong-lanceolate, 1.30-3.00 x 0.38-0.68 mm, leaf apex acute, slightly apiculate, margin entire, apical cell slightly red tinged; limbidium complete, 2-4 rows of elongated cells, vanishes near dorsal lamina base, confluent at apex, 2-5 rows at vaginant laminae base, vaginant laminae reaching half the leaf length, closed, unistratose, dorsal lamina narrow than apical and vaginant laminae, base wedge shaped, slightly decurrent, dorsal lamina and apical lamina unistratose; costa yellowish green, short, reaching only up to ¾ of leaf length, variable in length, bryoides type; laminal cells compactly arranged, smooth, shrunk well on drying, thin walled, elliptic-ovate to rhomboidal, basal cells of vaginant laminae near costa elongated, mid dorsal laminal cells plane, 10.14-12.47 x 9.78-11.15 µm, mid vaginant laminal cells plane or slightly convex, 10.09-14.68 x 11.64-14.75 µm; gemmae not found, but it is reported by Pursell (2007).

Fertile parts, perigonia not found; perichaetia terminal, plant similar to vegetative plants, perichaetial leaves elongated lanceolate with broad base than

vegetative leaves, 1.95-2.06 x 0.31-0.34 mm, archegonium 0.21-0.26 mm; sporophyte not found (Plate 68-70& Fig.33).

Diagnostic characters: *Fissidens flaccidus* Mitt. is characterised by limbidia on all lamina of all leaves reaching the apex, costa short, mid dorsal lamina large and presence of smooth laminal cells. *Fissidens crispus* and *F. zollingeri* have completely limbate leaves as well, but differ in the smaller cells and longer costae of both *F. crispus* and *F. zollingeri*.

Note: Iwatzuki and Suzuki (1982) reported *F. flaccidus* Mitt. as a rare species in Japan and has been collected only from a single locality. *Fissidens flaccidus* Mitt. is common species in India especially in Western Ghats and reported from almost all parts of Western Ghats.

This species is reported by many authors from Western Ghats in different names such as, Foreau,1930 & 1961 (as *Fissidens brachyneuron* M. Fleisch), Foreau, 1961 (as *F. minutus* Thwaites & Mitt.), Nair *et al.,* 2005; Chaudhary *et al.,* 2006; Mehta *et al.,* 2016; Daniels & Daniel, 2013 (as *F. splachnobryoides* Broth.). Among these synonyms, most of the authors are still using the name *F. splachnobryoides* as the correct name without considering the taxonomic change.

Habitat and General Ecology: Found on variety of microhabitat such as on land cuttings, moist soil, land cuttings, rotting wood, brick walls, concrete walls, base of tree trunks and small and large rocks. This species grows as patches of single species, but sometimes ferns such as *Adiantum philippense* Linn., *Selaginella ciliaris* (Retz.) Spring. and angiosperm like *Pilea microphylla* Liebm., *Ischaemum* spp. are also seen along with this species. It is not reported from twigs and submerged rocks. This species acts as a bed for growing higher plants. It is a very common species in all types of vegetation except in shola forests in Western Ghats from low to medium altitude areas.

Distribution: A widely distributed species reported from India (Andhra Pradesh, Bengal, Western Himalayas, Maharashtra (Bombay, Khandala), Gujarat, Madhyapradesh, Haryana, Tamil Nadu, Kerala, Goa (Chaudhary *et al.,* 2006 & 2008; Daniels, 2003 & 2010; Daniels & Daniel, 2013; Foreau, 1930, 1961; Gangulee, 1971; Lal, 2005; Manju *et al.,* 2008b; Magdum *et al*., 2017; Nair *et al.,*

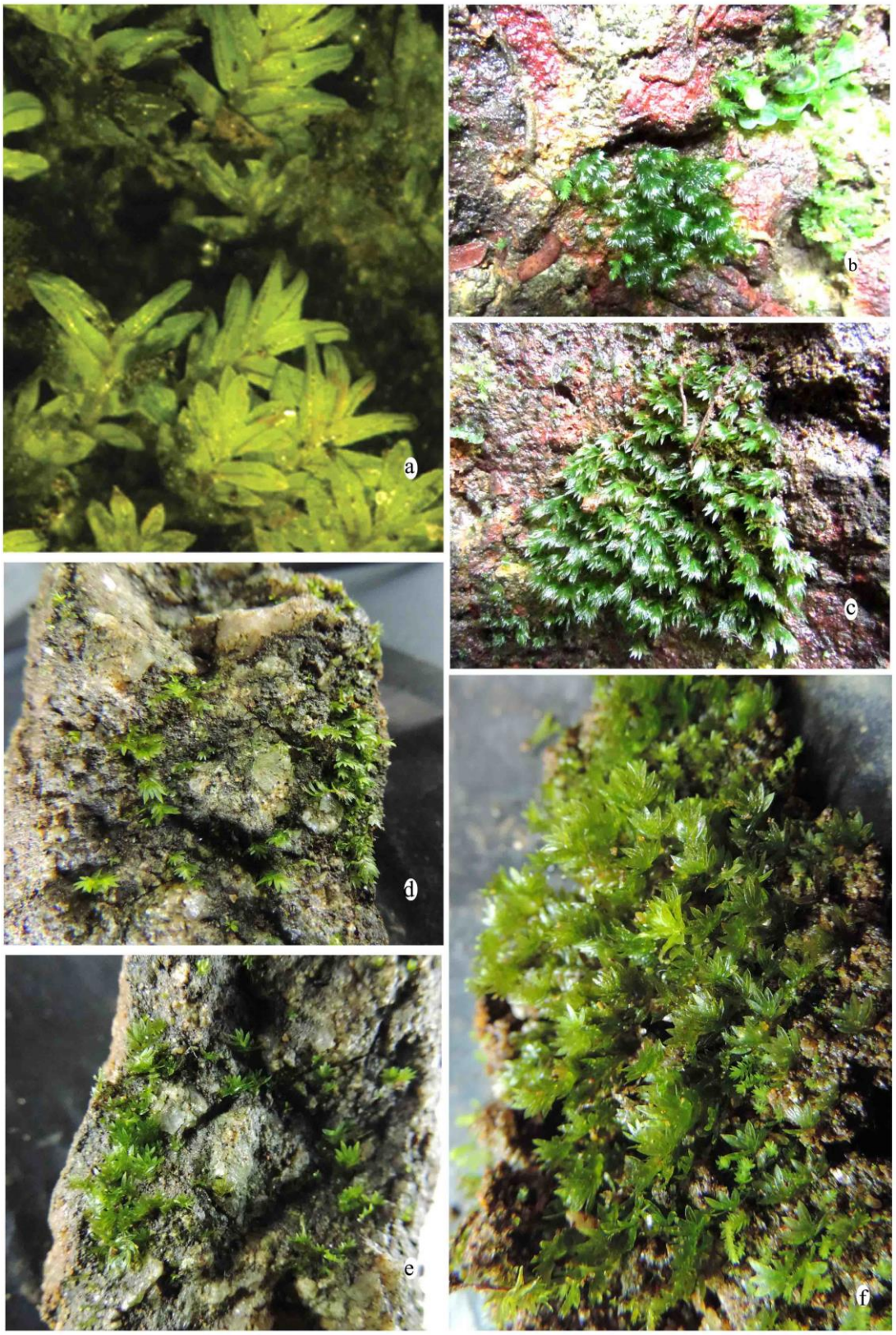


Plate 68. *Fissidens flaccidus* Mitt., habits & habitats; a. enlarged view of the plant, b-e. on cliff of rocky patch, f. on laterite stone

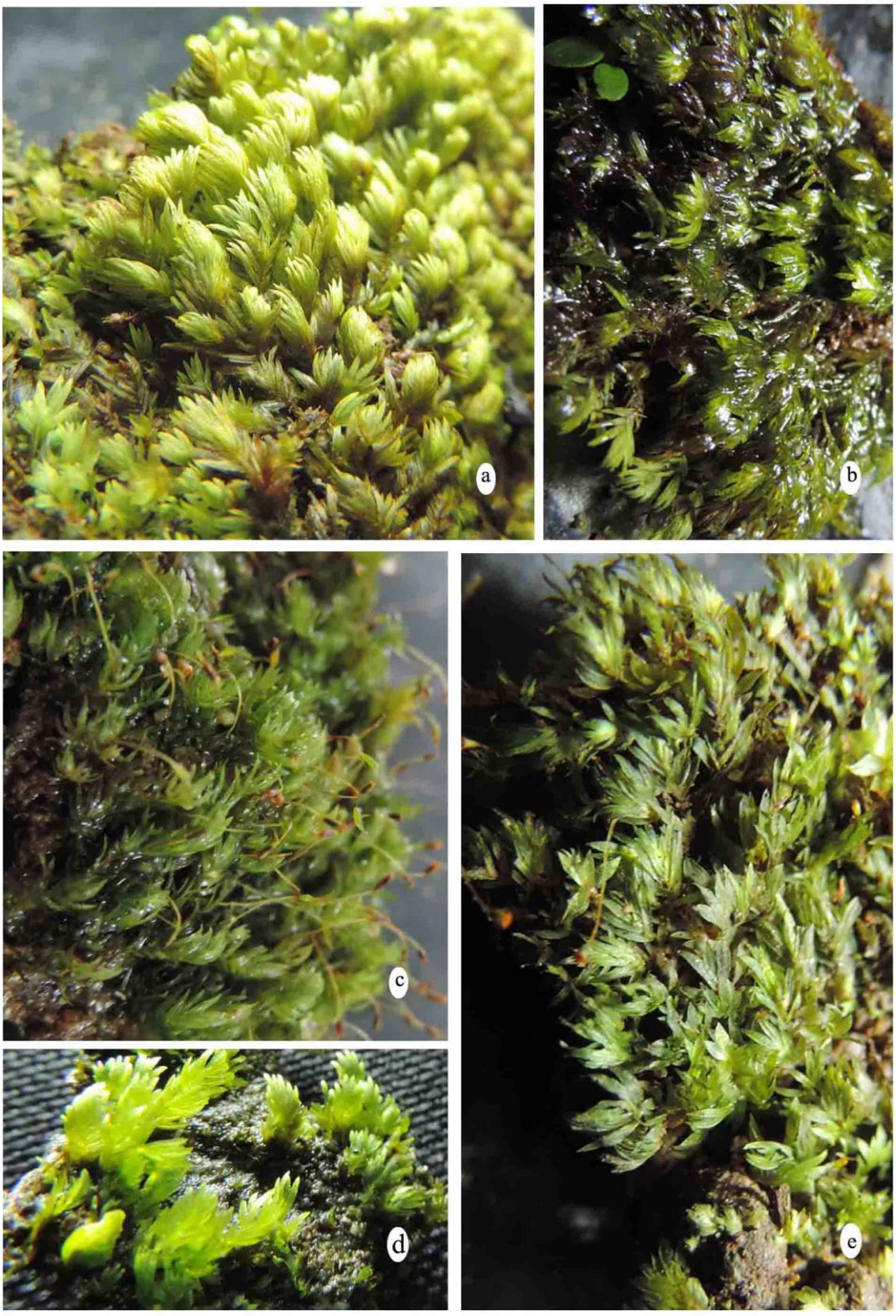


Plate 69. *Fissidens flaccidus* Mitt., habit & habitats; a-d. on soil, e. on land cuttings (enlarged view).

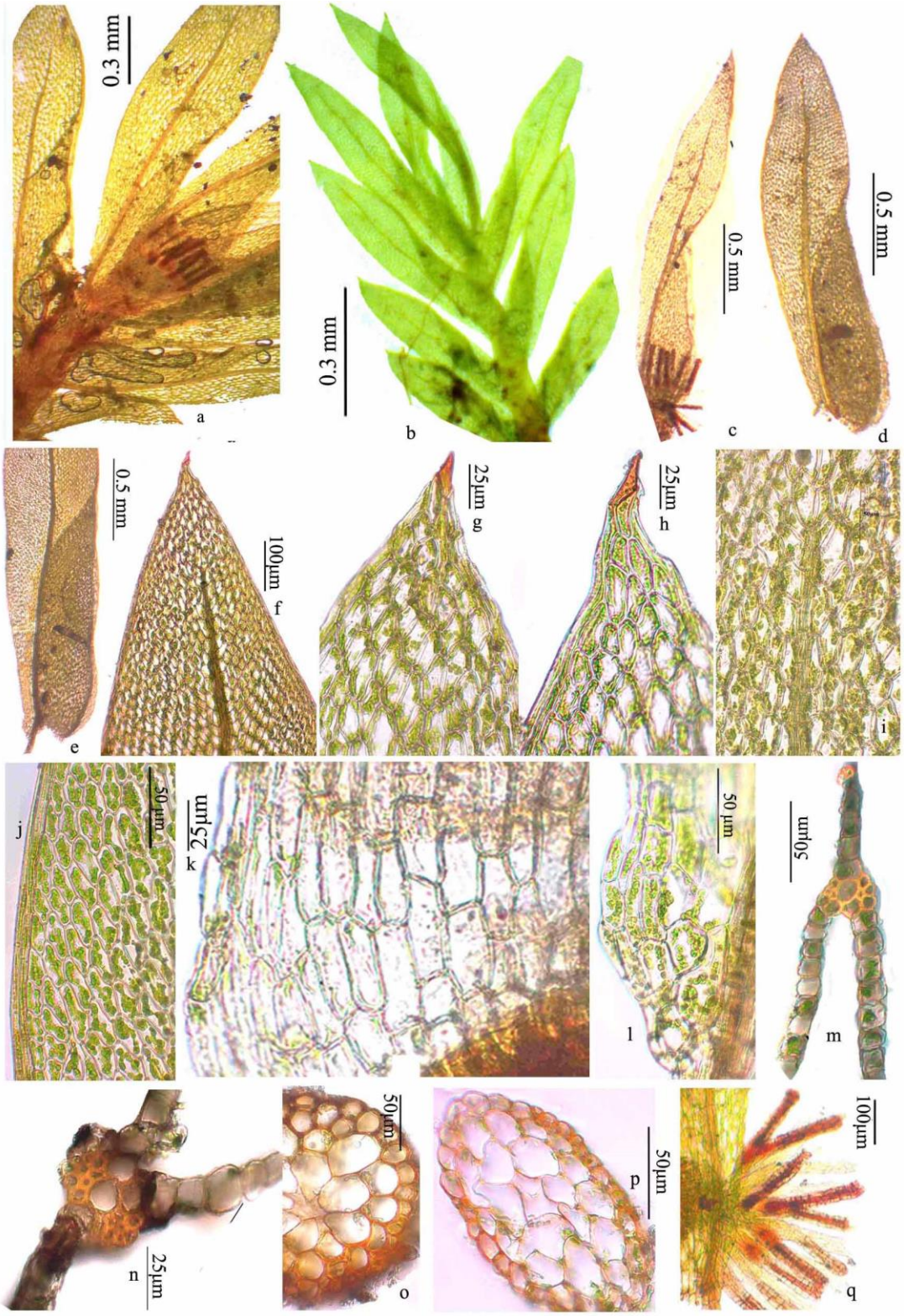


Plate 70a. *Fissidens flaccidus* Mitt., a. fertile plant apex, b. vegetative plant, c. perichaetial leaf, d. vegetative leaf, e. vaginant laminae, f-h. leaf apex, i. costa tip, j. leaf margin, k. vaginant laminae base, l. dorsal lamina base near insertion, m&n. leaf T.S., o&p. stem T.S., q. archegonia (a & b from ZGC3507; c, g & i-l from ZGC556; d & q from ZGC3514A; e, f, h & m from ZGC1241; n & o from ZGC1129; p from ZGC833)

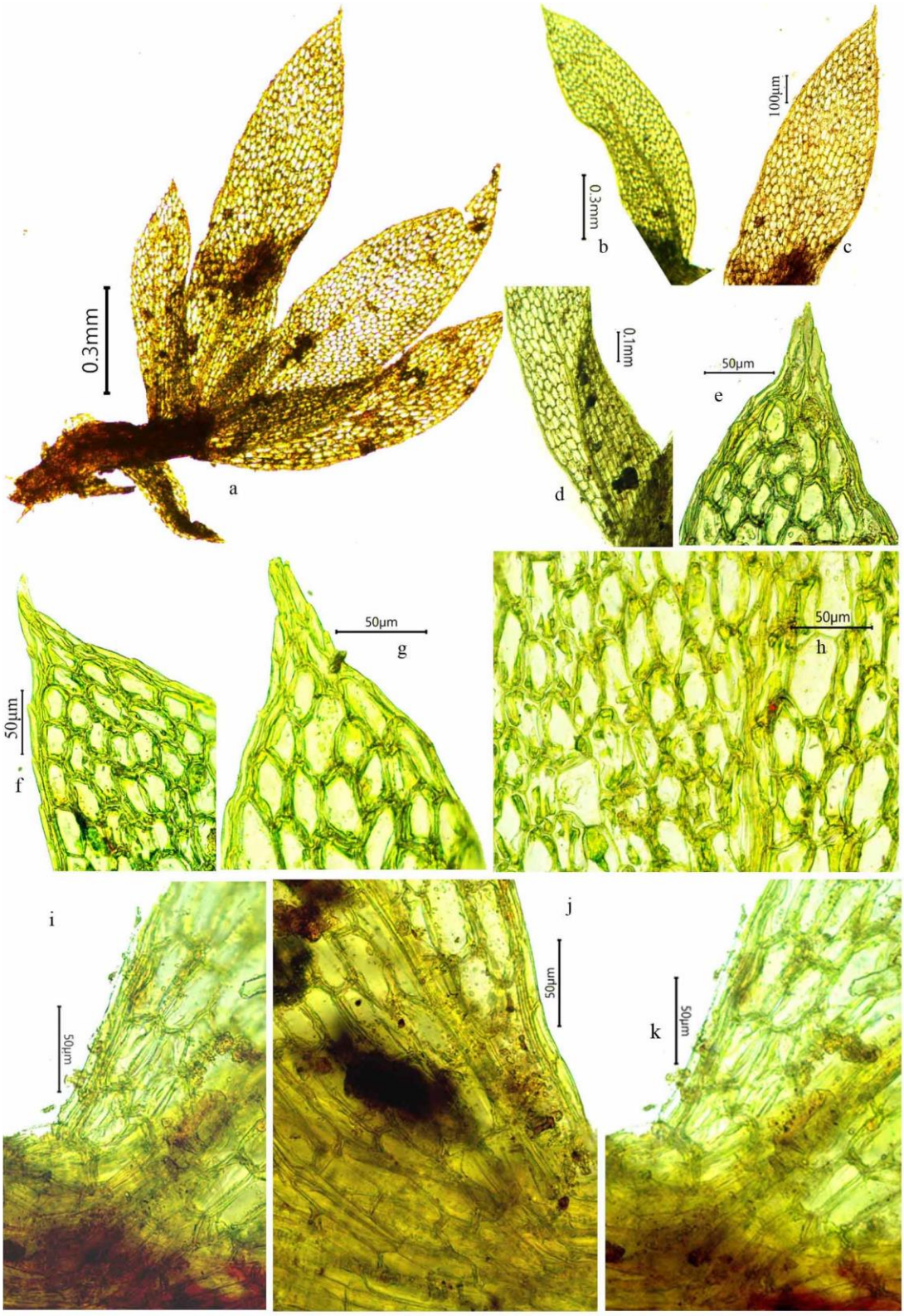


Plate 70b. *Fissidens flaccidus* Mitt., a. vegetative plant, b&c. vegetative leaf, d. vaginant laminae, e-g. leaf apex, h. laminal cells, i-k. leaf base (photos from ZGC 15557B).

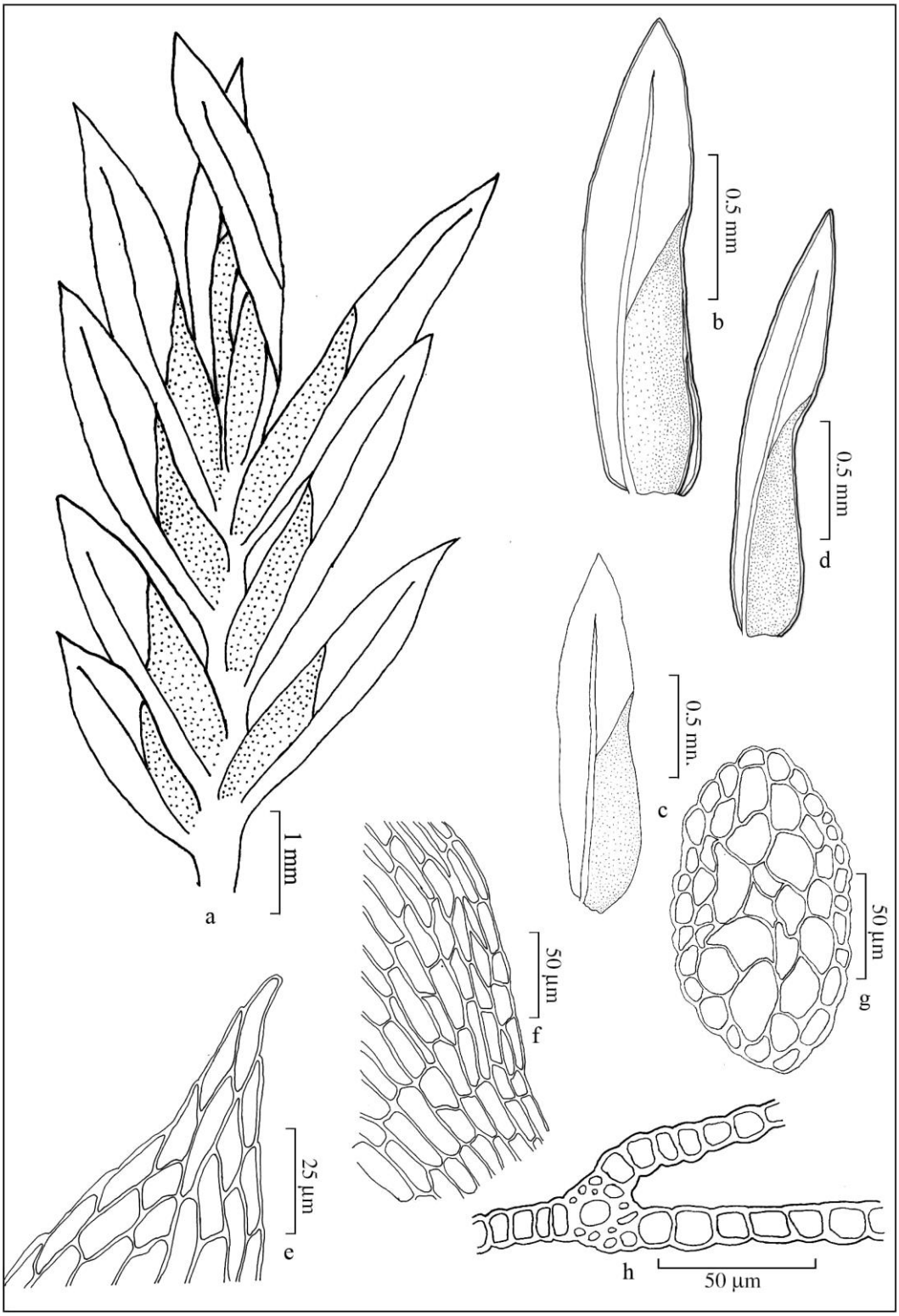
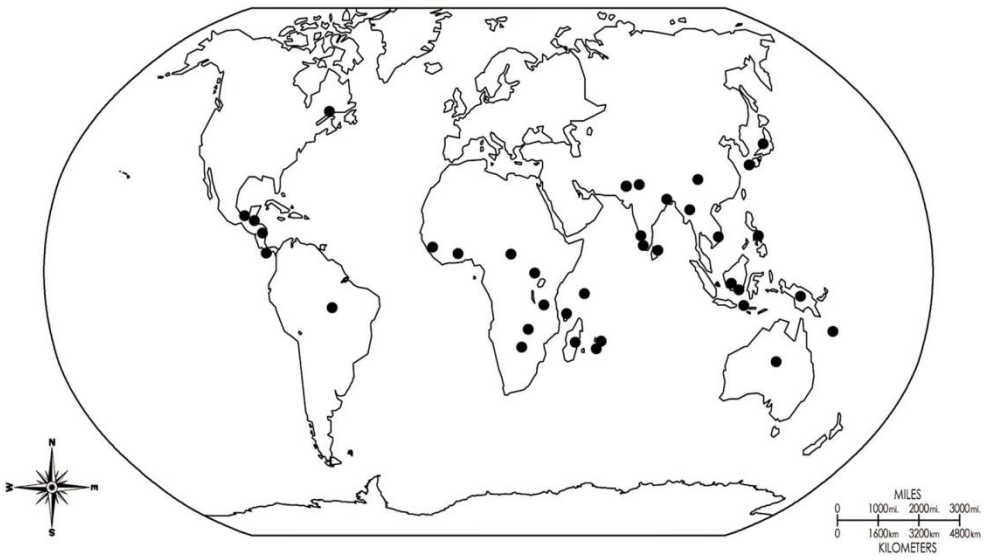


Fig. 33. *Fissidens flaccidus* Mitt., a. vegetative plant, b&c. vegetative leaves, d. perichaetial leaf, e. leaf apex, f. vaginant laminae base, g. stem T.S., h. leaf T.S.

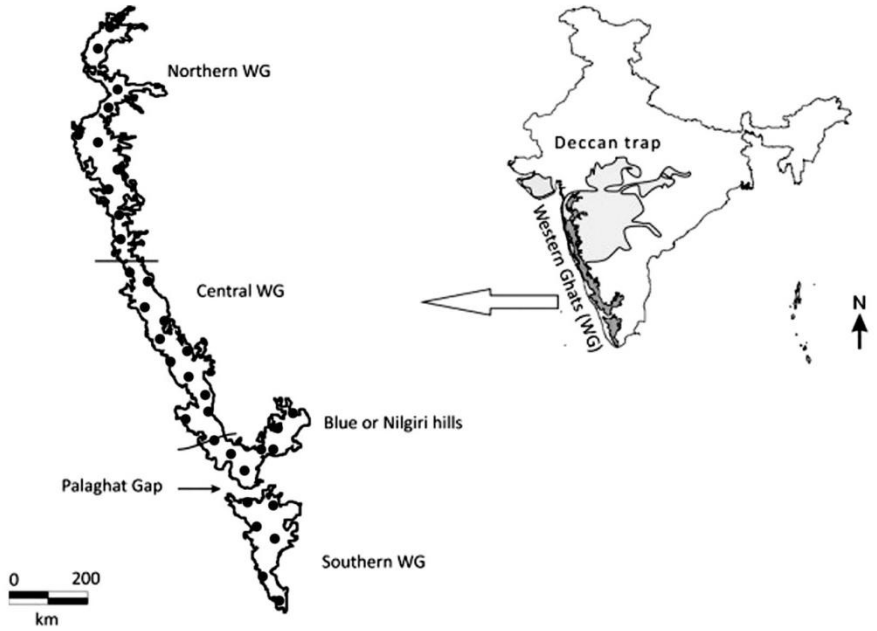
2005; Schwarz, 2014b); East Nepal, Sri Lanka, Myanmar, Java, North Borneo, Philippines, Ryukus, Japan, China, Nepal, Vietnam, Indonesia, the Philippines, Cape Verde, Central African Republic, Comoros, Madagascar, Mauritius, Nigeria, Rodrigues, Seychelles, Sierra Leone, Tanzania, Uganda, Zambia, Zimbabwe; Belize, Costa Rica, Guatemala, Mexico, Panama, Caribbean, El Salvador, Brazil, Australia, New Guinea, Fiji, Vanuatu, (Iwatsuki & Suzuki, 1995; Keurschner, 2000; Li & Iwatsuki, 2001; O'Shea, 2006; Pursell, 1994, 1997, 2007; Wijk *et al*., 1969). The present collection is a new record to Goa. (Map 36A&36B).

Specimens examined: India, Kerala; Palakkad district, (Chathanpara, 200m), 08.07.2014, Manjula (ZGC 1068), Nelliampathy, $10^{0}53'55"$ N, $76^{0}68'37"$ E, 900m, 17.08.2014, Maya, C. Nair (ZGC 1191, 3507A), (Anamada, 1000m), 13.07.2014, Manjula (ZGC 1131, ZGC 1129B), Dhoni hills, 100m), 13.08.2014, Manju (ZGC 1178A), Silent Valley NP (Arikan Para, 600m), 21. 11. 2016, Manjula & Deepa (ZGC 15557B), 26.08.2015, Manjula & Deepa (ZGC 15557b); Kozhikode district (Thamarassery Churam, 700m), 13.07.2015, Mithun Venugopal (ZGC 1241A), Meenchanda (Govt. Arts & Science College Campus, 22m), 04.10.2015 Deepa (ZGC 16049, 16050), Kozhikode district, Kakkadampoyil, Kozhippara water fall (657m), 12.10.2016, Manjula (ZGC 16174, ZGC 16177); Malappuram district (Near Civil station, 65m), 21.09.2013 Manjula (ZGC 833), Nilambur (Canoli Plot, $11^{0}26'62"$ N, $76^{0}20'59"$ E, 40m), 24.07.2013, Manjula (ZGC 669), 29.09.2013, (Valakulam, 82m), Chandini (ZGC 556); Kannur district (Mattool, sea level), 06.09.2014 Manju (ZGC 3514), Kerala, Kannur district, Aralam WLS, foot hills of Velimala (554m), 22.01.2017, Vijisha (ZGC 16355); Goa, Cancona, (Cotigao Wildlife Sanctuary, 88 m), 15.08.2015 Manjula & Deepa (ZGC 15119); Maharashtra, Mahabaleshwar, 868 m. 10. 11. 2016. Manjula (ZGC 16200), Nashik (Brahmagiri hills, 1020 m), 16. 09. 2017, Manjula (ZGC 7754); Gujarat, Gira fall, 18.09.2017, Manjula (ZGC 7765); Tamil Nadu, Palni Hills (Pragarapuram), 01.01.1958, G. Foreau (no coll. number), (CAL!); Uttar Pradesh; Pilibhit (Barhi range, Chimtiya, 163m), 11.09.2014, Vinay Sahu (LWG 258213 C).

Etymology: The specific epithet *flaccid* refers to the soft and delicate nature of the leaves.



Map. 36A. World distribution of ***Fissidens flaccidus*** *Mitt.*



Map. 36B. Distribution of ***Fissidens flaccidus*** *Mitt. in Western Ghats*

Fissidens ganguleei Nork., in Gangulee, Moss. E. India & Adj. 1(2): 527. 1971; Iwatsuki & Suzuki, J. Hattori Bot. Lab. 51: 392. 1982; Lal, Checklist Indian Moss. 61. 2005; Daniels & Daniel, Bryo. South. W. Ghat. 41. 2013.

Type. India: Darjeeling, Tongloo, 2600 m, Kurz 2302 (CAL!).

Fissidens lancifolius Hampe in Muell. Hal., Gen Musc. Fr.: 62. 1900.

Plants small, green, leafy stems simple, 2.5–4.0 mm long, 1.5–2.2 mm wide; rhizoids basal, smooth; axillary hyaline nodules not distinct; central strand slightly differentiated; leaves in 3–5 pairs, lower leaves smaller, loosely arranged, upper leaves much larger, oblong-lanceolate, 0.6–1.0 mm x 0.2–0.3 mm, acute at apex, margins serrulate; limbidium absent in all leaves, vaginant laminae 1/2 –3/5 of leaf length, unequal, upper part of minor lamina open towards costa, unistratose, base of dorsal laminae wedge-shaped, dorsal lamina and apical lamina unistratose; costa strong, percurrent, often showing a bend where it leaves the upper vaginant laminae, thus dividing the leaf into two unequal parts; cells of apical and dorsal laminae quadrate to irregularly hexagonal, 7–15 µm long, moderately thick-walled, smooth, cells of vaginant laminae similar to those of apical and dorsal laminae; gemmae not found.

Fertile parts, perigonium not found; perichaetium terminal on main stem, perichaetial leaves longer than stem leaves, vaginant laminae ca. 1/3 of the perichaetial leaf length, setae *ca*. 8 mm long, smooth, operculum long rostrate, *ca*. 0.6 mm long (Plate 71 & Fig.34).

Diagnostic characters: *F. ganguleei* is characterised by reddish brown plants, unequal vaginant laminae with open minor vaginant lamina which opens towards costa, smooth and thick walled laminal cells. This species is similar to *F. pellucidus* Mitt. but it differs in having a bent costa that divides the leaves into two unequal parts, asymmetric vaginant laminae that are free from the apical laminae, and thin-walled cells.

Habitat and General Ecology: On tree bases in evergreen forests, this species is also present on land cuttings in the sacred grooves in Northern Kerala.

Distribution: This is an Asiatic species distributed in India (Darjeeling, Tamil Nadu, Kerala; China, Japan, Nepal (Daniels, 2003; Daniels & Daniel 2013; Gangulee 1971; Jyothilakshmi *et al*., 2016) (Map 37A&37B).

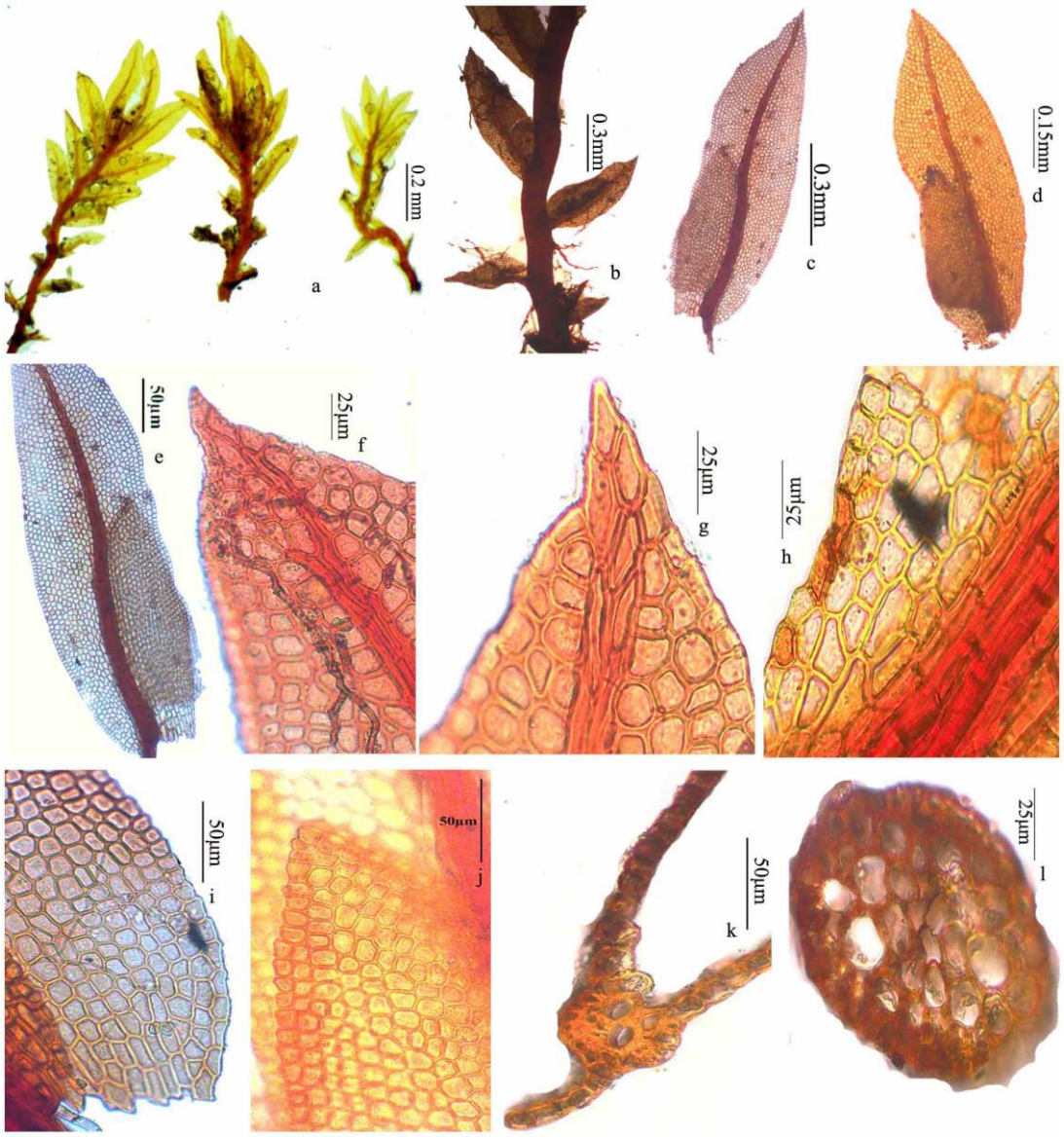


Plate 71. *Fissidens ganguleei* Nork., a. single plant, b. plant base, c & d. vegetative leaf, e. vaginant laminae, f & g. leaf apex, h. dorsal lamina base, i. vaginant laminae base, j. vaginant laminae apex, k. leaf T.S., l. stem T.S. (photo from Norkett 14979 BM!)

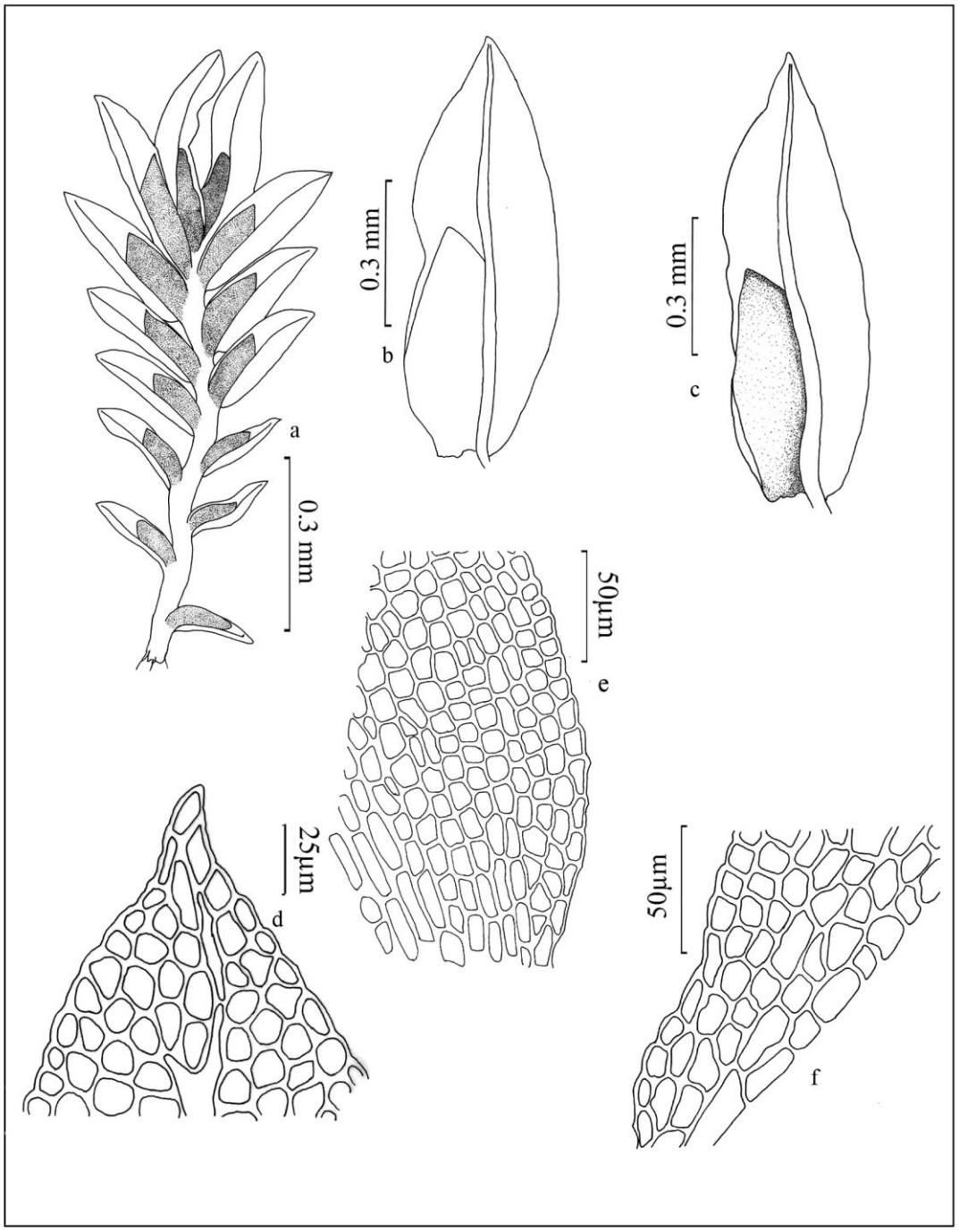
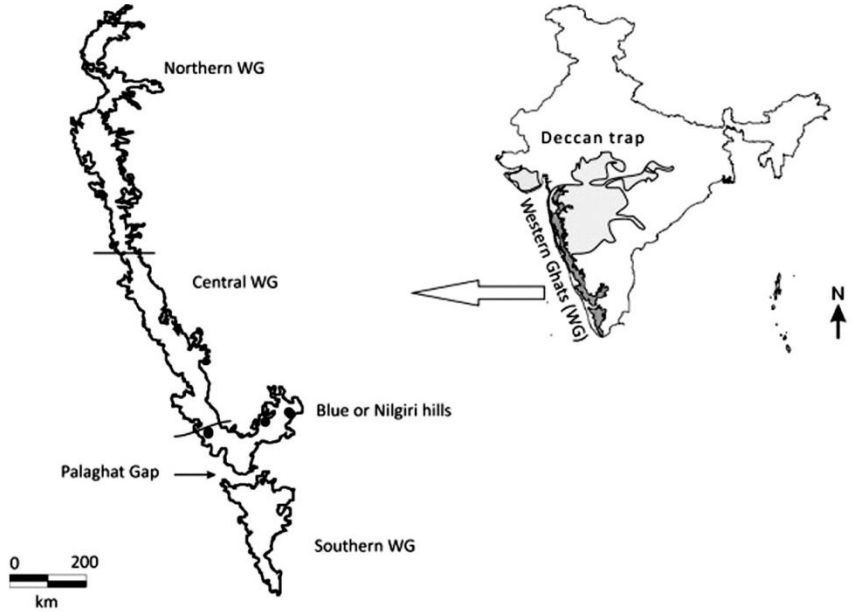


Fig. 34. *Fissidens ganguleei* Nork., a. habit, b&c. leaves, d. leaf tip cells, e. leaf cells at vaginant laminae, f. dorsal laminae base.

Map. 37A. World distribution of ***Fissidens ganguleei*** *Nork.*



Map. 37B. Distribution of ***Fissidens ganguleei*** *Nork. in Western Ghats*

Specimens examined: India, Kerala, Kozhikode District (VallikattuKavu, 53m), 27.09.2014, Jyothi & Mithun (ZGC3804, ZGC3828); Darjeeling, Tongloo, 2600 m, Kurz 2302 (CAL!); Darjeeling, Mungpoo, 24.10.1970, A.H. Norkett (14979) (BM!);

Etymology: The specific epithet *ganguleei* is in honour of the renowned Indian bryologist H.C. Gangulee who described several new species and new records.

Fissidens gardneri Mitt., J. Linn. Soc. Bot. 12: 593. 1869; Li & Iwatsuki, Moss Fl. China 2: 33. 2001; Pursell, Fissidentaceae Fl. Neo. Mono. 101: 150. 2007; Diop *et al.,* J. Bryology. 3. 2018.

Type: Brazil, (without locality) Gardner (Holotype NY)

F. microcladus Thwaites & Mitt., in Mitt., J. Linn. Soc. Bot. 13: 324. 1873; *F. elegans auct. non*. Brid., Iwatsuki & Suzuki, 1982.

Plants yellowish green, unbranched, monomorphic, 2.4-3.0 mm long; rhizoids basal, smooth; axillary hyaline nodules absent; stem outer cortical cells small, thick walled; inner cortical cells large, thin walled, central strand not differentiated or absent; leaves widely arranged with imbricating upper leaves, 10-15 pairs of leaves, lower leaves scaly, small, leaves oblong rounded, leaf apex widely acute to obtuse, margin serrate, 0.82-0.97 x 0.2-0.28 mm; limbidium absent on all laminae; costa light yellowish, ending far below apex, sometimes bifurcated towards tip, obscured due to overlying chlorophyllose laminal cells, bryoides type; vaginant laminae reaching 1/2 to 2/3 of leaf length, unequal, minor lamina narrowed, unistratose; dorsal lamina not decurrent, narrowed towards insertion, dorsal lamina and apical lamina unistratose; laminal cells irregularly quadrangular to polygonal, thick walled, minutely pluripapillose, 6-8 µm. gemmae not found (Plate 72 & Fig.35).

Fertile parts not found.

Diagnostic characters: *F. gardneri* Mitt. is characterised by minute plant with oblong rounded leaves, costa ending far below apex and minutely pluripapillose laminal cells. *F. gardneri* can be confused with *F. griffithi* in small pluripapillae

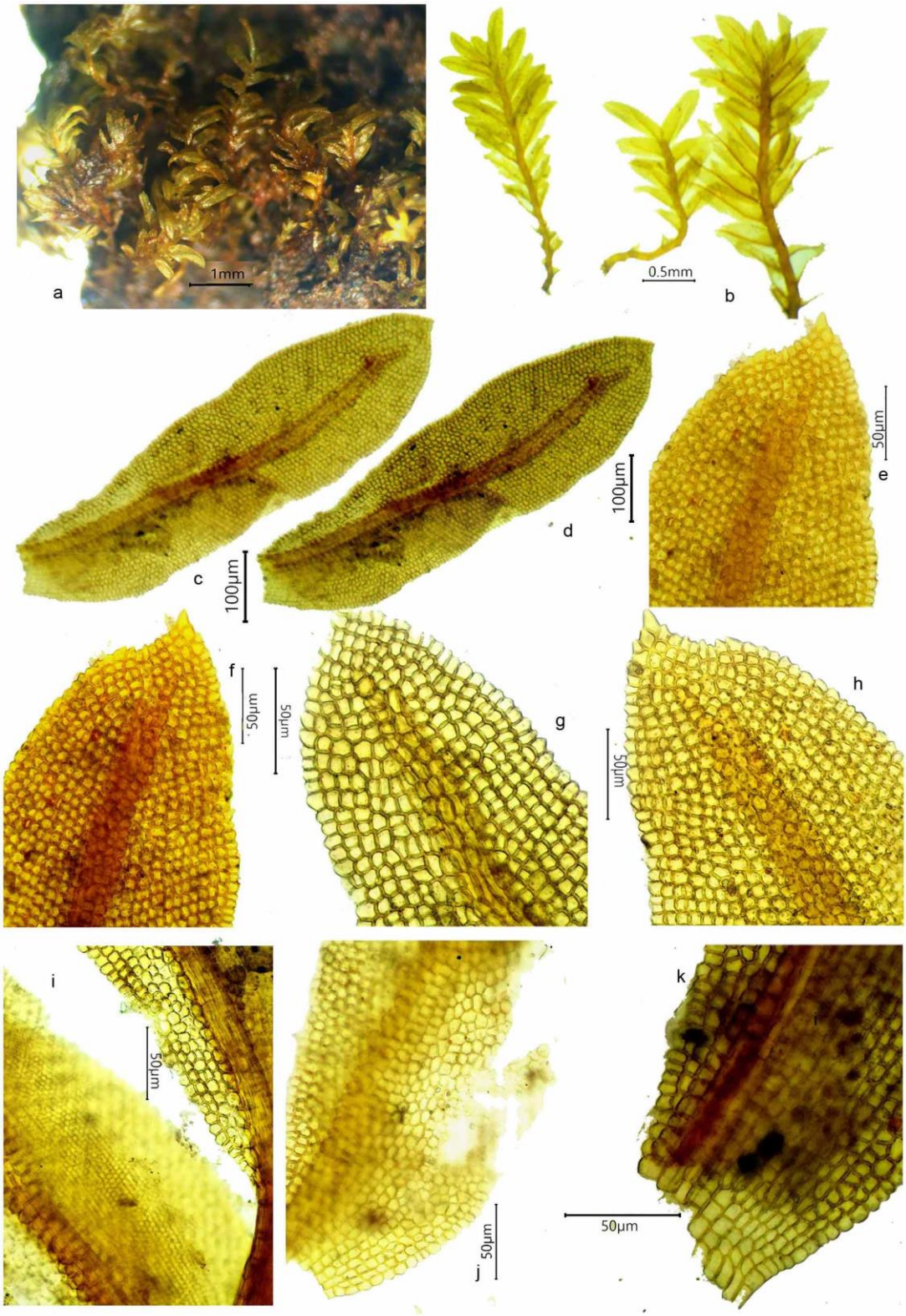


Plate 72. *Fissidens gardneri* Mitt., a. habit, b. vegetative plants, c&d. vagetative leaves, e-h. leaf apex, i. dorsal lamina base near insertion, j&k. vaginant laminae base. (photo from Norkett 10508 BM!)

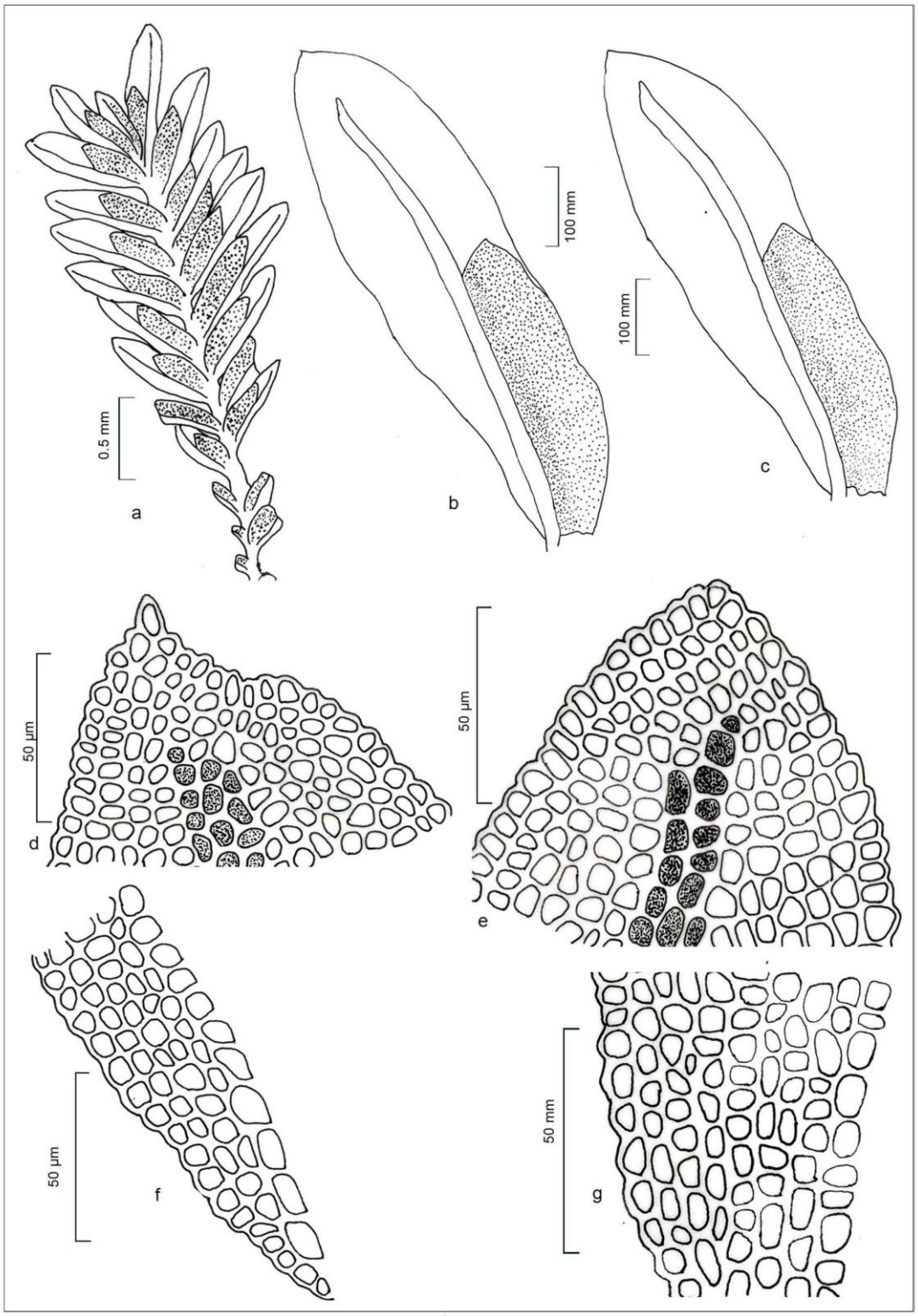


Fig. 35. *Fissidens gardneri* Mitt., a. vegetative plant, b&c. vegetative leaves, d&e. leaf apex, f. dorsal lamina base near insertion, g. vaginant laminae base

while differs in the costa and oblong rounded leaf of *F. gardneri.* It is also related to *F. brevinervis* in its costa ending far below apex and minutely pluripapillose laminal cells, but differs in the nature of the costa in Indian species of *F. gardneri*, like costa ends slightly beyond the distal end of the vaginant lamina and dorsal lamina ends above or close to the leaf base.

Note: Some authors like Pursell *et al*. (1993) synonimised *F. brevinervis* under *F. gardneri*, but Suzuki and Iwatsuki (2010) erected *F. brevinervis* as a distinct species. Schwarz (2014b) also commented that Indian species of *F. gardneri* and *F. brevinervis* are different. This species is reported from South India by [Dixon & Potier de la Varde in 1930 as *F. microcladus*]. The above description is based on authentic specimen deposited in BM.

Habitat and General Ecology: On large rocks and tree bark in evergreen forest in high altitude.

Distribution: India (Central India, Gujarat, Himalaya, Mundanthurai-Tamil Nadu (Daniels, 2010; Dixon & Potier de la Varde, 1930; Schwarz, 2014b), Africa, America, China, Japan, Nepal, Sri Lanka, Thailand, Laos, Philippines (Li & Iwatsuki, 2001; Pursell, 2007) (Map 38A&38B).

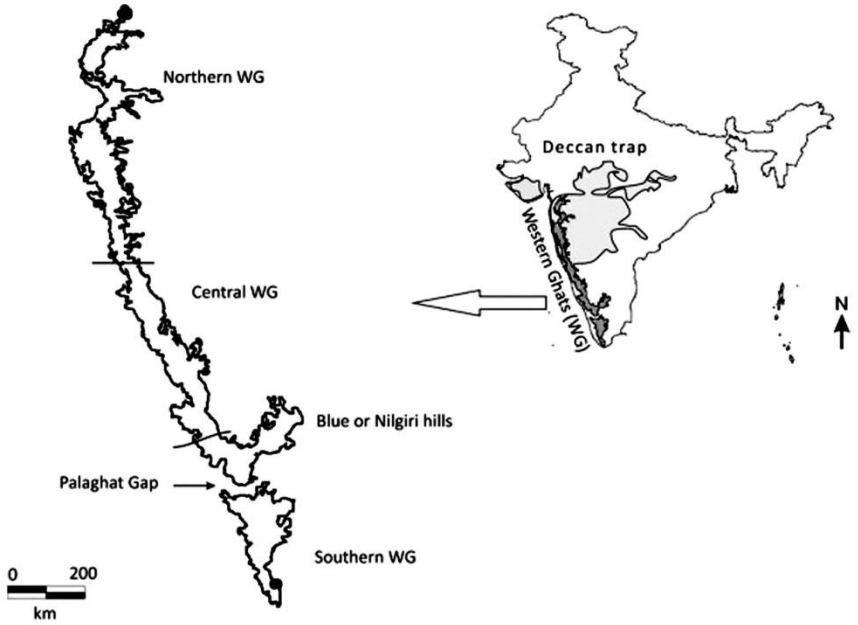
Specimen examined: India, Madhya Pradesh, Pachmarhi (400ft), A.H. Norkett (10508 BM!)

Etymology: The specific epithet *gardneri* is in honour of the botanist 'Gardner', the collector of the type specimen for this species.

Fissidens griffithii Gangulee, Nova Hedwigia 8: 143. pl. 2. 1964; Gangulee, Moss. E. India & Adj. 1: 520. 1971; Daniels & Daniel, Indian J. Forest. 26: 193. 2003b; Lal, Checklist Indian Moss. 61. 2005; Daniels & Kariyappa, Curr. Sci. 93(7): 980. 2007; Daniels & Daniel, Bryo. South. W. Ghat. 41. 2013.

Type: Bhutan. Griffith 52, Holotype: NY.

Map 38A. World distribution of *Fissidens gardneri* Mitt.



Map 38B. Distribution of *Fissidens gardneri* Mitt. in Western Ghats

Plants about 4 mm long, stem simple, reddish brown; leaves 6-8 pairs, neither curled nor contorted in herbarium, 1.0-1.5 x -0.30-0.35 mm, oblong-lingulate, slightly narrow at middle, bent to one side at apex, margin corrugate, apex acute to widely acute; limbidium absent; vaginant laminae open, unequal, minor lamina usually terminating on costa; dorsal lamina narrowing towards base and meeting costa at point of insertion; costa percurrent to short excurrent, orange; laminal cells pluripappillose, quadrate to hexagonal, apical and middle cells 8-10 x 7-8 µm, basal cells 10-14 x 7-12 µm, juxta costal cells large, 16-18 x 13-15 µm; gemmae not seen.

Fertile parts, perigonium and perichaetium not found; sporophyte apical, seta 3-4 mm, capsule inclined, about 0.9 x 0.4 mm, brown, operculum conic, rostrate, peristome teeth dicranate, about 0.21 x 0.08 mm, rough, spores 10-15 µm, globose with elongated papillae like protuberance.

Diagnostic characters: *F. griffithii* Gangulee is characterised by simple plants, leaves slightly narrow at middle, bent one side at apex, percurrent to excurrent costa and pluripapillose laminal cells.

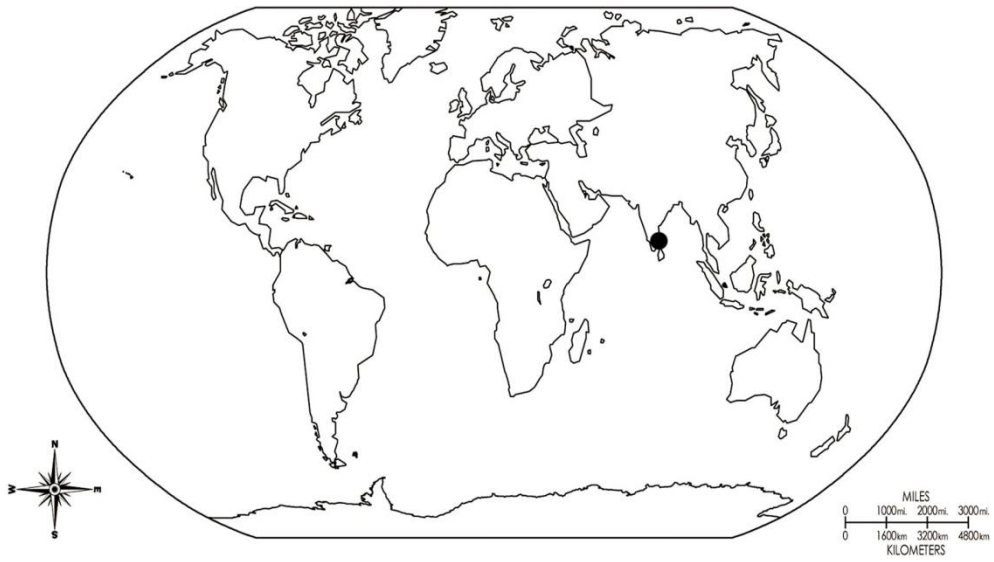
Note: Type specimen collected by Griffith is scribed as *Fissidens dispar* (‘Griffth 52’) by Mitten on the sheet but it is a later homonym and Gangulee (1964) vaidly published by givimg the name *F. griffithii*. During my present study I could not locate this species. The description is based on *Daniels 402* from SCCN.

Habitat and General Ecology: Corticolous on *Tamarindus indica* L. in mixed plantations at an altitude of 450m.

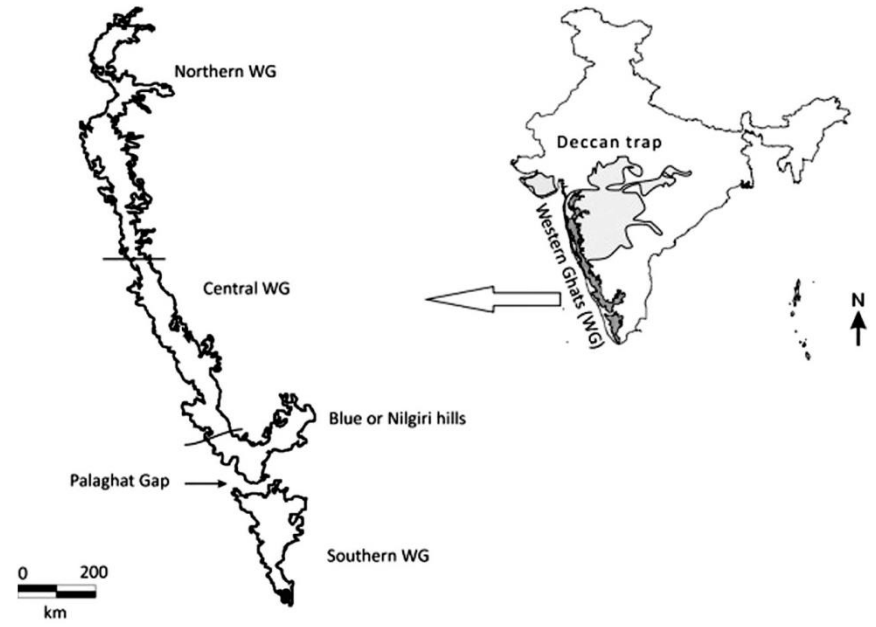
Distribution: An Indo- Bhutan species distributed in India (Tamil Nadu (Daniels & Daniel, 2003b; Daniels & Daniel 2013); Bhutan (Gangulee, 1964, 1971) (Map 39A&39B).

Specimens examined: India, Tamil Nadu, Kanyakumari (Maramalai, 450m), 23.01.1999; Daniels, A.E.D. (402) (SCCN!).

Etymology: The specific epithet is in honour of H. Griffith who collected the type specimen of this species from Myanmar.



Map 39A. World distribution of ***Fissidens griffithii*** *Gangulee*



Map 39B. Distribution of ***Fissidens griffithii*** *Gangulee in Western Ghats*

Fissidens hollianus Dozy & Molk., Bryol. Jav. 1: 4. 4. 1855; Bruehl, Rec. Bot. Surv. India 13(1): 17. 1931; Gangulee, Moss. E. India & Adj. 1: 507. 1971 (as *F. asperisetus*); Eddy, Handb. Malay. Moss. 1: 83. 1988; Li & Iwatsuki, Moss. Fl. China 2: 39. 2001; Lal, Checklist Indian Moss.: 60. 2005; Nair, *et al.,* Bryo. Wayanad, W. Ghats 104. 2005 (as *F. asperisetus*); Manju *et al.,* Geophytology 36(1&2): 11. 2006 (as *F. asperisetus* var. *andamanensis* Gangulee); Manju *et al.,* Tropical Bryol. Res. Rep. 7: 12. 2008b (as *F. asperisetus* var. *andamanensis* and *F. hollianus*); Daniels & Daniel, Bryo. South. W. Ghat. 36. 2013 (as *F. asperisetus*).

Type: Indonesia: Java, Holle 13.

F. asperisetus Lac., Naturk. Verh. K. Akad. Wet. Amsterdam 13: 2. 1872. *F. asperisetus* var. *andamanensis* Gangulee Moss. E. India 2: 507. 1971.

Plants green to yellowish green, not much curled in herbarium, stem without central strand, mostly unbranched, yellowish green, 0.13-0.20 mm in diameter 5-9 x 1.00-1.50 mm, 8-18 pairs of leaves; rhizoids dark brown, smooth; axillary hyaline nodules absent; leaves on vegetative stem lanceolate, 0.90-1.19 x 0.22-0.30 mm, 4 times long as wide, base more broad, margin not entire due to papillae projection, apex acute, ends in costal cells; limbidium present only on vaginant laminae, 3-4 rows of elongated cells at base and one or two rows above; vaginant laminae reaching more than half or up to 2/3 of leaf length, closed or slightly open, 0.18-0.20mm wide at base, unistratose; dorsal lamina wedge shaped towards base, narrow than vaginant laminae and apical lamina, dorsal lamina and apical lamina unistratose; costa excurrent in short apiculus, bryoides type; laminal cells irregularly polygonal, pluripapillose, apical cells 18.65–25.88 x 6.81–10.5 µm; mid dorsal laminal cells irregularly rectangular, slightly convex, 13.55-15.03 x 8.64-9.76 µm, 2-4 papillose; mid vaginant laminal cells plane or slightly convex, 9.40-11.50 x 6.88-10.25 µm, 2-5 papillose. Gemmae not found.

Fertile parts, perigonia and perichaetia not observed; sporophyte slightly inclined; setae 2.00-2.60 mm, not smooth, scabrous; capsule 1.20-1.40 x 0.40-0.45 mm, exothecial cells 26-29 columns, vertically thickened; peristome teeth 42.30–

46.60 µm wide at base, bryoides type; operculum 0.50–0.60 mm long, rostrate; spores 10.52–13.74 µm long, papillose (Plate 73-74 & Fig.36).

Diagnostic characters: *F. hollianus* Dozy & Molk. is characterised by lanceolate leaves with broad base, large vaginant laminae, limbidia that reach the apex of the vaginant lamina in well-developed plants, but are shorter in others, excurrent costa, distinct pluripapillae in laminal cells and papillose spores. *F. hollianus* is similar to *F. ceylonensis*is Dozy & Molk. in its nature of papillae and excurrent costa, but differs in leaf size and costa, length of vaginant laminae and limbidial cells.

Note: Rajeevan, 1990 mentioned this species in his Ph.D thesis but it is unpublished. Manju *et al.* (2008b) also listed this species from Kerala based on his collection. Hence the present collection is a detailed description of this species from Kerala. Many authors from India such as Gangulee (1971); Daniels and Daniel (2013); Nair *et al.* (2005) etc., considered *F. asperisetus* Lac. as a distinct species. While, Tan and Iwatsuki (1991) followed *F. asperisetus* Lac. as a variety of *F. hollianus* Dozy & Molk. Detailed taxonomic study of the two species in the present collection shows that *F. asperisetus* should be considered as a synonym of *F. hollianus*.

Habitat and General Ecology: On soil, land cuttings and exposed roots of large trees in evergreen forest, semi evergreen and moist deciduous forest mostly in shady areas from low to medium altitude area. In sacred grove it is found on *Myristica* root. Some times the species found on roots may flooded in rainy season and in evergreen areas it is found submerged along with *F. firmus*. This species is found growing as a mat, mostly seen as single species in other areas.

Distribution: India (Karnataka, Kerala, Andaman Islands, Tamil Nadu (Daniels & Daniel, 2013; Gangulee, 1971; Manju *et al.*, 2008b; Nair *et al.*, 2005; as *F. asperisetus;* Schwarz, 2014b). Borneo, Celebes, China, India, Indonesia, Japan, Java, Laos, Malaysia, Myanmar, New Guinea, Philippines, Sumatra, Taiwan, Thailand, Vietnam, (Daniels & Daniel, 2013; Eddy, 1988; Gangulee, 1971; Iwatsuki & Suzuki, 1982; Li & Iwatzuki, 2001; Manju *et al.*, 2008b; Nair *et al.*, 2005)(Map 40A&40B).

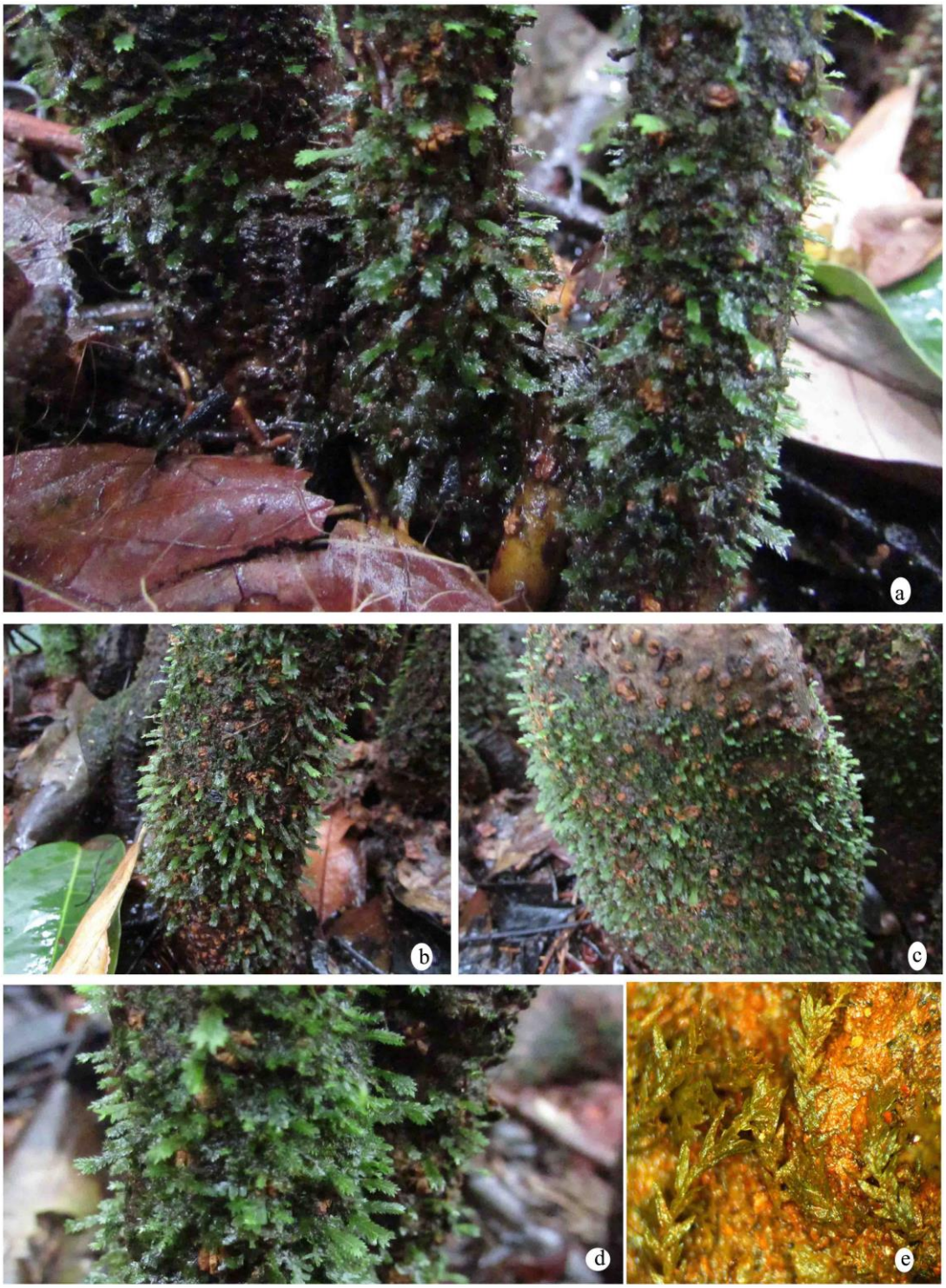


Plate 73. *Fissidens hollianus* Dozy & Molk., different views on habit & habitat on exposed root.

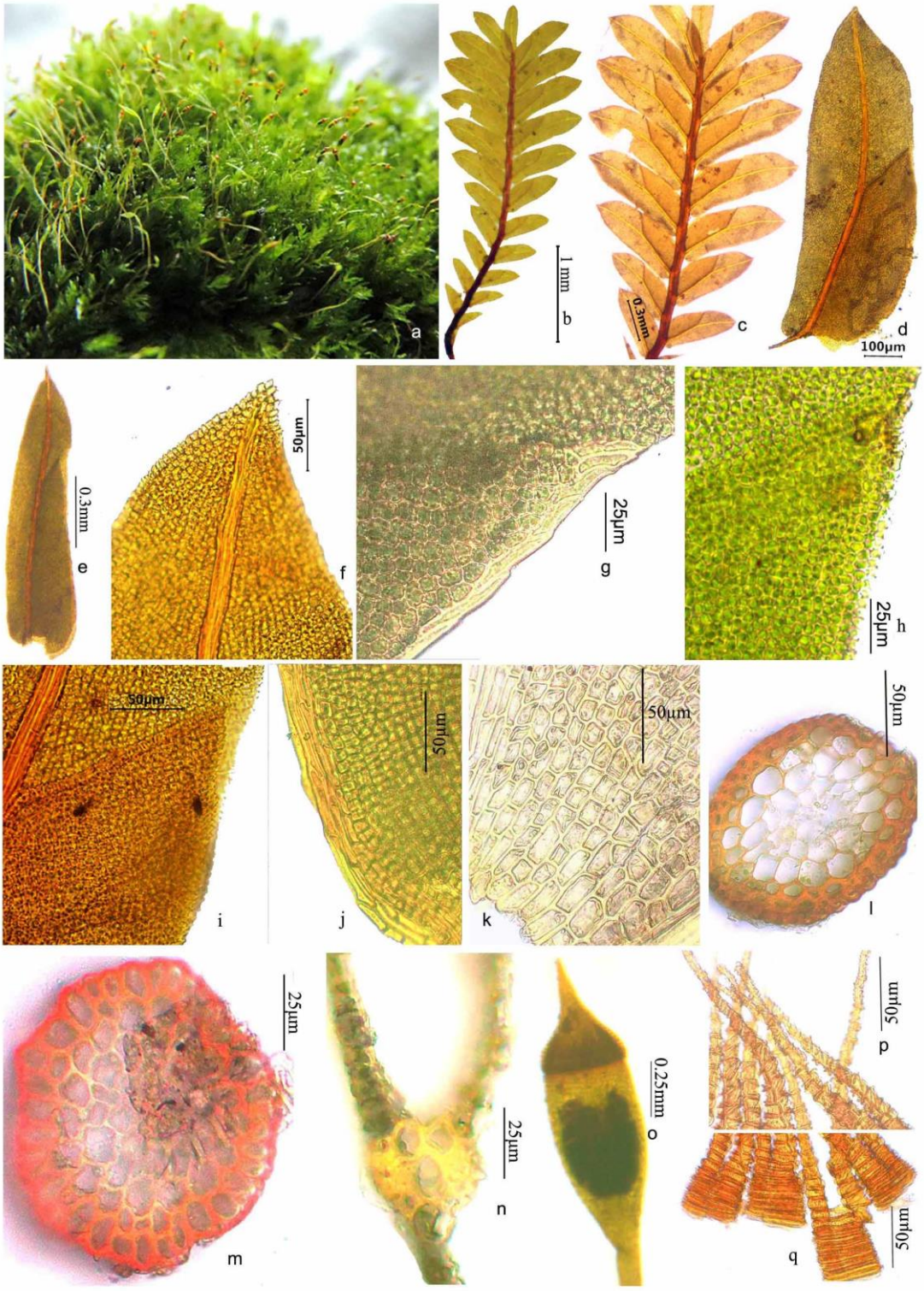


Plate 74. *Fissidens hollianus* Dozy & Molk., a. habit, b&c. vegetative plants, d&e. vegetative leaves, f. leaf apex, g-i. vaginant laminae apex, j. limbidium on vaginant laminae base, k. vaginant laminae base, l. stem T.S., m. seta T.S., n. leaf T.S., o. capsule, p&q. peristome (a,c,f,h,k from ZGC10493; b,d,f & i from ZGC7012; g,l & o from ZGC1053A; n from 84692 (CALI))

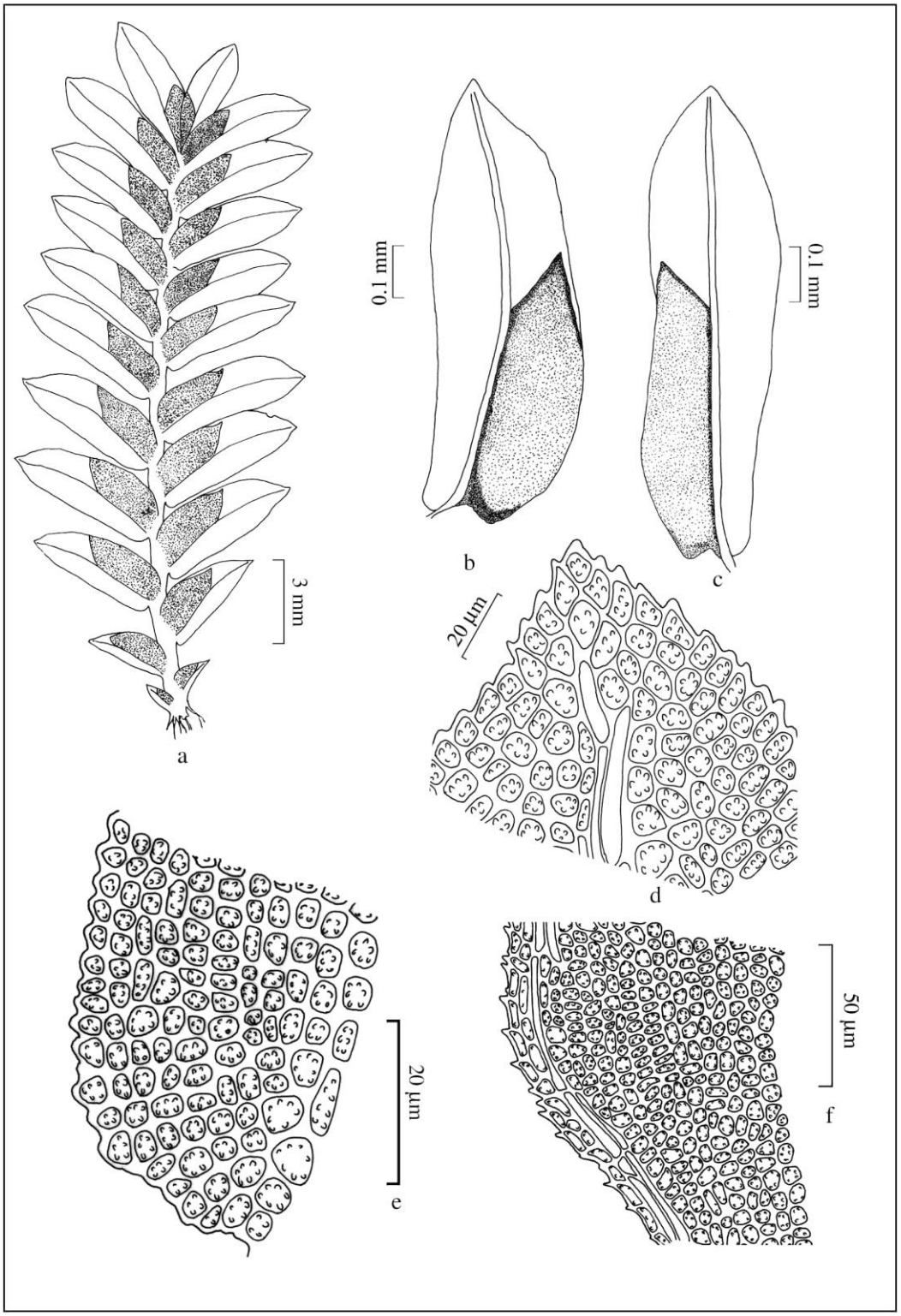
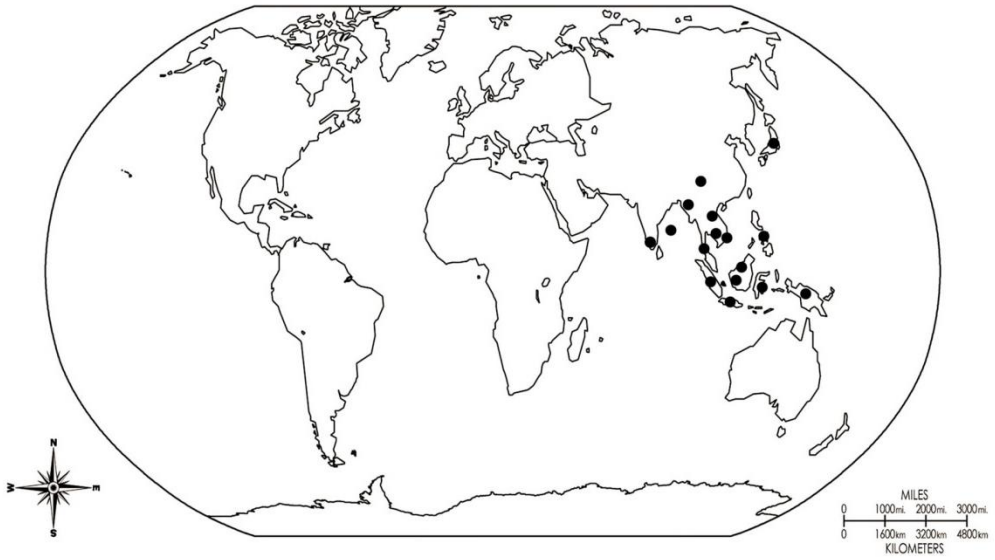
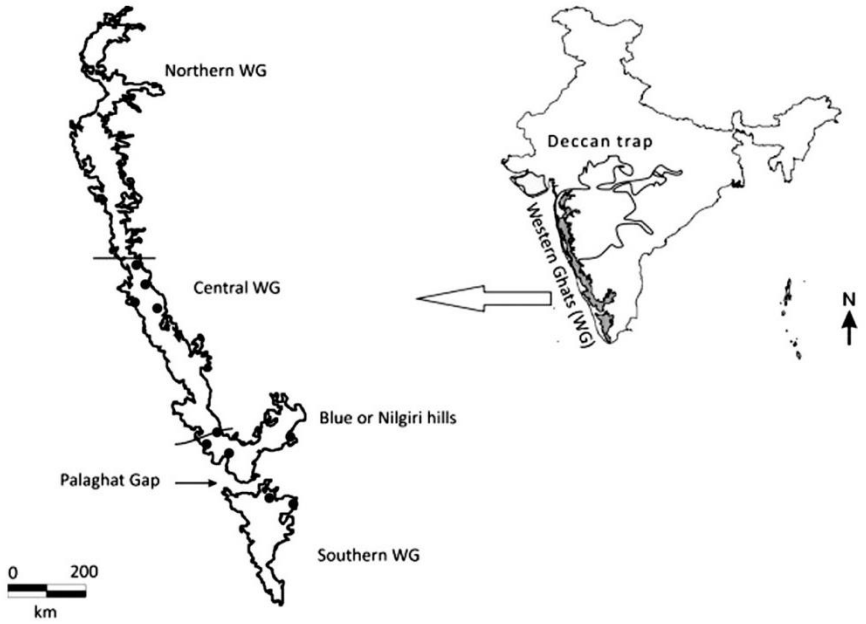


Fig. 36. *Fissidens hollianus* Dozy & Molk., a. vegetative plant, b&c. leaves, d. leaf apex with costa, e. dorsal lmaina base near insertion, f. vaginant laminae base.



Map 40A. World distribution of ***Fissidens hollianus*** *Dozy & Molk.*



Map 40B. Distribution of ***Fissidens hollianus*** *Dozy & Molk. in Western Ghats*

Specimen examined: India, Kerala; Kannur district (Theyyottukavu, 50m), 23.08.2002, K.P. Rajesh (84692) (CALI!), Aralam WLS (Chavachi, $11^0$55'91.87" N, 75^0 51'21.4" E, 180 m), MCN (87558 C) (CALI!) (as *F. asperisetus* var. *andamanensis*), Palakkad district, Silent Valley NP (Kammattam thodu to Kunthipuzha,), 20.04.1980, Vohra & Kar (3895, 3911) (CAL!), (Veliapara thodu to Karimala), 29.04.1980, Vohra & Kar (4086) (CAL!), 30.04.1980, Vohra & Kar (4140) (CAL!), Thrisur district (Vengappara, Peechi-Vazhani WLS) 09.02.2011, Rajilesh *et al.* (7021) (MBG!), Wayanad district (Noolpuzha, 1200m), 19.06.2014, Dhanya (ZGC 1053A),; Tamil Nadu; Tirunelveli (Kannikatti), 30.07.1999, A.E.D. Daniels (620) (SCCN!) (as *F. asperisetus* var. *andamanensis*); Goa (Zuari river), 04.01.1971, A.H. Norkett (15843A) (CAL!).

Fissidens incognitus Gangulee, Bull. Bot. Soc. Bengal. 11:70. 1957; Gangulee, Moss. E. India & Adj. 1: 500. f. 233. 1971; Li & Iwatsuki, Moss. Fl. China 2. 40. 2001; Lal, Checklist Indian Moss. 61. 2005; Daniels & Kariyappa, Curr. Sci. 93(7): 980. 2007; Daniels & Daniel, Bryo. South. W. Ghat. 43. 2013.

Type. India: West Bengal, 26 XII 1870, Kurz 3358 (Holotype CAL!, Isotype H-BR).

Fissidens granulatus Hampe in Muell. Hal., Gen. Musc. Frond. 61. 1900, *nom. nud*.

Plants small, yellowish green to brown, leafy stems simple or sometimes with a few branches, 1.3–5.8 mm long, 1.0–1.3 mm wide; rhizoids smooth, basal; axillary hyaline nodules not differentiated; central strand lacking; leaves in 5–16 pairs, the lowest leaves much smaller than the upper ones, more or less loosely arranged; middle to upper leaves densely arranged, oblong-lingulate, 0.7–0.8 mm × 0.20–0.25 mm, acute at apex, margins serrulate throughout; limbidia of vaginant laminae of most leaves composed of 2–3 rows of cells, and edged on outside by one row of highly mamillose, pluripapillose cells with thickened walls; vaginant laminae ca. 1/2 –3/5 the leaf length, equal to slightly unequal; base of dorsal laminae rounded; costa stout, light yellowish brown, percurrent to shortly excurrent; cells of apical and dorsal laminae quadrate to hexagonal, 7–12 µm long, thin-walled, highly

mamillose and obscure, with cluster of 2–5 high papillae at centre; cells of vaginant laminae similar to those of apical and dorsal laminae; gemmae not found.

Fertile parts, dioicous, perichaetial leaves narrower and longer than stem leaves, archegonia terminal on stems or on branches, *ca*. 157 µm long, setae erect, 2.5 mm long, smooth, capsules erect, symmetrical, urns 0.8 mm long (Plate 75 & Fig.37).

Diagnostic characters: This species is well characterised by its oblong-lingulate leaves with dorsal laminae rounded at the base and submarginal limbidia on the vaginant laminae, highly mamillose laminal cells with a central cluster of 2–5 high papillae, capsule symmetrical on its terminal stem.

Habitat and General Ecology: On soil in moist deciduous forest.

Distribution: An Indo- Chinese species distributed in India (West Bengal, Darjeeling and Tamil Nadu (Daniels & Daniel, 2013; Gangulee, 1971); China, (Li & Iwatsuki, 2001; Redfearn, & Wu, 1986) (Map 41A&41B).

Specimens examined: India, West Bengal, Birma (3358), 26.12.1970. (CAL, Isotype!), Sikkim (Darjeeling), 26.12.1870, S.Kurz (Kurz 3358) (CAL!), (Bagora, ± 2250m), Oct. 1960, N.K. Chatterjee (5111 XII) (CAL!); Tamil Nadu, Kanyakumari, Maramalai, 550 m, 17.09. 2004, R.Sreeba 61 (SCCN).

Note: Gangulee (1971) reported this species as endemic to India with distribution in West Bengal, Darjeeling and Ooty. He mentioned this species distributed in Ooty and collected by Norkett but without any collection number, later any authors cited this species from Ooty. During our present survey also we could not locate this species from Ooty. Li and Iwatsuki (2001) recorded this species from China also.

On the type packet this species was wrongly named as *F. granulatus* (Geh. & Hampe) Paris which is corrected by Gangulee and designated as holotype.

Plate 75. *Fissidens incognitus* Gangulee., a. vegetative plants, b. fertile plant, c-e. vegetative leaves, f&g. leaf apex, h&i. vaginant laminae apex, j&k. dorsal lamina base near insertion, l&m. vaginant laminae base. (photo from Kurz 3358 CAL!)

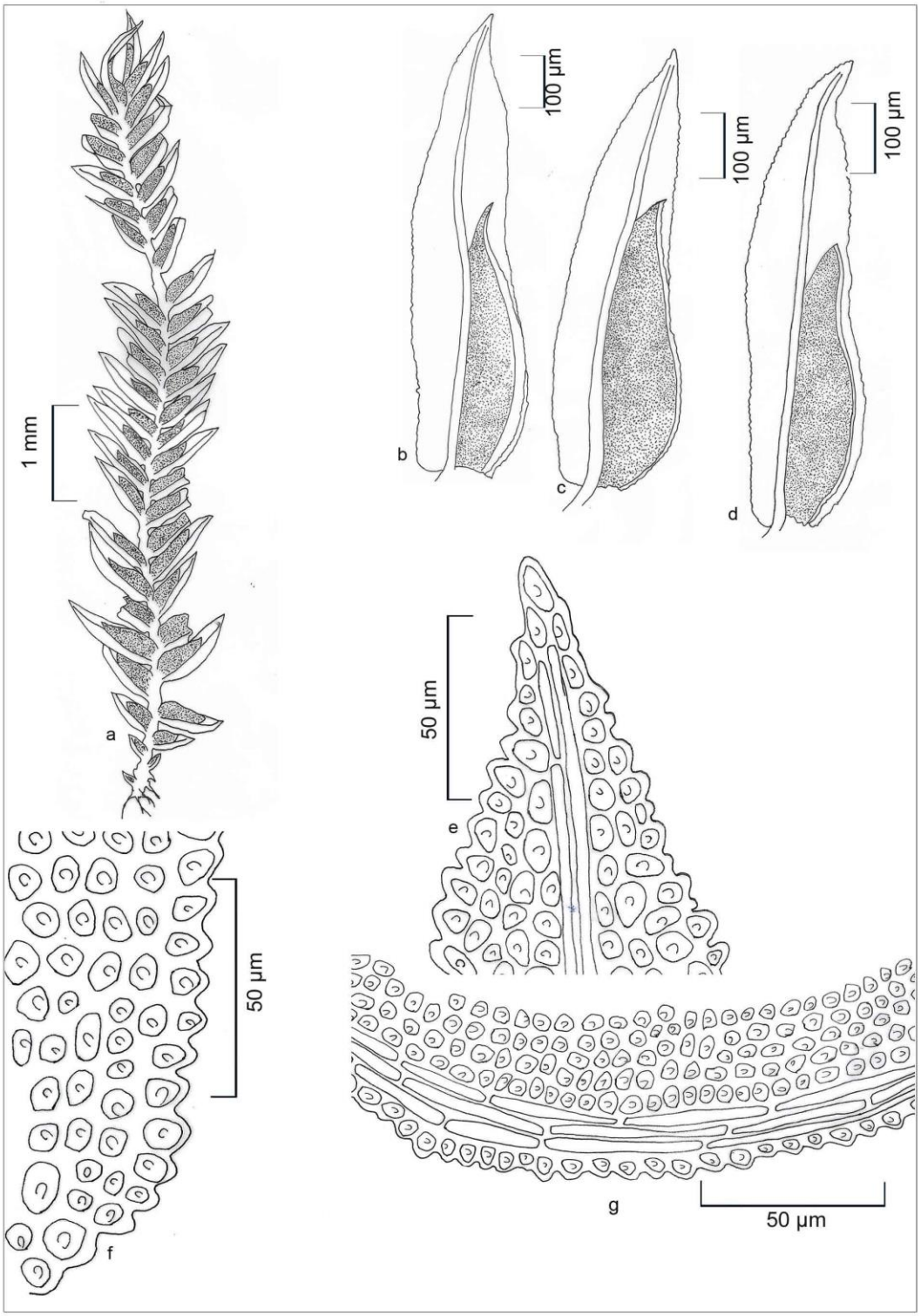
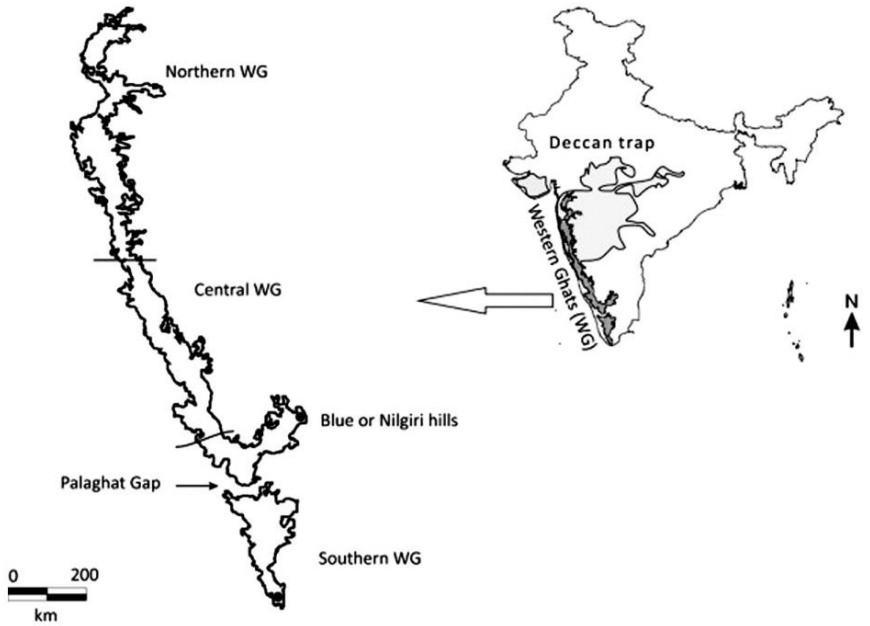


Fig. 37. *Fissidens incognitus* Gangulee, a. vegetative plant, b-d. vegetative leaves, e. leaf apex, f. dorsal lamina base near insertion, g. vaginant laminae basal margin.

Map 41A. World distribution of ***Fissidens incognitus*** *Gangulee*



Map 41B. Distribution of ***Fissidens incognitus*** *Gangulee in Western Ghats*

Fissidens kalimpongensis Gangulee, Bull. Bot. Soc. Bengal 11: 71. f. 10. 1957 & Moss. E. India & Adj. 1(2): 518, f. 244. 1971; Bruggeman-Nannenga & Berendsen, J. Hattori Bot. Lab. 68: 206. 1990; Daniels & Daniel, Indian J. Forest. 26(4): 389. 2003; Lal, Checklist Indian Moss.: 62. 2005; Daniels & Kariyappa, Curr. Sci. 93(7): 980. 2007; Daniels & Daniel, Bryo. South. W. Ghat. 44. 2013.

Type: India, W. Bengal, Kalimpong, 1200m, Gangulee 750 (CAL!).

F. pergracilis Broth. in Bruehl, Rec. Bot. Surv. India 13(1): 126. 1931.

Plants small, not much curled in herbarium, 3 x 1-2 mm, 7-11 pairs of leaves; rhizoids smooth, brown, axillary hyaline nodules present in some leaf axils, but inconspicuous; stem strong, brownish; leaves oblong lanceolate, leaf margin serrulate, 2 papillae projections from some marginal cells, margin not entire, apex acute; limbidium absent in sterile leaves, present only at the base of fertile leaves and one or two leaves below; vaginant laminae reaching 1/2 the leaf length, open or slightly open, base 13-16 cells wide, uniseriate; dorsal lamina base round, not decurrent, 7-9 cells wide, dorsal lamina and apical lamina uniseriate; costa prominent, ending two or three cells below apex but costal cells extend up to apex, bryoides type; laminal cells irregularly polygonal, pluripapillose, juxta costal cells elongated, smooth; gemmae not found.

Fertile parts, perignium not found, perichaetium terminal, perichaetial plant 2-3 mm long, 7-9 pairs of leaves, two or three rows of slightly elongated marginal cells present in vaginant laminae of perichaetial leaf, archegonium and sporophyte not seen (Plate 76-77 & Fig.38).

Diagnostic characters: *F. kalimpongensis* Gangulee is characterised by small sized plants with inconspicuous axillary hyaline nodules, laminal cells distinctly and sharply pluripapillose and juxta costal cells elongated. The pluripapillose laminal cells are similar to *F. ceylonensis* Dozy & Molk. but differs in the nature of limbidium and excurrent costae of *F. ceylonensis*.

Habitat and General Ecology: On rocky patch in shaded areas.

Distribution: An endemic species to Indo-Nepal region distributed in India (Himalayas, Kerala (pres. coll.), Tamil Nadu) and Nepal, (Daniels & Daniel, 2003c, 2013; Gangulee, 1971). The present collection is a new record for Kerala (Map 42A&42B).

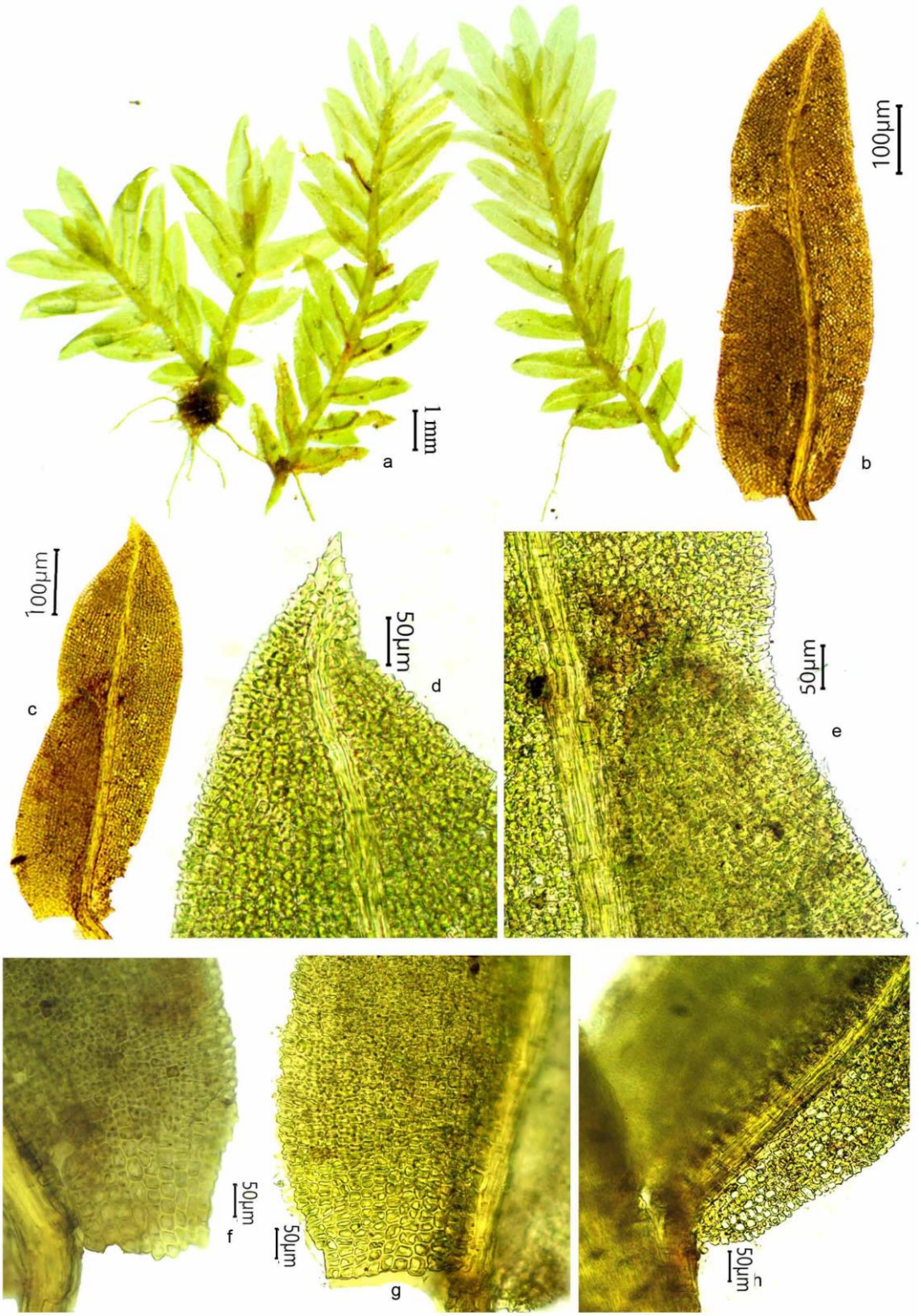


Plate 76. *Fissidens kalimpongensis* Gangulee, a. vegetative plants, b&c. vegetative leaves, d. leaf apex, e. vaginant laminae apex, f&g. vaginant laminae base, h. dorsal lamina base near insertion

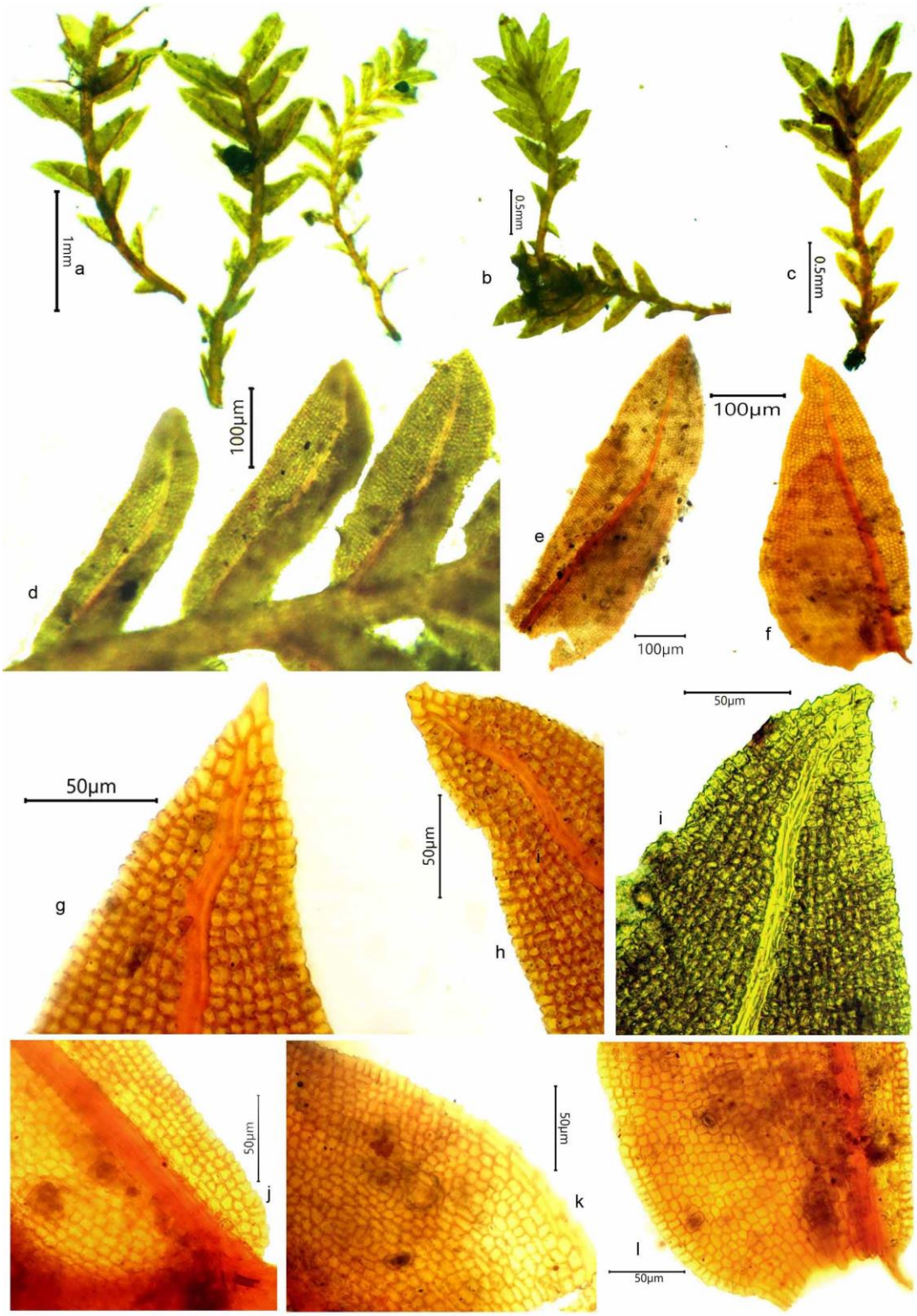


Plate 77. *Fissidens kalimpongensis* Gangulee, a&b. vegetative plants, c. fertile plant, d-f. vagetative leaves, g-i. leaf apex, j. dorsal lamina base near insertion, k&l. vaginant laminae base (photo from 11527 (BM!).

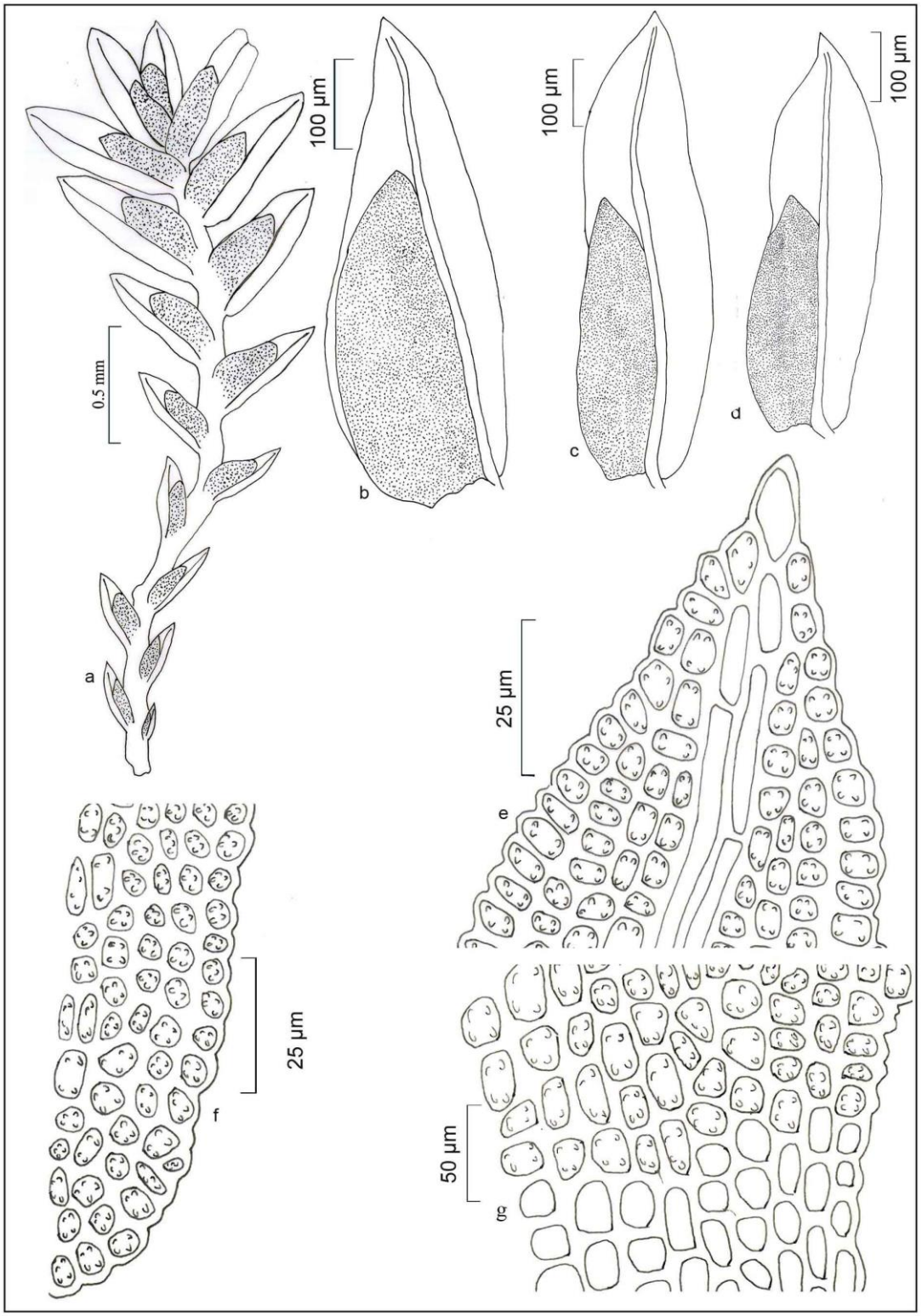
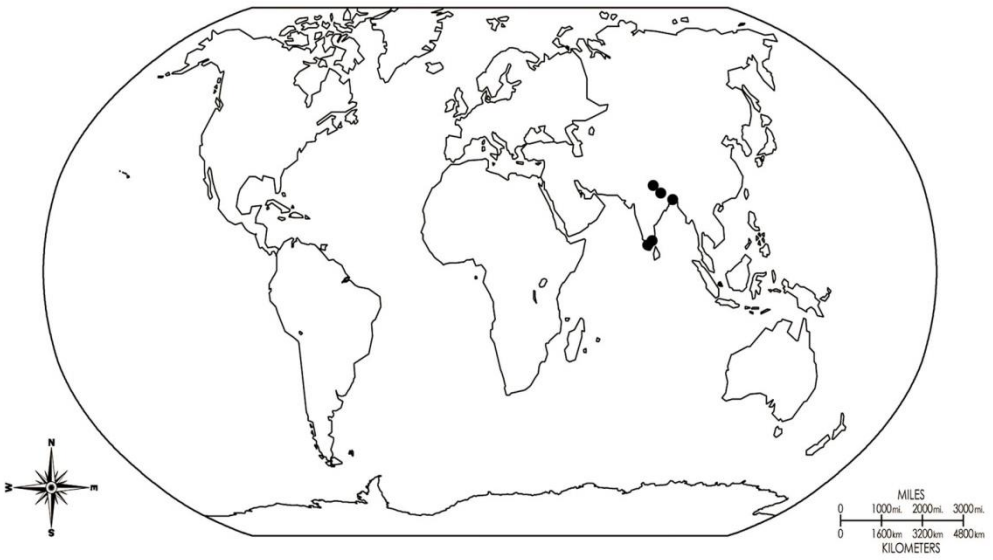
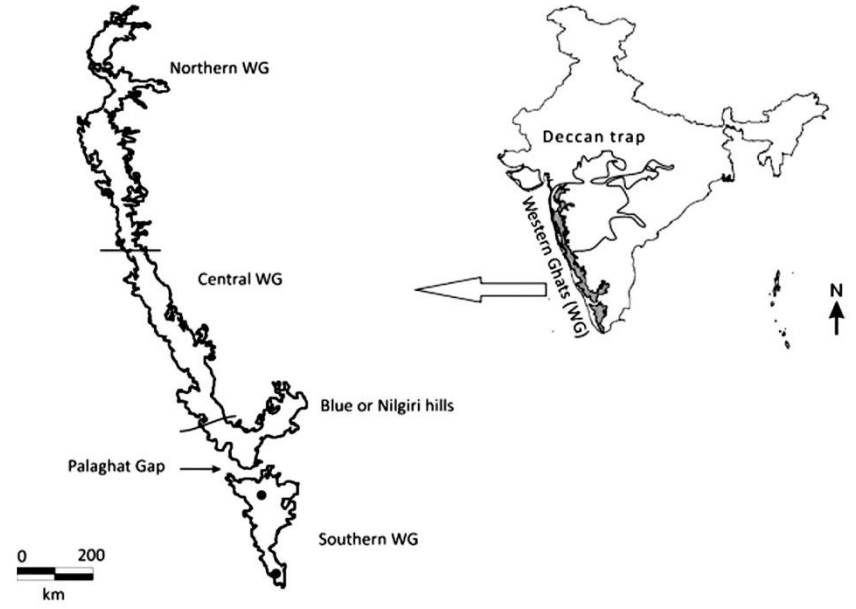


Fig 38. *Fissidens kalimpongensis* Gangulee, a. vegetative plant, b-d. vegetative leaf, e. leaf apex, f. dorsal lamina base near insertion, g. vaginant laminae base



Map 42A. World distribution of Fissidens kalimpongensis Gangulee



Map 42B. Distribution of Fissidens kalimpongensis Gangulee in Western Ghats

Specimens examined: India, Kerala, Kannur district, Aralam WLS, (Meenmutty water fall, $11^0$56'65.5" N, $75^0$52'90" E, 800m), 18.09.2015, Manjula (ZGC 15631b), Kozhikode district, Malabar WLS (Kakkayam, Thattitta para, $11^0$34'05" N, $75^0$54'23" E, 720m), 14.11.2014, Manjula (ZGC 3906b); Tamil Nadu, Kanyakumari district (Ashambu, 360-430 m), 22.10.2010, Kariyappa, K.C. & Mabel, J.L. (5624 (SCCN 3972); W. Bengal, Kalimpong, 1200m, Gangulee 750 (CAL!); Uttar Pradesh (Ranikhet, 6000ft), 29.09.1966 , A.H.Norkett (11527, 11535) (BM!).

Etymology: The specific epithet *kalimpongenesis* is derived from the type locality 'Kalimpong' of Darjeeling in India

Fissidens kammadensis Manju, K.P. Rajesh & Madhus., Acta Bot. Hungarica 50: 160. 2008a. Manju *et al.,* Tropical Bryol. Res. Rep. 7: 12. 2008b;

Type: India, Kerala, Kasaragode district, Kammadam kavu (K.P.Rajesh, 80049).

Plants gregarious, yellowish green, branching by innovations with basal rhizoids, 6-9 x 1.5-2.0 mm, stem orange brown; axillary hyaline nodules absent; rhizoids smooth, brown; leaves 14-20 pairs, curled but not much contorted when dry, ovate-lingulate, 1.6-1.9 x 0.45 mm, apex blunt, acute, margin not entire, serrulate; limbidium on vaginant laminae base only, 4-6 rows at base; vaginant laminae unequal, minor lamina slightly unequal, reaching 1/2 the leaf length, 0.5-0.8 mm long, uniseriate; dorsal lamina base round, not decurrent, margin crenulate, dorsal lamina and apical lamina uniseriate; laminal cells quadrate hexagonal, mamillose, 5.0-7.5 µm long, juxta costal cells elongated, 7.5-12.5 x 7.5-10.0 µm; gemmae not found.

Fertile parts, perigonium not found; perichaetium terminal, archegonium not found; seta terminal, yellowish brown, 4-5 mm long, smooth, capsule cylindrical, 1.0-1.2 mm long, stomata present on neck, peristome teeth light brown, 2.5 µm long, spirally thickened, spores smooth, 10.0-12.5 µm (Plate 78a-c,79 & Fig.39a-g).

Diagnostic characters: *F. kammadensis* Manju, K.P. Rajesh & Madhus. is characterised by oblong lingulate leaves, blunt leaf apex, 4-6 rows of limbidium restricted to vaginant laminae base only, mamillose laminal cells and elongated juxta costal cells.

Habitat and General Ecology: On shaded, humid earth bank and on the *Myristica* roots close to soil in marshy land along with gametophytes of ferns in sacred groves.

Distribution: It is an endemic species to Kerala (Manju *et al.,* 2008a, 2008b; Jyothilakshmi *et al.,* 2016) (Map 43A&43B).

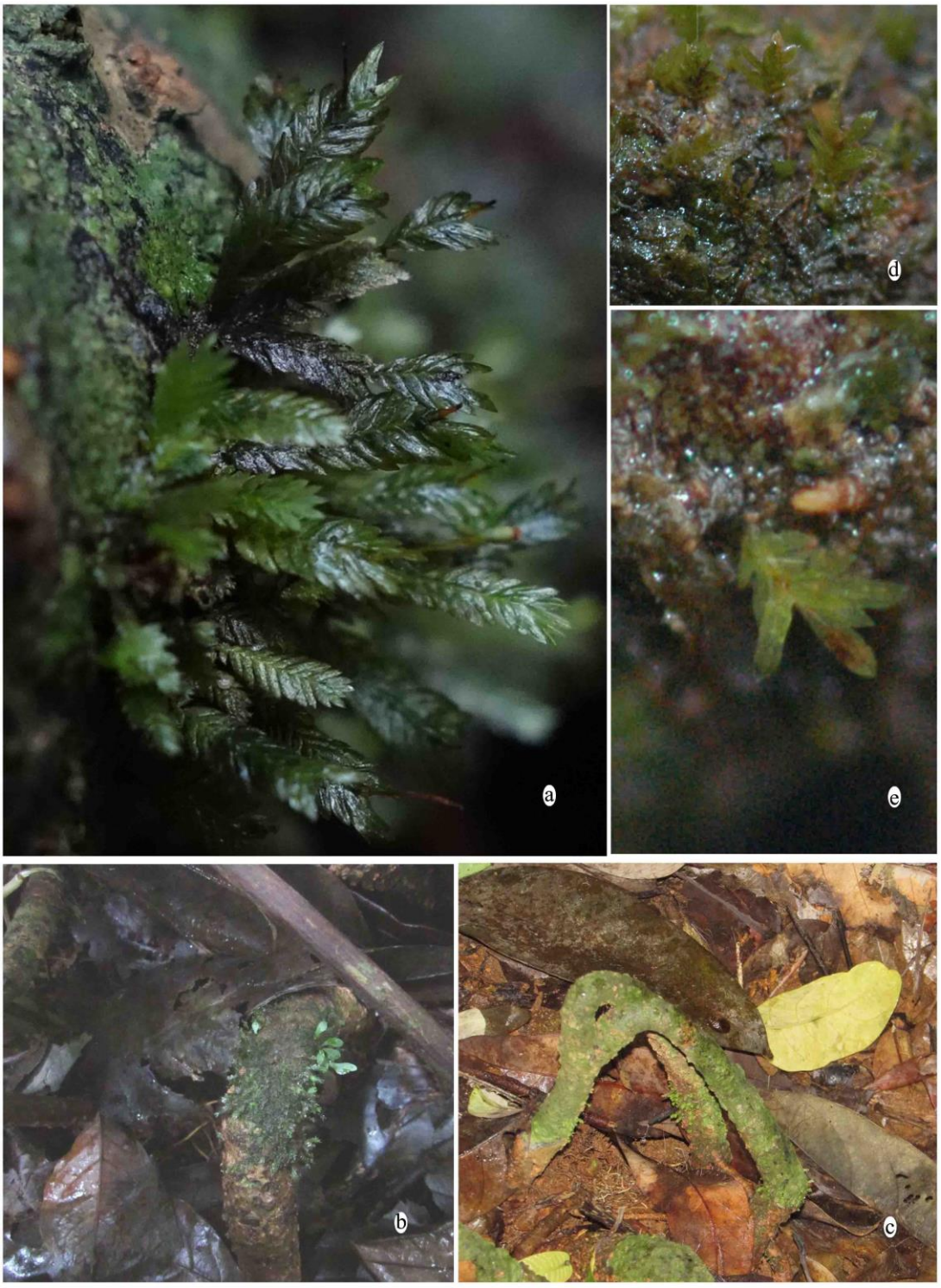


Plate 78. a-c. *Fissidens kammadensis* Manju, K.P.Rajesh & Madhus., a. enlarged view of plant on basal part tree trunk, b&c. habit on *Myristica* root.; d&e. *Fissidens kurzi* Mull. Hal., enlarged view of plant

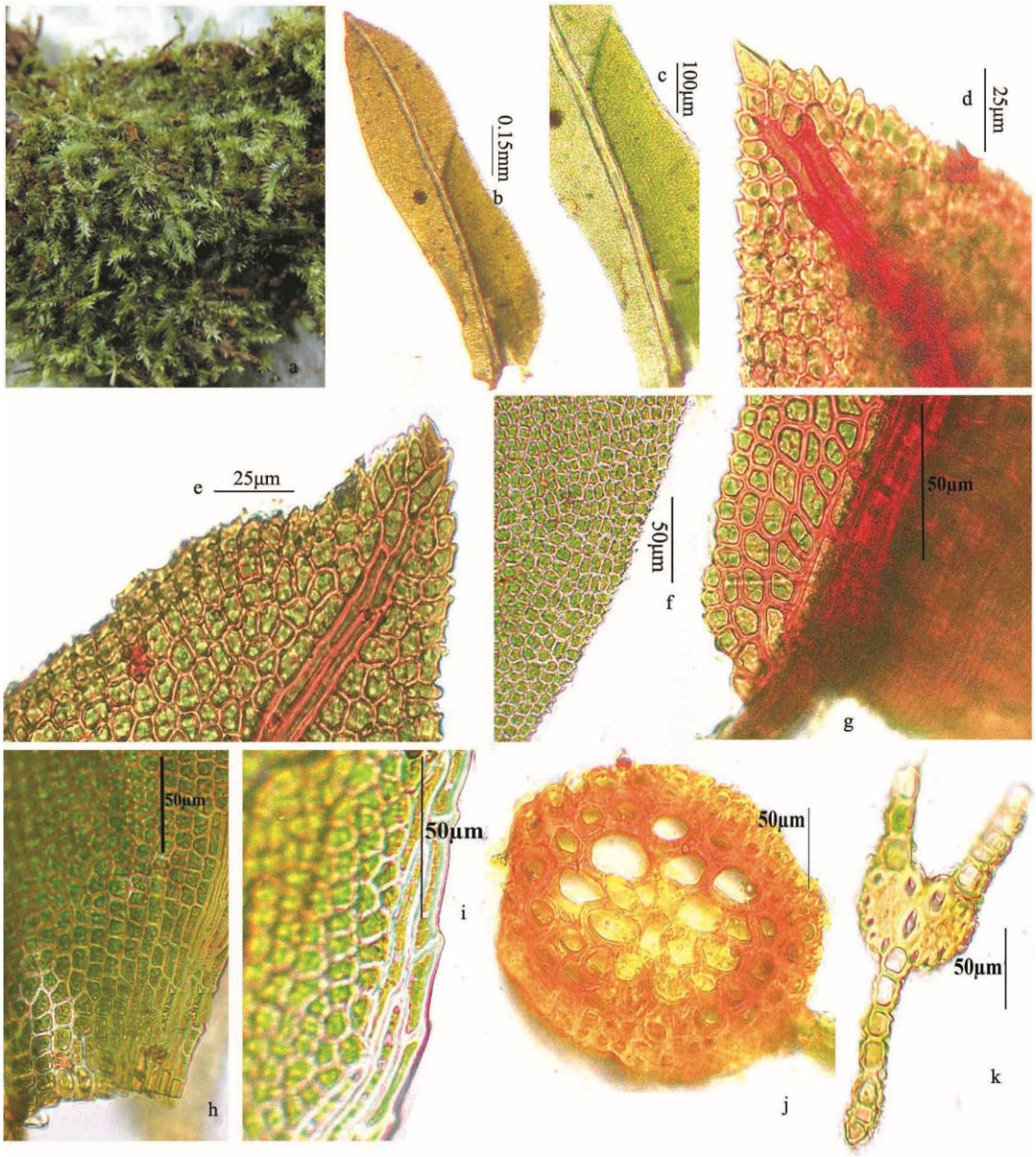


Plate 79. *Fissidens kammadensis* Manju, K.P. Rajesh & Madhus., a. habit, b. vegetative leaf, c. vaginant laminae, d & e. leaf apex, f. leaf margin, g. dorsal lamina base, h. vaginant laminae base, i. vaginant laminae apex, j. stem T.S., k. leaf T.S.

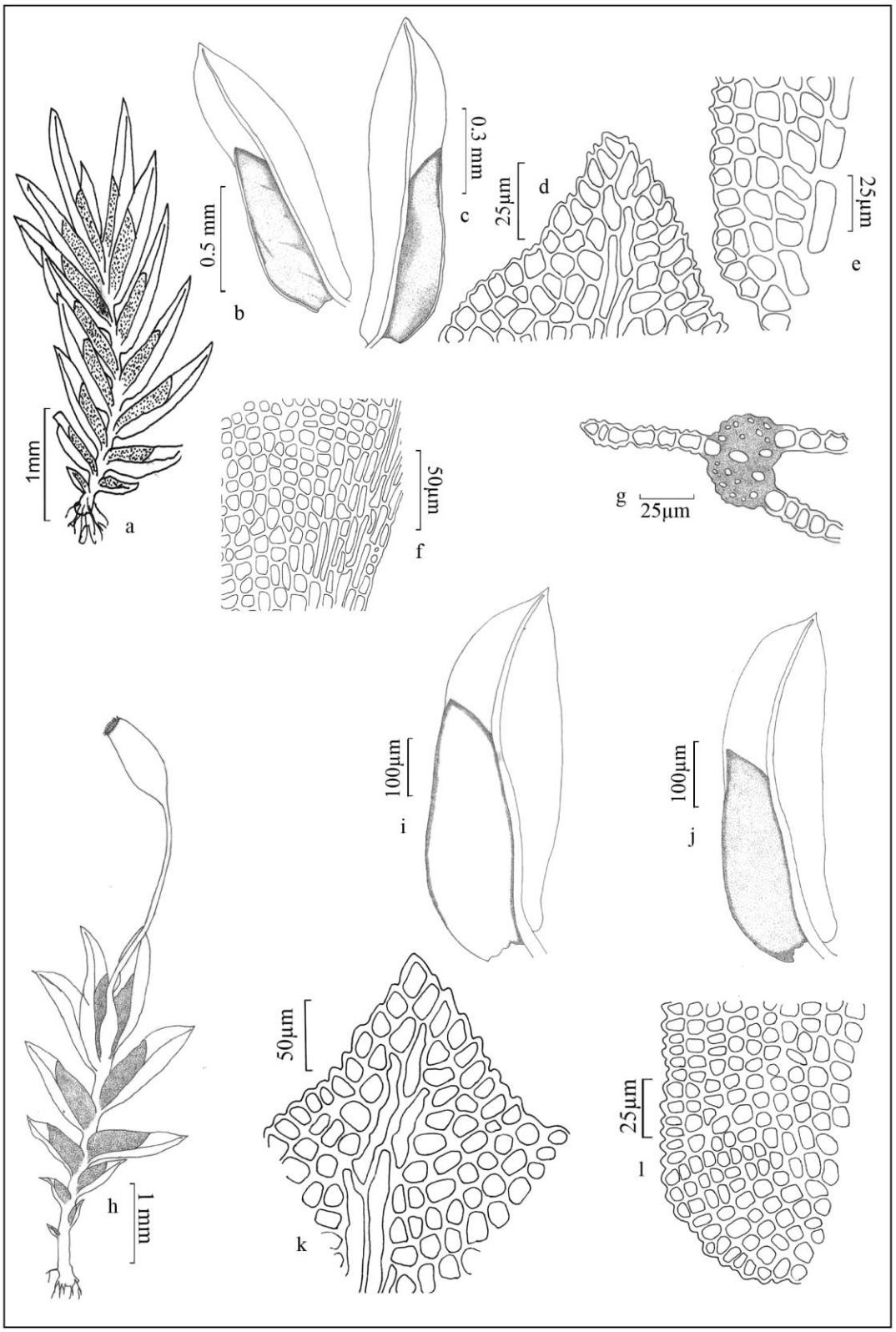
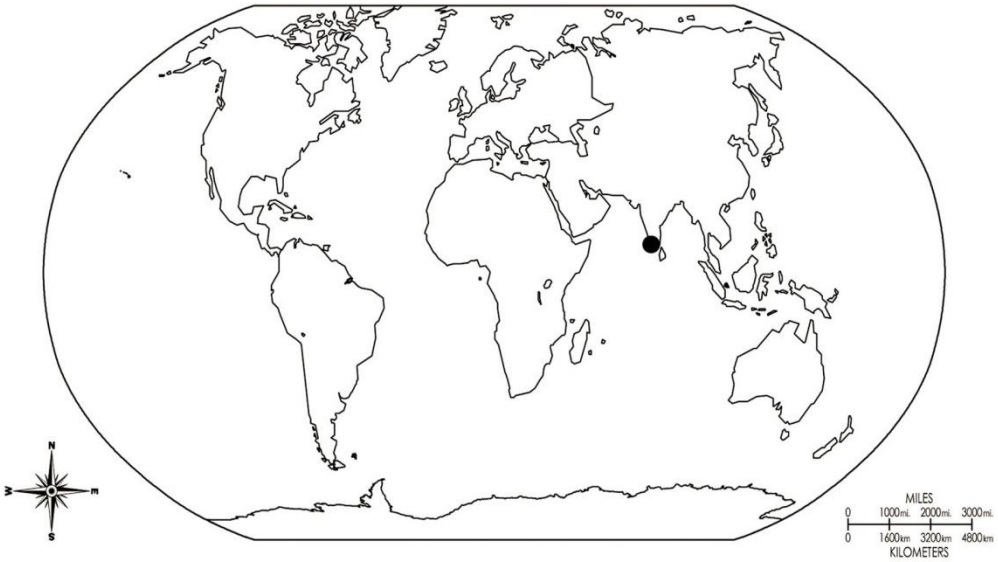
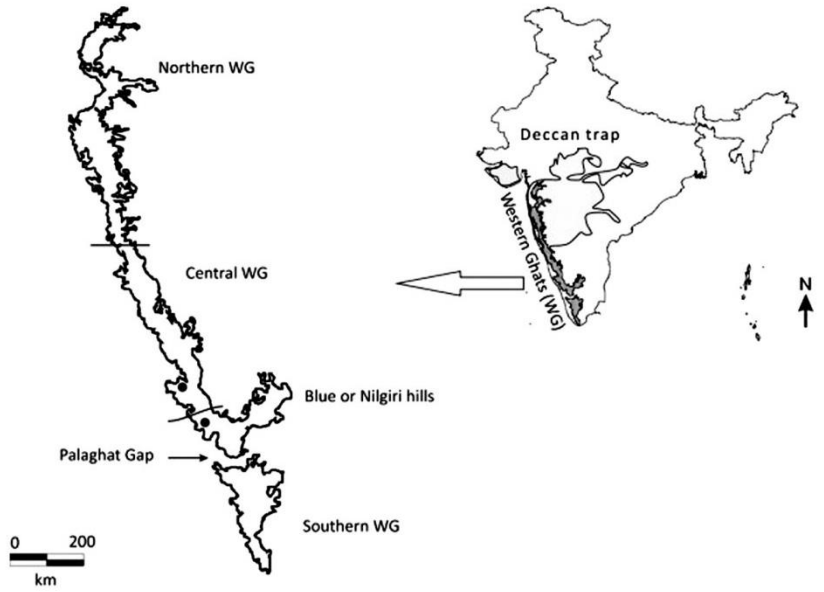


Fig. 39. (a-g)- *Fissidens kammadensis* Manju, K.P. Rajesh & Madhus. a. vegetative plant, b&c. vegetative leaves, d. leaf apex, e. dorsal lamina base near insertion, f. vaginant laminae base with limbidium, g. leaf T.S.; (h-l)- *Fissidens kurzii* Müll. Hal., h. fertile plant, i&j. vegetative leaves, k. leaf apex, l. dorsal lamina base near insertion.



Map 43A. World distribution of Fissidens kammadensis Manju, K.P. Rajesh & Madhus.



Map 43B. Distribution of Fissidens kammadensis Manju, K.P. Rajesh & Madhus. in Western Ghats

Specimens examined: India, Kerala, Kasaragod District (Kammadam Kavu, 100m), 01.10.2001, K.P.Rajesh (80049, 80050) (CALI!); Kozhikode, Vallikkattukavu (53m) 29. 6. 2014, Jyothilakshmi *et al.,* ZGC 576, ZGC 578, ZGC 588, ZGC 592a).

Etymology: The specific epithet '*Kammadensis'* refers to the type locality 'Kammadam kavu' in the Kasaragod district of Kerala.

Fissidens kurzii Muell.Hal., Linnaea 37: 163. 1871; Gangulee, Moss. E. India & Adj. 1: 516. 1971; Manju *et al*., Tropical Bryol. Res. Rep. 7: 12. 2008b.

Type: Patria, Bengalia septentrionalis, inter Douk & Titalya, 28. Oct. 1868: S. Kurz. (lost during world war)

Plants small, 2-3 x 1-2 mm, light green, 5-7 pairs of leaves, central strand well differentiated; rhizoids brown, smooth, axillary nodules absent; leaves oblong-lingulate, 0.80-0.90 x 0.30-0.34 mm, 3 times long as wide, margin serrate, leaf apex widely acuminate or mucronate; limbidium at base of vaginant laminae and apical lamina of older leaves, not complete and clear; vaginant laminae reaching ±1/2 of apical lamina, 0.17-0.21 mm wide at base, unequal, unistratose; dorsal lamina narrows towards insertion, not decurrent, dorsal lamina and apical lamina unistratose; costa prominent, yellowish orange, ends two or three cells below apex or percurrent, bryoides type; laminal cells irregularly rectangular or oval, pluripapillose with 2-4 papillae; mid dorsal laminal cells slightly convex, 10.30-12.36 x 4.12-6.18 µm; mid vaginant laminal cells plane, 8.24-10.3 x 5.15-9.27 µm; gemmae not found.

Fertile plants; perigonia not found, perichaetia terminal, plants 5.00-6.80 x 1-2 mm, 5-7 pairs of leaves, perichaetial leaves 0.99-1.15 x 0.12-0.25 mm; sporophyte one per perichaetia, inclined or horizontal, setae 1.60-3.00 mm, capsule 0.70-1.40 x 0.20-0.35 mm, 23-26 files of exothecial cells with thickened longitudinal walls, operculam not found, peristome 20.60-24.72 µm wide at base, 74.16-88.58 µm long, spore 16.48-22.66 µm (Plate 78d&e,80&Fig.39h-l).

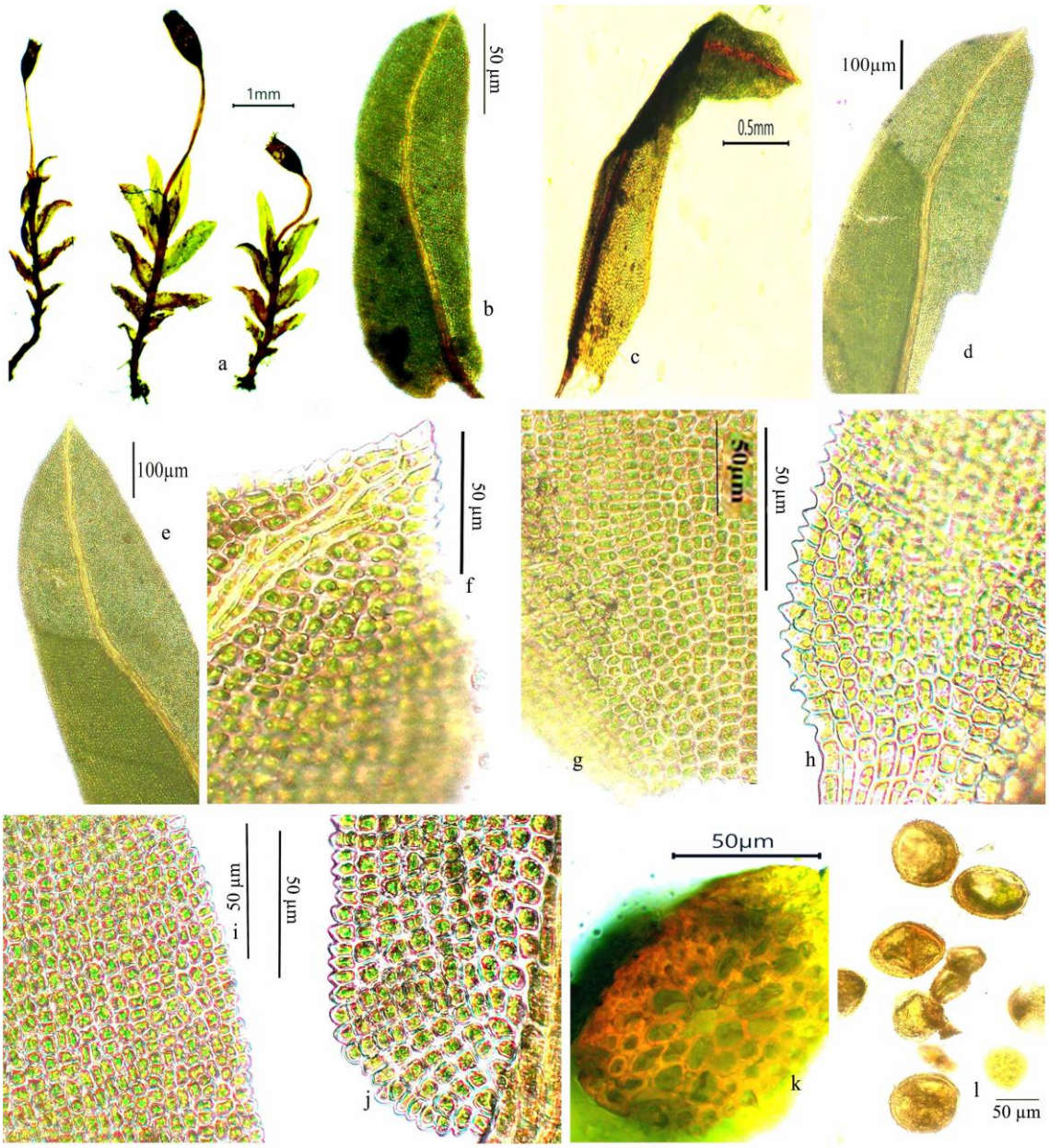


Plate 80. *Fissidens kurzii* Mitt., a. fertile plants, b&d. vegetative leaves, c. perichaetial leaf, e&f. leaf apex, g&h. vaginant laminae base i. leaf margin, j. dorsal lamina near insertion, k. stem T.S., l. spores.

Diagnostic characters: *F. kurzii* Muell. Hal. is characterised by oblong lingulate leaves, open and unequal vaginant laminae, percurrent costa and pluripapillose laminal cells. It is related with *F. hollianus* Dozy & Molk. in papillose cells and slightly percurrent costa but differs in intramarginal prominent limbidium of latter.

Note: The holotype of *F. kurzii* Muell. Hal. is lost during destruction of Berlin Herbarium during world war. Gangulee (1971) compared the species based on *Kurz 3421* (collected from Myanmar) which is kept in Mitten Herbarium, New York Botanical Garden. Gangulee (1971) noticed some variations in that specimen compared to original description such as, costa is percurrent and laminal cells are unipapillose. He explained that costal length may vary and the difference in the papillosity may be due to the unclear nature of cells. The present collection also shows pluripapillose nature and percurrent costa. During my present study I have requested for *Kurz 3421* and type, but they have not mentioned this number in virtual herbarium and we could not trace the specimen. In the protologue they have not mentioned any type (Muell.Hal, 1871) and isotypes. Further investigation is needed for designating a neotype.

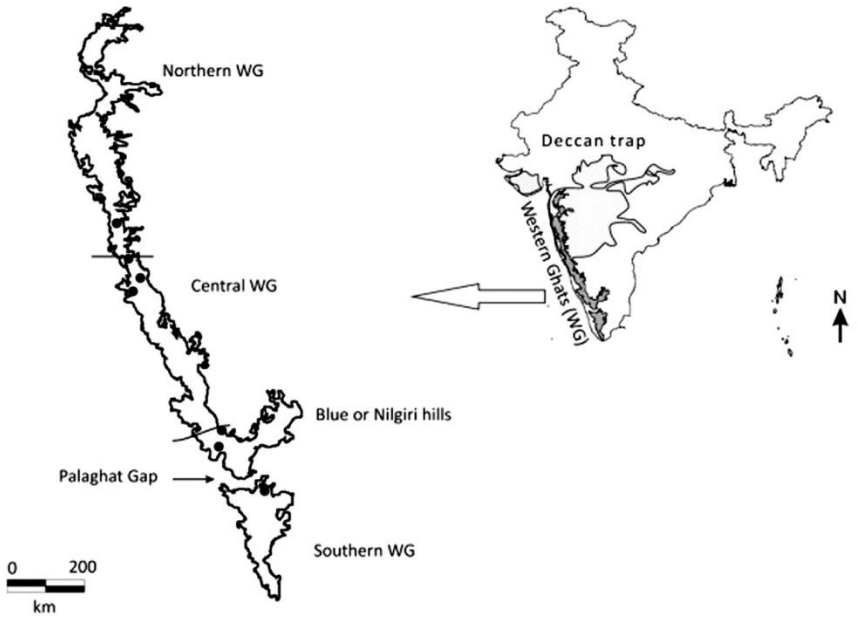
Habitat and General Ecology: On land cuttings and on bark of trees along with other bryophytes such as *Lejeunea flava* (Sw.) Nees and *Stereophyllum sp.* in the evergreen and semi evergreen forests on medium altitudes.

Distribution: An Indo-Burmese species reported from India (Bengal, Kerala (present collection), Karnataka (Schwarz (pers.comm.) and Myanmar (Gangulee, 1971) (Map 44A&44B).

Specimens examined: India, Kerala, Kozhikode district (Vellarimala, $11^{0}49'64''$ N, $76^{0}14'21''$ E, 998m), 18.07.2013, Manjula (ZGC 625a), Palakkad district (Parambikulam WLS, 700m), 09.10.2007, Sreenivasan V.K. (106398B) (CALI!), Wayanad district (Kuruva dweep, $11^{0}82'184''$ N, $76^{0}08'792''$ E, 975m), 25.09.2013, Manjula K.M. (ZGC 859, ZGC 860A).

Etymology: The specific epithet *kurzii* named in honor of the botanist Kurz who collected the type specimen of this species.

Map 44A. World distribution of ***Fissidens kurzii*** **Müll.Hal.**



Map 44B. Distribution of ***Fissidens kurzii*** **Müll.Hal. in Western Ghats**

Fissidens laxitextus Broth. ex Gangulee, Nova Hedwigia 8: 144. 1964; Gangulee, Moss. E. India & Adj. 2: 529. 1971; Suzuki & Iwatsuki, Hattoria 3: 14. 2012.

Type: India, Darjeeling, Prope Kurseong, Sepoydura forest 6800p Brotherus 20.10.1898, pares intermixtus (CAL!).

Fissidens laxitextus Broth. in Bruehl, Rec. Bot. Surv. India 13(1): 126. 1931.

Plant in loose tufts, rhizoids basal, smooth, reddish brown; axillary hyaline nodules absent; stem usually unbranched, 3.5-5.0 x 1.0-1.5 mm, cortical cells small, thick walled, central strand slightly differentiated, 7-9 pairs of leaves, leaves oblong lingulate, small, 0.6-0.9 x 0.2-0.25 mm, lower leaves reduced, scaly, leaves curls well in herbarium, margin serrate, leaf apex acute, pointed; limbidium absent on all laminae; costa ends few cells below apex, 3-6 cells below, shows a small bend where it leaves vaginant laminae, bryoides type; vaginant laminae reaching half of leaf length, unistratose, unequal, minor lamina slightly open; dorsal lamina base round, not decurrent, dorsal lamina and apical lamina unistratose; laminal cells irregularly quadrate to hexagonal, 10-16 µm long, smooth, thin walled, walls clear. Gemmae not found(Plate 81 & Fig.40).

Fertile parts not found

Diagnostic characters: *F. laxitextus* is characterised by oblong lingulate leaves with smooth laminal cells, costa ending 3-6 cells below apex, serrate margin and unequal minor vaginant lamina. This species is similar to *F. pellucidus* in smooth laminal cells, serrate margin and unequal minor vaginant lamina but differs in percurrent to excurrent costa, apiculate leaf apex and guttulate laminal cells of *F. pellucidus.*

Note: This species is mentioned in Gangulee (1971), but Daniels (2010); Daniels and Daniels (2013) does not mentioned this species from Tamil Nadu. It is a valid species and I could not locate this species during my present study. The above description is based on authentic specimen procured from BM.

Habitat and General Ecology: On rocks in high altitude evergreen forest.

Distribution: India (Darjeeling, Tamil Nadu); Nepal, (Gangulee, 1971); Japan (Suzuki & Iwatsuki, 2012) (Map 45A&45B).

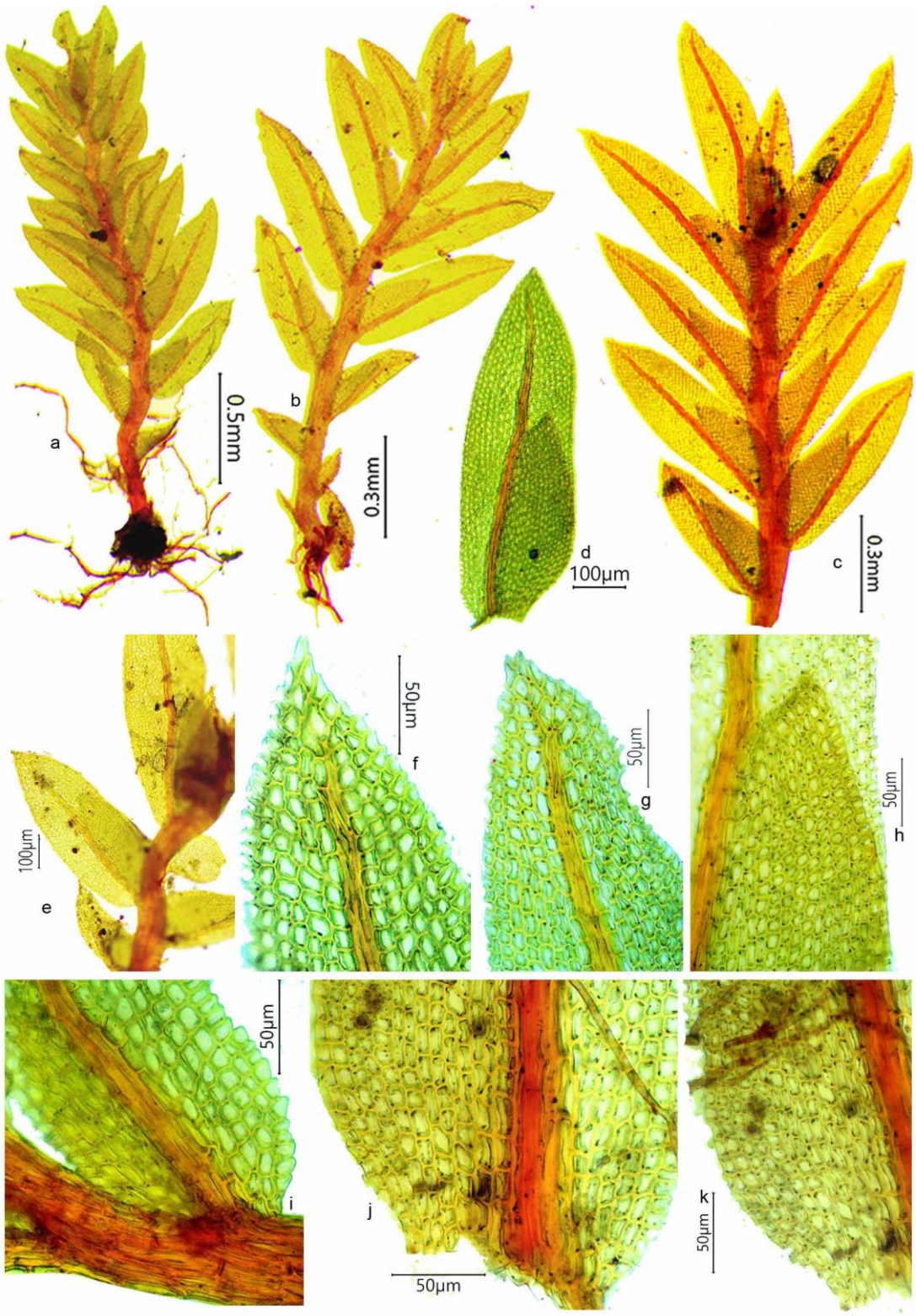


Plate 81. *Fissidens laxitextus* Broth. *ex* Gangulee, a-c. vegetative plant, d&e. vagetative leaves, f&g. leaf apex, h. vaginant laminae apex, i&j. leaf base near insertion, k. vaginant laminae base.(Brotherus (no collection number) CAL!)

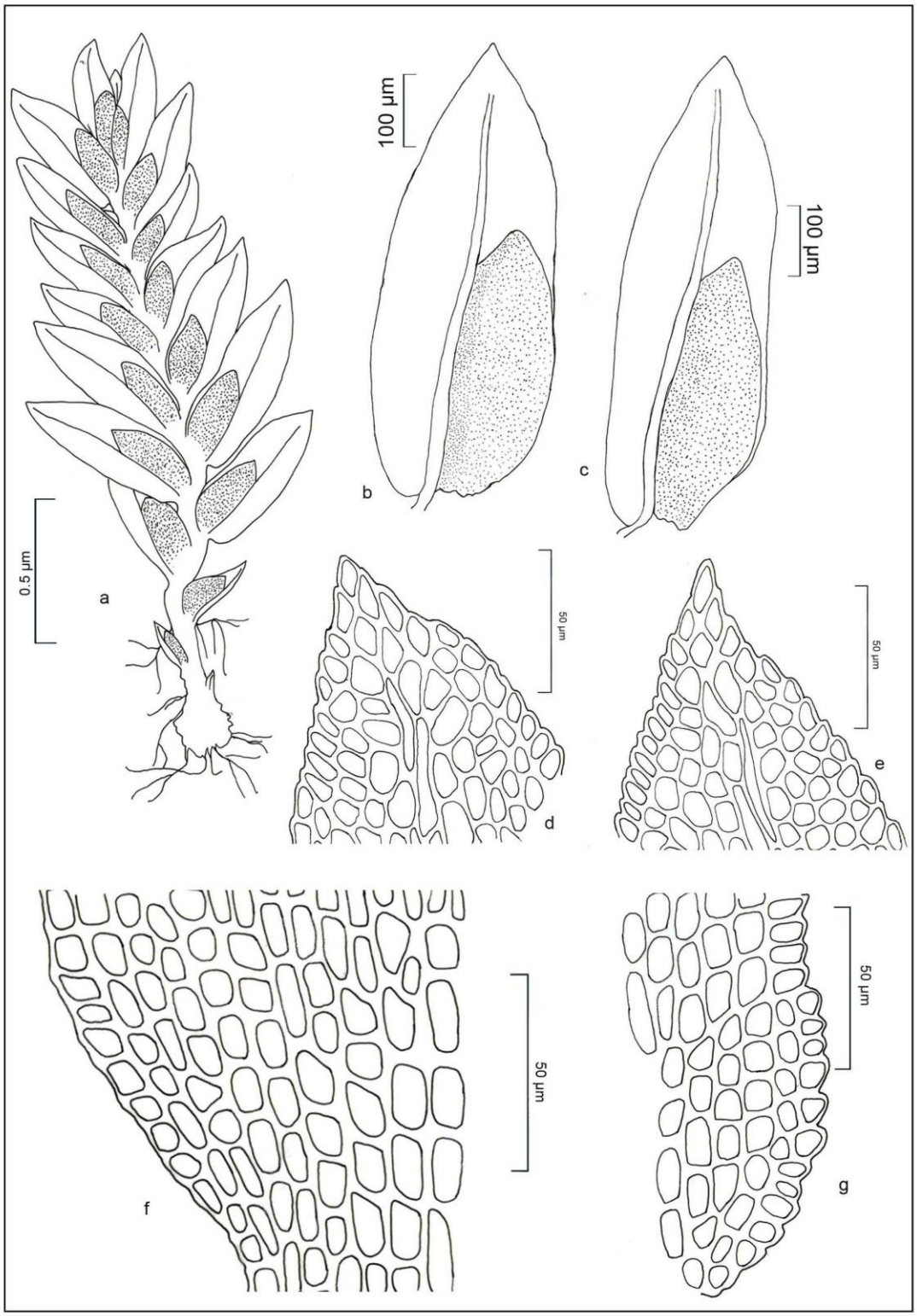
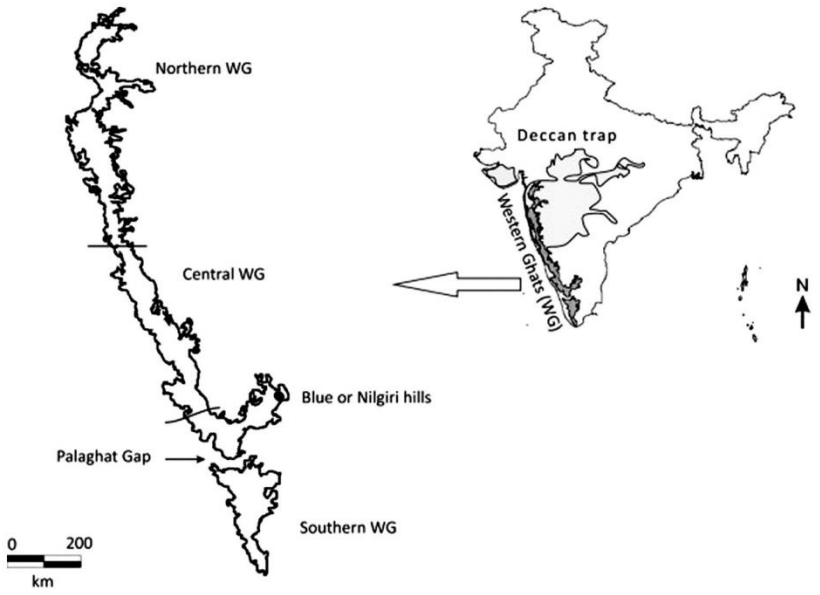


Fig. 40. *Fissidens laxitextus* Broth. *ex* Gangulee, a. single plant, b&c. vegetative leaves, d&e. leaf apex, f. vaginant laminae base, g. dorsal lamina base near insertion.

Map 45A. World distribution of ***Fissidens laxitextus*** **Broth. ex Gangulee**



Map 45B. Distribution of ***Fissidens laxitextus*** **Broth. ex Gangulee in Western Ghats**

Specimens examined: India, Darjeeling, Prope Kurseong, Sepoydura forest 6800p Brotherus 20.10.1898, pares intermixtus (CAL!); East Nepal, Sangu, Tamrang Khola Path (5900ft), 19.10.1961, Anonymous (6310 BM!)

Fissidens longtonianus Z. Iwats. & Tad. Suzuki, J. Bryol. 27: 244. 2005; Iwatsuki & Suzuki, J. Bryol. 27: 244. 2005; Manju *et al.*, Tropical Bryol. Res. Rep. 7: 12. 2008b.

Type: South India, Kerala, Idukki district, Kulamavu. 80802 (B. Rajeevan). (Holotype NICH!)

Light green to yellowish, proliferations present, 3.50-6.00 x 2-3 mm, older stem reddish, central strand differentiated; rhizoids axillary and terminal, reddish brown; axillary hyaline nodules absent; leaves more crowded towards tip, 6-9 pairs of leaves, alternate, slightly overlapping, broadly lanceolate, margin crenate with acute or apiculate apex, 1.50-1.70 x 0.32-0.35 mm, 5 times long as wide; limbidium absent; vaginant laminae reaching half the leaf length, 0.83-0.90 mm long, 0.17-0.18 mm wide at base, slightly open, unistratose; dorsal lamina margin crenulate, base wedge shaped, 3-5 cells wide at base, dorsal lamina and apical lamina unistratose; costa bryoides type, slightly excurrent, yellowish green; mid dorsal laminal cells plane, smooth 52.20-60.90 x 17.40-34.8 µm, mid vaginant laminal cells plane, 52.20-60.9 x 34.8-39.15 µm; gemmae not found.

Fertile parts, perigonia not found; perichaetia terminal, plants 4-8 x 2.50-4.00 mm, 7-11 pairs of leaves, perichaetial leaves 1.94-2.08 x 0.31-0.34 mm, archaegonia not found; sporophyte emergent, 2.00-2.50 mm long, seta short 0.70–0.75 mm long, capsule symmetric, cylindrical, 1.35-1.40 x 0.50-0.53 mm, operculum rostellate, exothecial cells irregularly quadrate, 34-37 files of cells, peristome teeth 40.68-45.20 µm wide at base, not correctly divided at base but longitudinally perfoliated or fenestrated, finely papillose; spores large, smooth, 27.12-33.9 µm. (Plate 82a-f, 83 & Fig.41).

Diagnostic characters: *F. longtonianus* Z. Iwats. & Tad. Suzuki is characterised by differentiated central strand of stem, broadly lanceolate leaves with crenate margins and acute to apiculate apex, laminal cells smooth, emergent sporophyte, perforated,

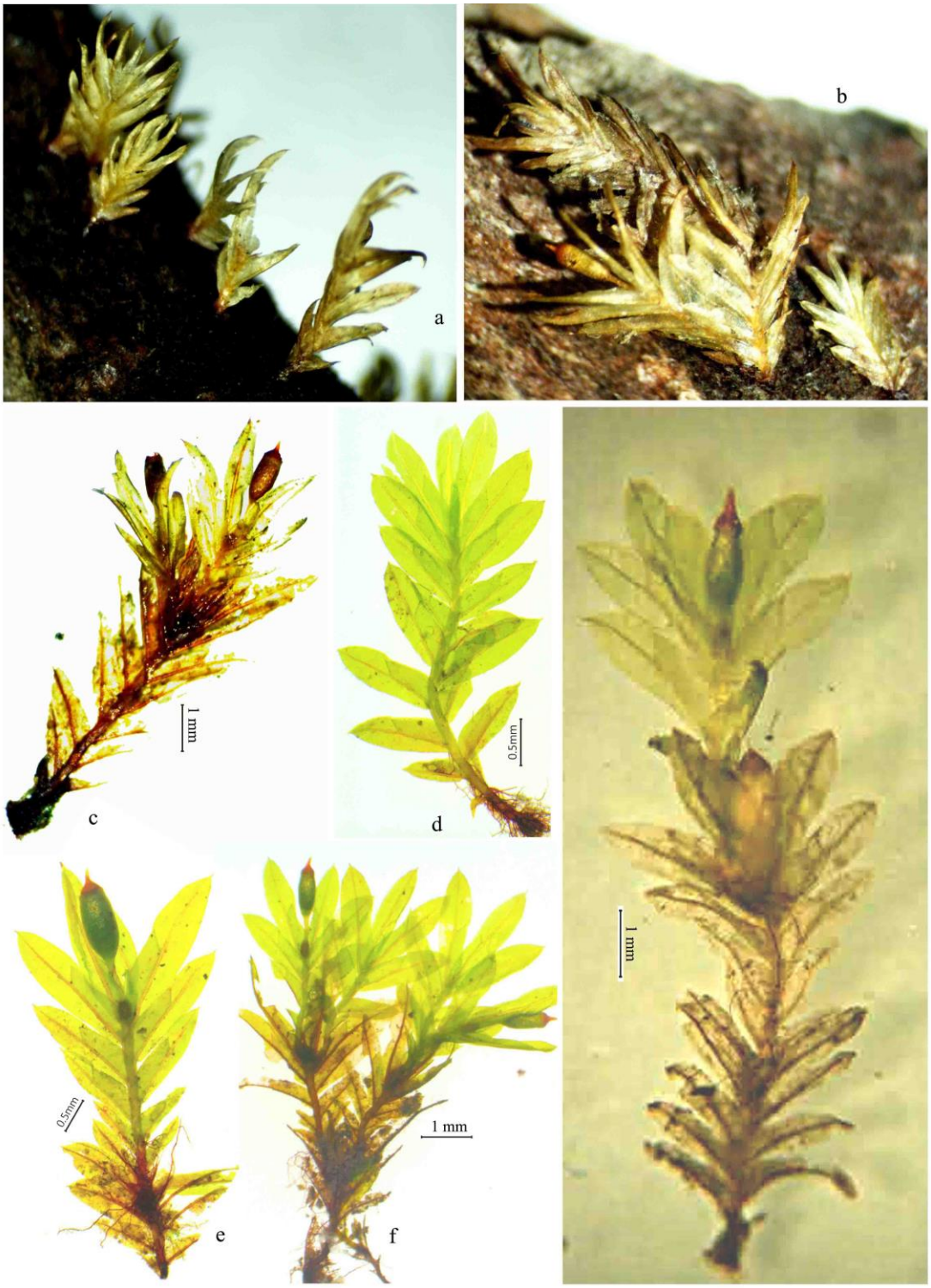


Plate 82. a-f. *Fissidens longtonianus* Z. Iwats. & Tad. Suzuki*;* a&b. dried plant on bark of tree, c,e&f. fertile plants, d. vegetative plant (c-f. taken using stereo microscope); g. *Fissidens macrosporus* Dixon taken using stereo microscope

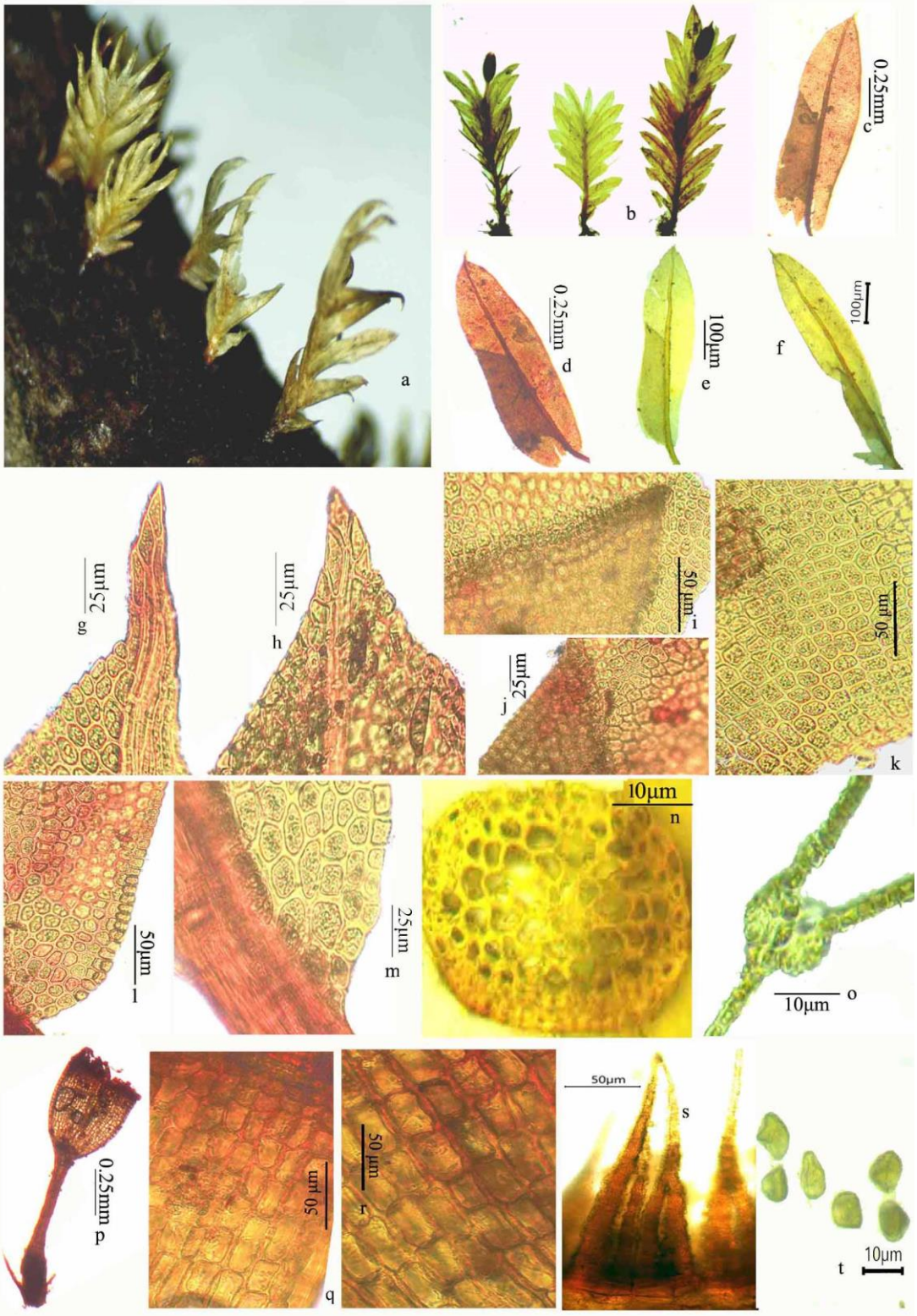


Plate 83. *Fissidens longtonianus Z.* Iwats. & Tad. Suzuki, a. habit, b. single plants, c,d&e. vegetative leaves, f. perichaetial leaf, g&h. leaf apex, i&j vaginant laminae apex, k. vaginant laminae base, l&m. dorsal lamina base, n. stem T.S., o. leaf T.S., p. sporophyte, q&r. exothecial cells, s. peristome, t. spores.

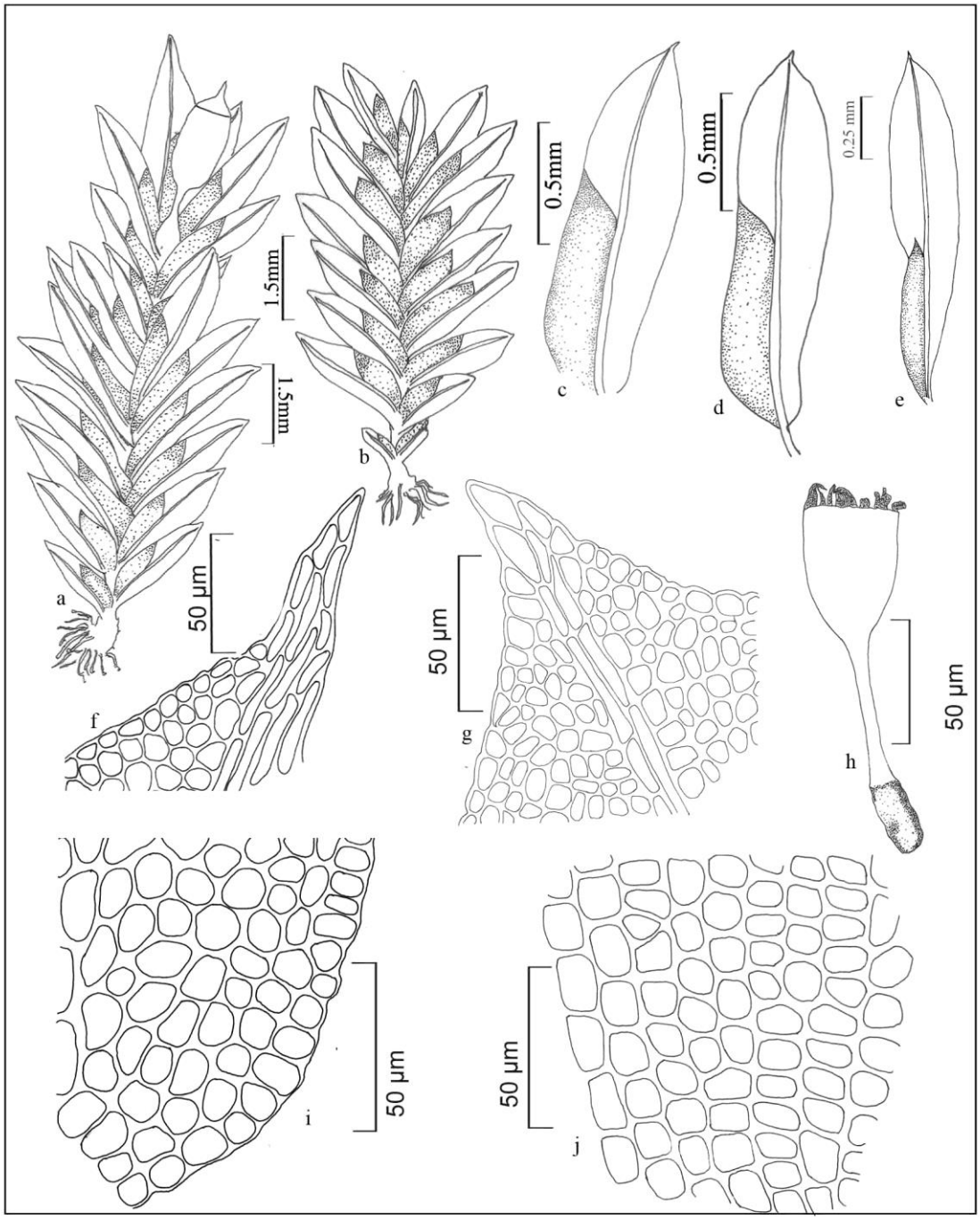


Fig. 41. *Fissidens longtonianus Z.* Iwats. & Tad. Suzuki, a. sporophytic plant, b. vegetative plant, c&d. vegetative leaves, e. perichaetial leaf, f&g. leaf apex, h. leaf basal cells

papillose peristome teeth and large spores. *F. longtonianus* is similar to *F. macrosporus* Dixon in its epiphytic habitat with short sporophyte, apiculate leaf apex and perfoliated peristome teeth, but differs in oblong leaves, papillose laminal cells and very short setae of later. *F. longtonianus* is endemic to Kerala.

Note: Iwatzuki and Suzuki (2005) reported this species as new to science based on the collection by Rajeevan (1990) from Idukki district. This was reported as *F. choprai* B. Rajeevan *sp.nov*. by Rajeevan in his Ph.D. thesis and Iwatzuki and Suzuki (2005) later renamed and described the same as new species *viz*., *F. longtonianus*.

Habitat and General Ecology: On twigs of large trees in evergreen forests and shrubs in semi evergreen forest along with crustose lichen in evergreen forest.

Distribution: Endemic to Kerala. India; Kerala, Idukki district (Iwatsuki & Suzuki, 2005; Kozhikode district (Present collection) (Map 46A&46B).

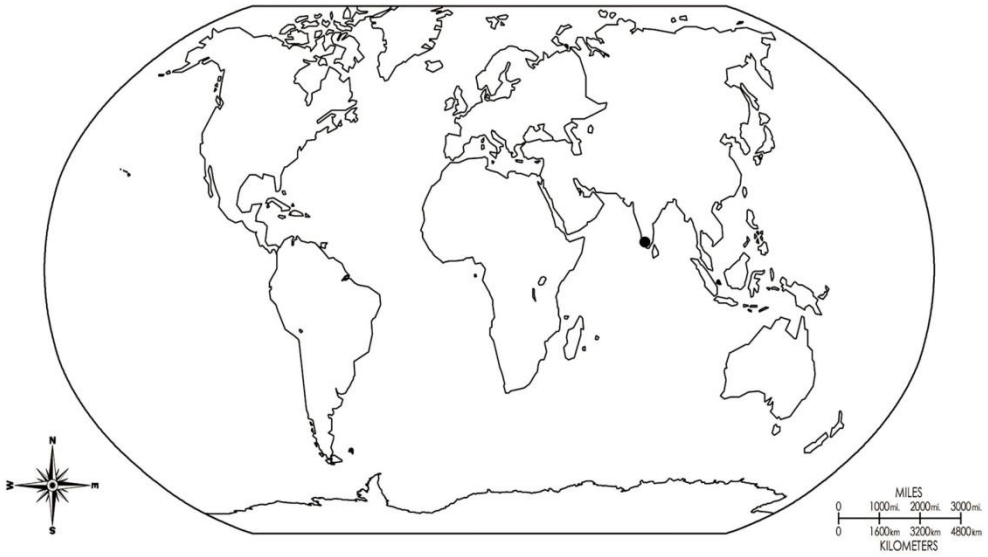
Specimens examined: India, Kerala, Kozhikode district (Malabar WLS, Kakkayam, 720m), 14.11.2014, Manjula (ZGC 3902); Idukki, near Kulamavu (550m) 23.12.1983, B. Rajeevan (MH 80208) (MH!).

Etymology: This species is named in honour of Dr Royce E. Longton.

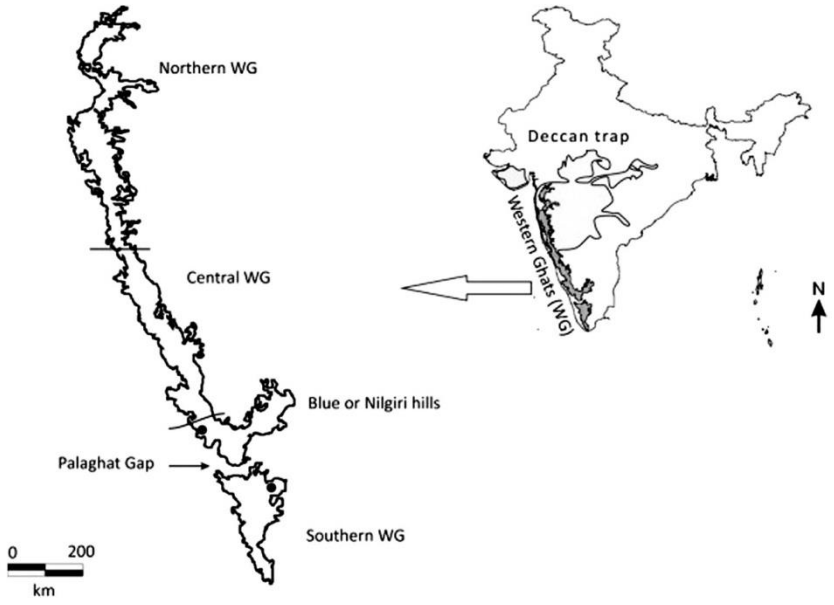
Fissidens macrosporus Dixon, J. Indian Bot.2: 180. 1921; Schwarz, Arch. Bryol. 181: 25. 2013; Manjula *et al.*, Lindbergia 38: 1. 2015a.

Type: India, Karnataka; Gairsoppa falls, Kanara district, coll. L.J. Sedgwick (6463) (BM!)

Epiphytic plants with light greenish to dark greenish; stem brownish green with central strand of ± 6 cells, with two or three tiers of thin walled large (15.00-22.50 µm) inner and 1-3 tiers of small thick walled (10-15µm) outer cortical cells, vegetative stem 4-7 (without branch) x 1.50-2.00 mm (including leaves), 11-17 pairs of slightly overlapping closely arranged leaves; rhizoids brown, smooth; axillary hyaline nodules absent; leaves oblong with apiculate apex, margin crenulate, 1.00-1.50 x 0.42-0.50 mm, 2 times long as wide, leaf apices curls when dry; elimbate; vaginant laminae slightly open to closed, reaching more than half the length of apical lamina, 0.19-0.30 mm wide, unistratose; dorsal lamina tapering



Map 46A. World distribution of *Fissidens longtonianus* *Z. Iwats. & Tad.Suzuki*



Map 46B. Distribution of *Fissidens longtonianus* *Z. Iwats. & Tad.Suzuki in Western Ghats*

towards the insertion at base, 2-4 cell wide, not decurrent, dorsal lamina and apical lamina unistratose; costa prominent, dark yellowish, bryoides type, ending 2 or 3 cells below the leaf apex; laminal cells irregularly hexagonal, unipapillose, apical cells 12.50-17.50 x 5.00 µm; mid dorsal laminal cells plane to slightly convex, 10.71-14.30 x 10-11µm; mid vaginant laminal cells 11.00-14.32 x 11.90-12.30 µm; basal cells 12.50-25.00 x 7.50 µm; gemmae not found.

Fertile parts; perigonia not found; perichaetia terminal on main stems and also on proliferated branches, one or two sporophyte present on same branch, perichaetial leaf base broad with 0.52-0.55 mm; sporophyte 1.40-1.50 mm long, dark brown; setae very short, 0.09-0.17 mm long, not smooth, capsule erect, 0.80-1.10 mm long; exothecial cells 28-30 files of quadrate or rectangular cells with more thickened vertical walls; peristome teeth 16, brownish-orange, 61-78.10 µm long, which is bifid above, but irregularly divided (2 or 3) and perforated, 27.50-47.64 µm wide at base; calyptra rostrate, 0.37-0.42 mm long, not smooth, spores large sub-globose to ellipsoid 22.50-35.00 µm. (Plate 82g, 84 & Fig.42).

Diagnostic characters: *Fissidens macrosporus* Dixon is characterised by bryoides type costa, elimbate and oblong leaves, axillary hyaline nodules lacking, unipapillose laminal cells, sporophyte with very short, almost lacking seta, immersed to emergent capsules, 28-30 columns of exothecial cells and large spores. Peristome, sporophyte and habitat resemble those of *F. longtonianus* Z. Iwats. & Tad. Suzuki which can be distinguished by its smooth laminal cells, broadly lanceolate leaves and slightly longer setae.

Note: Manjula *et al.* (2015a) reported this species as a rediscovery after more than 90 years which supposed to be disappeared from Western Ghats.

Habitat and General Ecology: Epiphytic on branches and twigs along with *Syrrhopodon parasiticus* (Brid.) Besch. in evergreen forest.

Distribution: It is an endemic species to South India and distributed in Kerala and Karnataka (Dixon, 1921; Schwarz, 2013; Manjula *et al.,* 2015a). The present collection is a new record to Kerala. (Map 47A&47B).

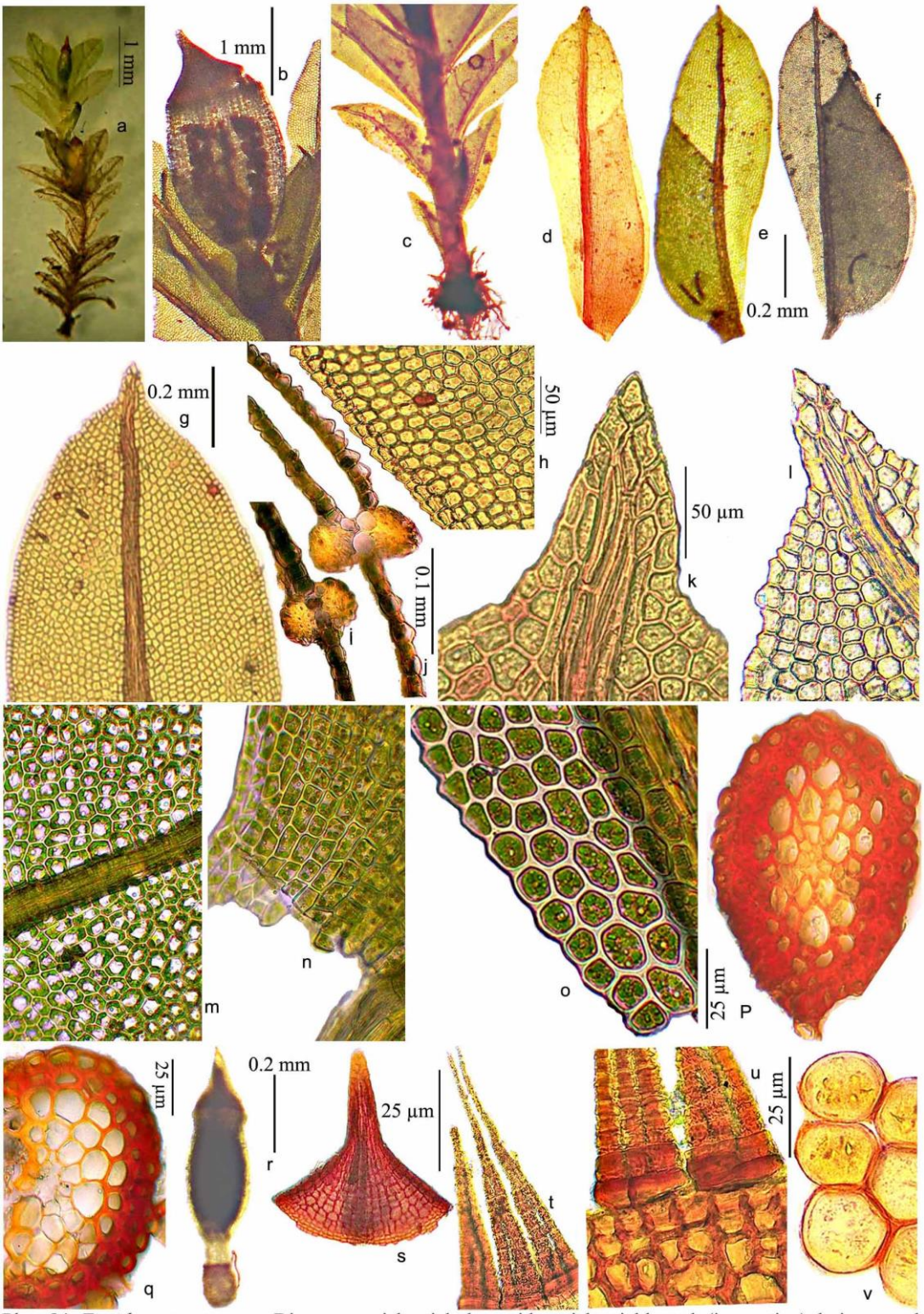


Plate 84. *Fissidens macrosporus* Dixon, a. perichaetial plant with perichaetial branch (innovation), b. immersed sporophyte, c. basal part of plant, d. vegetative leaf, e&f. perichaetial leaves, g,k&l. leaf apex, h. middle marginal cells, i. leaf T.S. above vaginant laminae, j. Leaf T.S., m. mid laminal cells, n. vaginant laminae base, o. dorsal lamina near insertion, p&q. stem T.S., r. sporophyte, s. operculum, t. peristome teeth, u. capsule mouth and upper exothecial cells, v. spores.

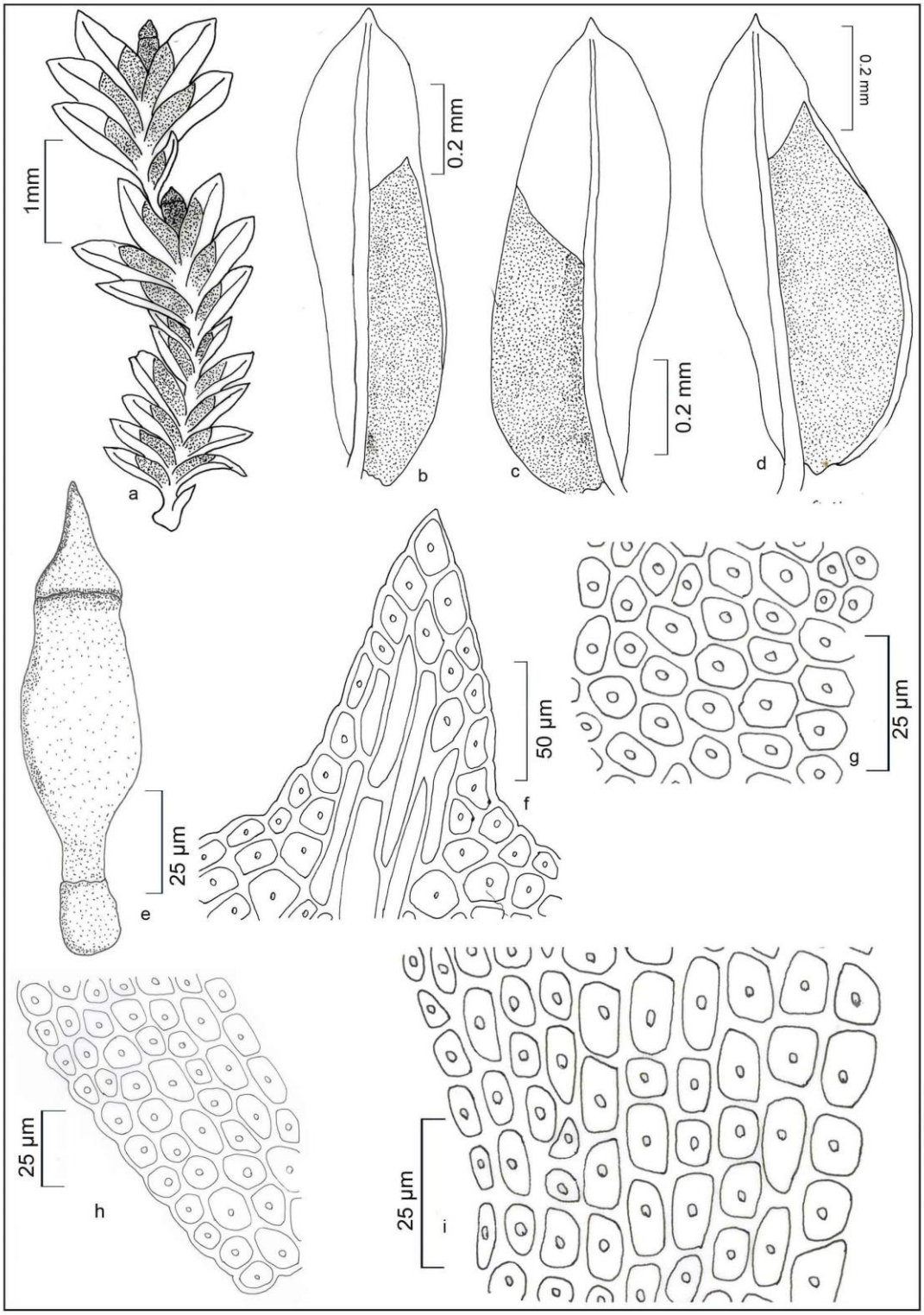
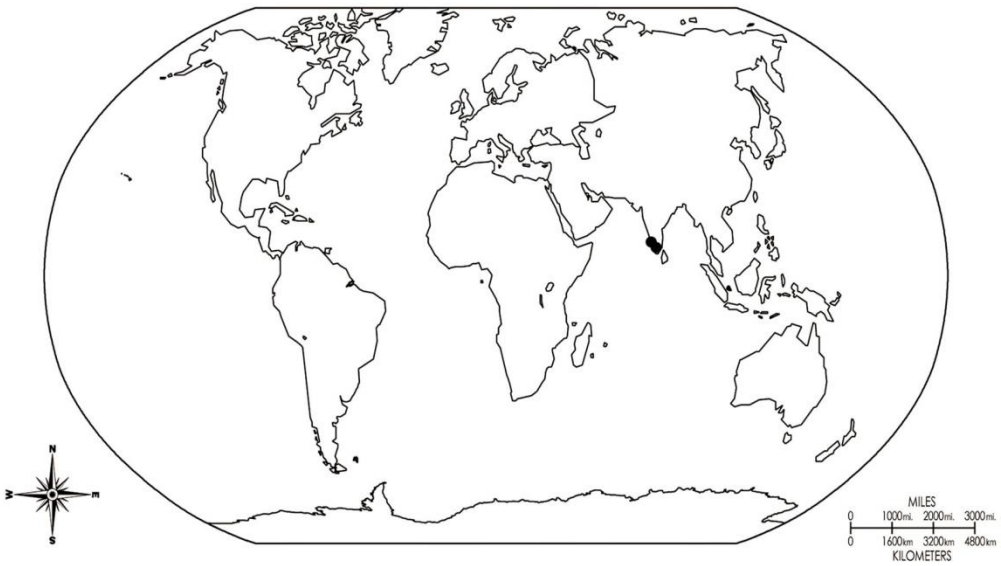
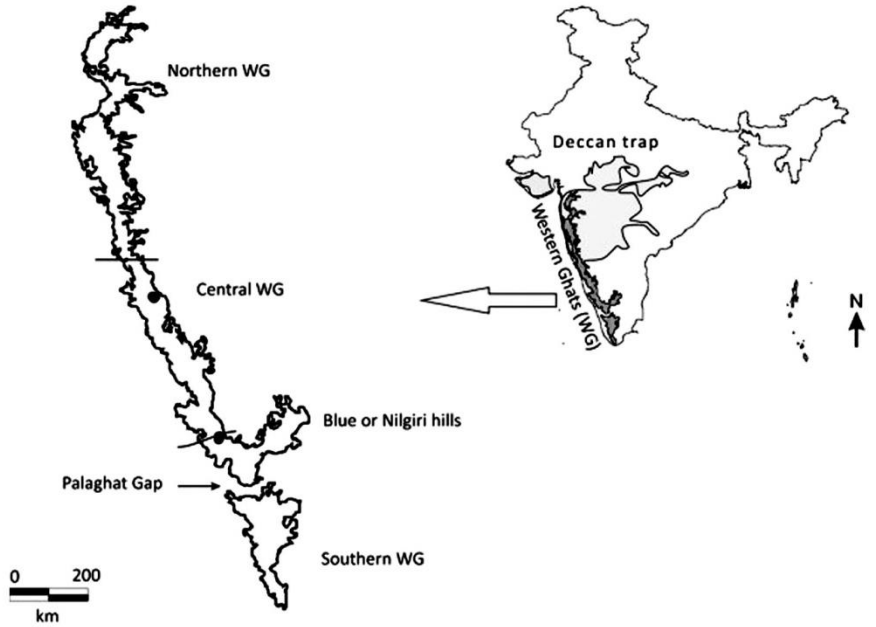


Fig. 42. *Fissidens macrosporus* Dixon, a. fertile plant, b&c. vegetative leaves, d. perichaetial leaf, e. sporophyte, f. leaf apex, g. laminal cells, h. dorsal lamina base near insertion, i. vaginant laminae base.



Map 47A. World distribution of *Fissidens macrosporus* Dixon



Map 47B. Distribution of *Fissidens macrosporus* Dixon in Western Ghats

Specimens examined: India, Kerala, Wayanad district (Kuruva dweep, $11^{0}82'184''$ N, $76^{0}08'792''$ E, 900-950m), 25.09.2013, Manjula (ZGC 861A, ZGC 862A, ZGC 865A); Karnataka, North Canara district (Gairsoppa Fall), 1919 October, L. Sedgwick (6463) (BM!).

Etymology: The specific epithet *macrosporus* refers to the comparatively large spores of this species.

Fissidens macrosporoides Dixon & P. de la Varde, Ann. Cryptog. Exot., 3(4): 169, 1. f. 3. 1930; Chaudhary *et al.*, Bryo. Flora Gujarat 77. 2006; Daniels & Kariyappa, Curr. Sci. 93(7): 980. 2007.

Type: India,Bombay, Vikhrol, Charles Mc cann (46)

Plants in loose tufts, unbranched, rhizoids basal, smooth; stem axillary hyaline nodules absent; 1.5-2.5 x 0.8-1.0 mm, 6-10 pairs of leaves, 0.6-0.8 x 0.2 mm, leaves oblong lingulate, leaf apex acute to mucronate, margin serrulate; limbidium completely absent; costa strong, ending 3-5 cells below apex, vaginant laminae reaching half of leaf length, open, minor lamina unequal, base broad, unistratose; dorsal lamina base round, not decurrent, slight dipression near leaf insertion, dorsal lamina and apical lamina unistratose; laminal cells irregularly quadrate to hexagonal, pluripapillose; gemmae not found (Plate 85 & Fig.43).

Fertile parts not found.

Diagnostic characters: This species is characterised by oblong lingulate leaves with acute to mucronate leaf apex, serrulate leaf margin and pluripapillose laminal cells. The pluripapillose laminal cells and costa length are similar to *F. pallidinervis* Mitt. but differs in leaf shape and epiphytic habitat of *F. pallidinervis.*

Habitat and General Ecology: On land cuttings in evergreen forest and plantations.

Distribution: It is an endemic species to India distributed in Gujarat (Not from Western Ghat part), Karnataka, Maharashtra, Tamil Nadu) (Chaudhary *et al*., 2008; Daniels & Kariyappa 2007; Lal, 2005; Frahm *et al.,* 2013*;* Schwarz & Frahm, 2013; Magdum *et al*., 2017) (Map 48A&48B).

Specimens examined: India, A.H. Norkett (10697) (BM!).

Etymology: The specific epithet is based on large size of the spores.

Plate 85. *Fissidens macrosporoides* Dixon & P. de la Varde, a. habit, b&c. vegetative plants, d-f. vegetative leaves, g-i. leaf apex, j&k. vaginant laminae apex, l-o. leaf base near insertion (photos from Norkett 10697 BM!).

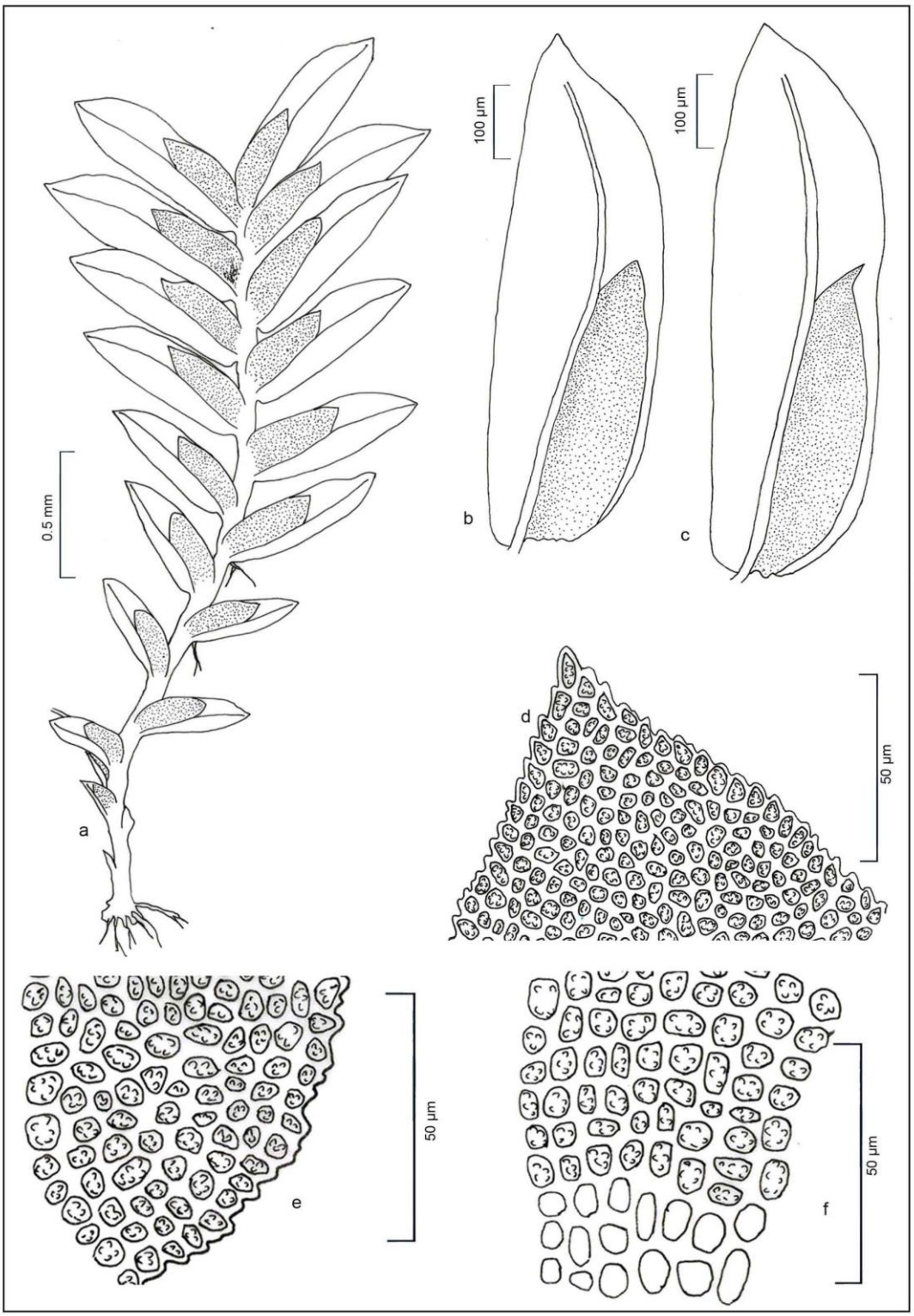
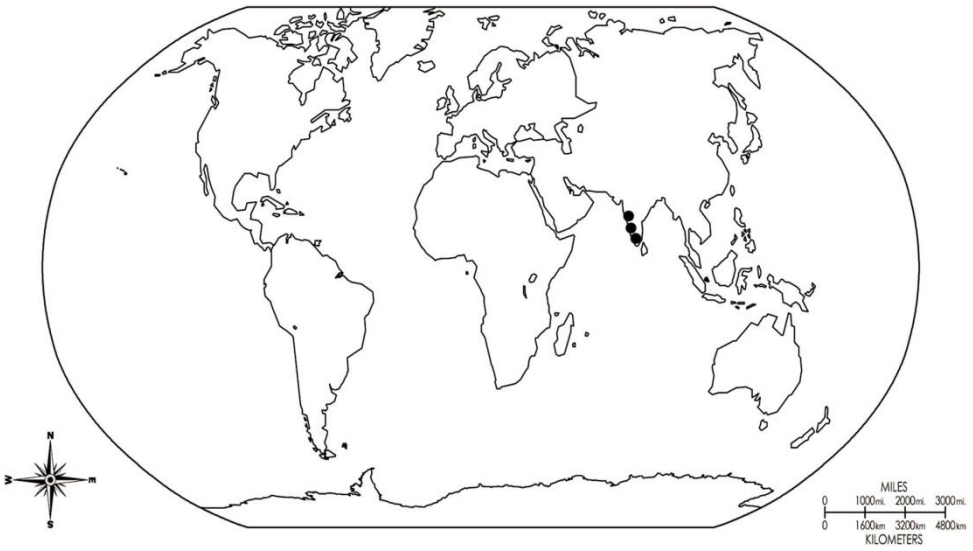
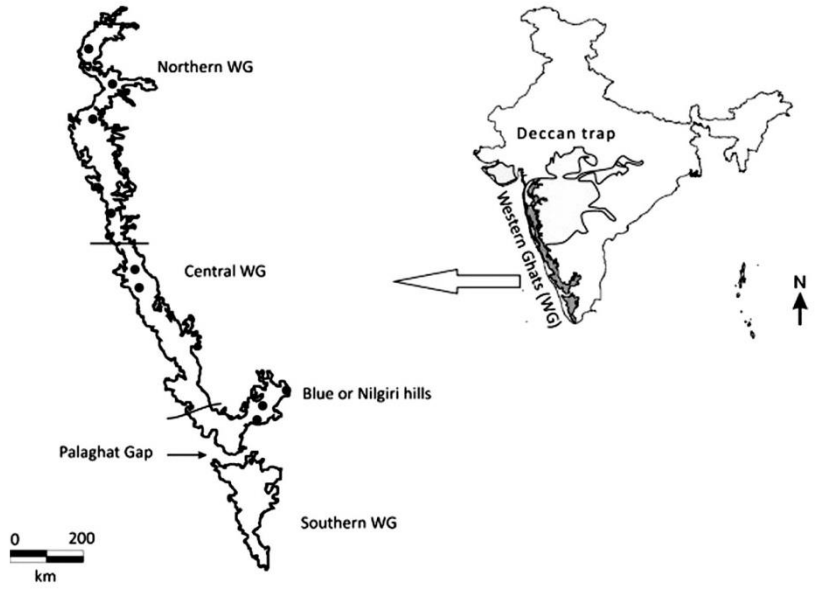


Fig. 43. *Fissidens macrosporoides* Dixon & P. de la Varde, a. vegetative plant, b&c. vegetative leaves, d. leaf apex, e. dorsal lamina base near insertion, f. vaginant laminae base.



Map 48A. World distribution of ***Fissidens macrosporoides*** *Dixon & P.de la Varde*



Map 48B. Distribution of ***Fissidens macrosporoides*** *Dixon & P.de la Varde in Western Ghats*

Fissidens manilalia Manjula, Manju & K.P. Rajesh, Bryologist 120 (3): 263-269. 2017.

Type: India, Kerala, Kozhikode District, Meenchanda, *Manjula K.M.& Chandini15995.* (CAL!, CALI!)

Plants small on bark of avenue trees, 1.40-1.71 x 0.74-1.11 mm, unbranched, stem light green in fresh, reddish orange in herbarium, algal association noticed, 5-7 pairs of leaves crowded towards tip; axillary hyaline nodules absent; rhizoids simple, smooth, reddish; stem weakly differentiated, cortical cells one or two rowed, reddish, moderately thick walled, 11.14-13.98 x 5.25-9.89 µm, medullary cells thin walled, large 16.38-28.66 x 9.75-23.83 µm; leaves small, broadly lanceolate to lingulate, curls in herbarium, very delicate and pale green, 0.52-0.69 x 0.22-0.27 mm, margin crenulate or wavy, apex broadly acute; limbidium absent; vaginant laminae open and unequal, about half of leaf-length, 0.30-0.45 mm, margin not entire, uniseriate; dorsal lamina base round, 13.30-19.97 x 4.50-5.97 µm, dorsal lamina and apical lamina uniseriate; costa light green, reaching far below apex, slightly bifurcating at apex, 0.613-0.754 mm long; laminal cells irregularly rectangular or irregularly polygonal, compactly arranged with wavy and moderately thickened cell wall, cells smooth, marginal cells triangular, tip cell 15.0-17.5 x 12.0-13.0 µm, apical laminal cells 16.78-27.92 x 14.22-16.11 µm, cells near costa larger, 24.69-40.82 x 9.84-15.18 µm; mid vaginant laminal cells plane to slightly convex, 5.98-17.31 µm; mid dorsal laminal cells almost plane, 15.31-25.32 x 15.64-17.76 µm; highly branched gemmae present from leaf axils.

Fertile parts, perigonia not found; perichaetial plants similar to vegetative plants, 3.98-4.25 x 0.98-1.45 mm, perichaetial leaf slightly elongated, 0.88-0.96 x 0.22-0.27 mm, sporophyte terminal, single from perichaetium rarely two, seta yellowish orange, capsule inclined or straight, 0.88-1.00 x 0.32-0.35 mm, 36-38 files of exothecial cells, archegonium brownish, 0.23-0.25 mm, calyptra not found,

operculum conic, Peristome scariosus type, 31.43-34.09 µm wide at base, spores elliptic to rounded, 17.41-18.92 µm (Plate 86 & Fig.44).

Diagnostic characters: *F. manilalia* Manjula, Manju & K.P. Rajesh is characterised by small epiphytic plants with 5-7 pairs of leaves, weakly differentiated central strand, axillary hyaline nodules not differentiated, leaves broadly lanceolate to lingulate, costa ending below apex with slightly bifurcating tip, smooth cells with moderately thickened cell walls, scariosus type peristome and 36-38 files of exothecial cells.

Note: This species resembles with *F. flabellulus* Thwaites & Mitt. in plant size, more or less distinctly serrate leaf margin, vaginant laminae of 1/2 to 1/3 of leaf length, quadrate-hexagonal laminal cells, but linear lanceolate leaves, stout and percurrent costa, mamillose to smooth laminal cells, more or less differentiated axillary hyaline nodule of *F. flabellulus* Thwaites & Mitt. along with its terricolous habitat, it differs from former.

Habitat and General Ecology: On bark of avenue trees such as *Albizia saman* (Jacq.) F. Muelll. and *Terminalia kadamba* L. in highly disturbed human settlement area. *Fissidens manilalia* grows along with *F. pallidinervis* Mitt., *Calymperes erosum* Möll. Hal., and *Cyathodium cavernarum* Kunze.

Distribution: Endemic to Kerala (Manjula *et al.*, 2017) (Map 49A&49B).

Specimens examined: India, Kerala, Kozhikode District (Meenchanda, 20m), 24.08.2011, Manju (ZGC 6387A, ZGC 16161); 27.07.2016, Manjula & Chandini (ZGC 15995, ZGC 15996), 04.10.2015, Deepa (ZGC 16051), 29.06.2016, Manjula & Deepa (ZGC 16082A, ZGC 16083A, ZGC 16084A).

Etymology: The specific epithet *manilalia* honours Indian botanist Prof. K.S. Manilal, who translated the pronounced work '*Hortus Malabaricus'* into English and Malayalam.

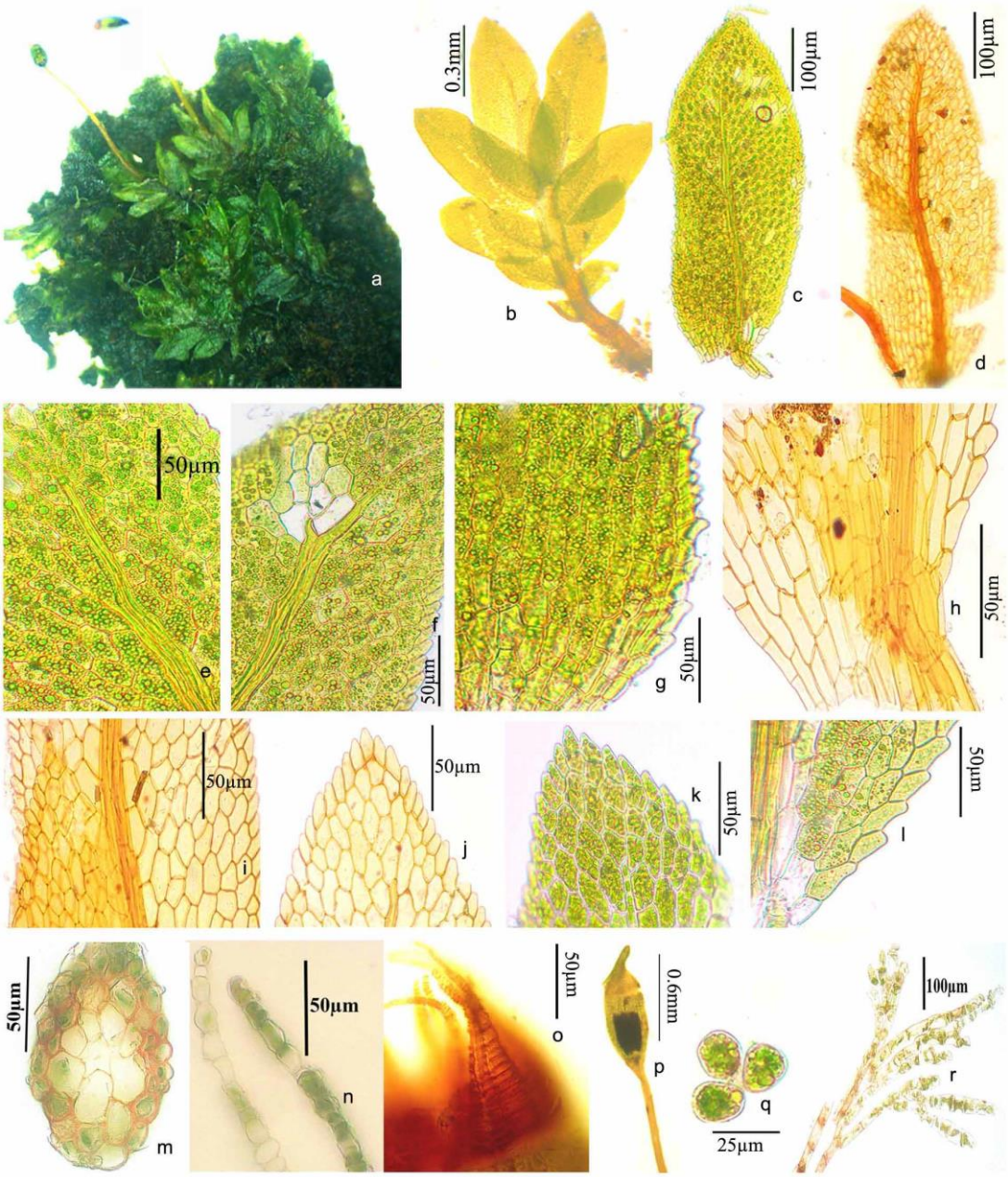


Plate 86. *Fissidens manilalia* Manjula, Manju & K.P. Rajesh, a. habit, b. vegitative plant, c&d vegetative leaves, e&f. laminal cells with costa, g. vaginant laminae base, h. leaf base, i. vaginant laminae apex, j&k. leaf apex, l.dorsal lamina base near insertion, m. stem T.S., n. vaginant laminae margin in trans-section, o. peristome, p. sporophyte, q. spores, r. gemmae (a-r from holotype (ZGC 15995)).

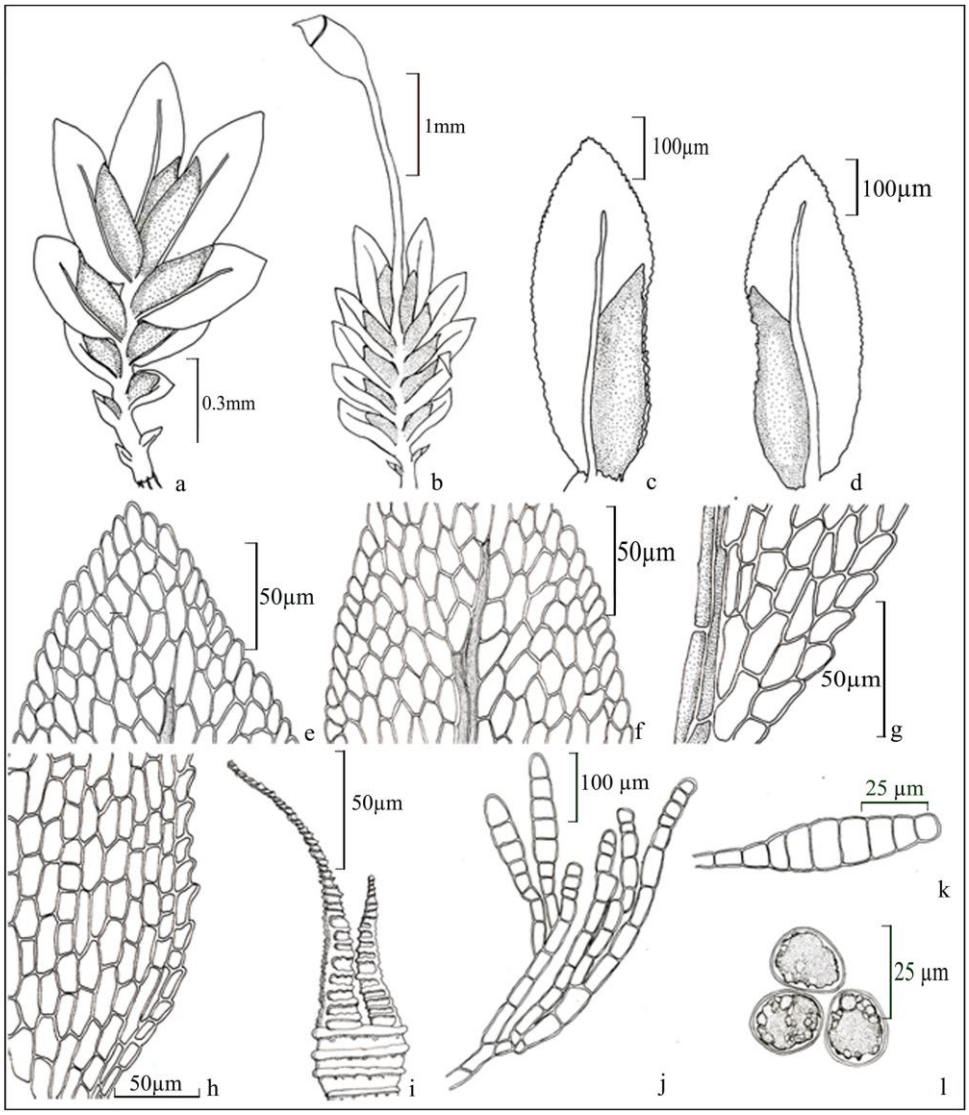
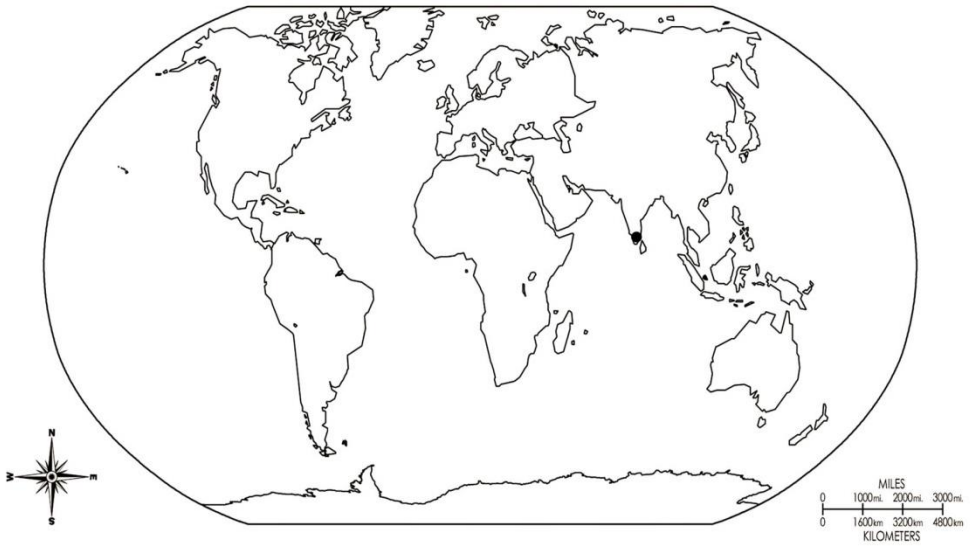
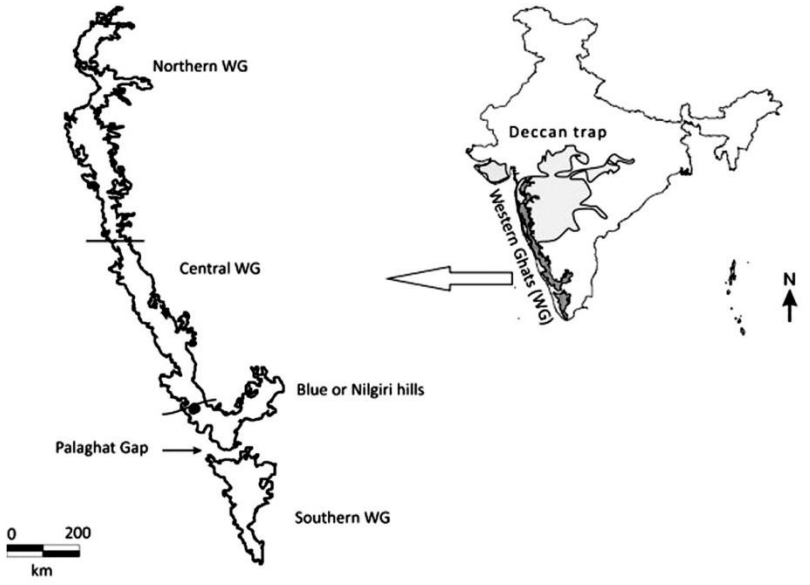


Fig. 44. *Fissidens manilalia* Manjula, Manju & K.P. Rajesh. a. vegetative plant, b. fertile plant with sporophyte, c,d. vegetative leaves, e. leaf apex, f. distal part of costa, g. dorsal lamina near insertion, h. basal part of vaginant lamina, i. peristome tooth, j. gemmae on branched axillary rhizoids, k. single gemma, l. spores.



Map 49A. World distribution of ***Fissidens manilalia*** *Manjula, Manju et. K.P.Rajesh*



Map 49B. Distribution of ***Fissidens manilalia*** *Manjula, Manju et. K.P.Rajesh in Western Ghats*

Fissidens neomagofukui Z. Iwats. & Tad. Suzuki, J. Hattori Bot. Lab. 92: 165. 2002.

Type: Japan, Honshu, Mie-ken, Iinan-gun, Iidaka-cho, Miyamae, Hanaoka Shrine, *ca*. 180 m, on trunk of *Ginkgo*, July 18, 1975, *T. Magohuku* 16240 (NICH).

Plants greenish, 3–5 mm long, stems erect, central strand absent, brownish-orange below; outer cortex 1 or 2 layered, thick-walled, medullary cells thin-walled; leaves complanate, 4-8 pairs, 0.6–0.8 x 0.28–0.32 mm, ovate-lanceolate, margin entire, broadly acute at apex; weak limbidium of 1 or 2 rows of pale-brown cells onvaginant laminae of sterile leaves, extending 1/2 to almost its full length; costa ending below apex, with 3 guide cells in cross section; vaginant laminae subequal, closed, 1/2 to more than 1/2 as long as leaves; dorsal lamina narrowing down and ending at costa base near leaf insertion; vaginant laminae cells with more or less bulging walls, apical laminal cells 5–10 x 4–8 µm, quadrate-hexagonal; median cells 6–10 x 5–8 µm, quadrate-hexagonal; basal cells 8–16 x 6–10 µm, quadrate to rectangular,

Fertile plants 1.8–3 mm long, perichaetial leaves oblong-lingulate, 1.12–1.10 x 0.38–0.40 mm, with a weak limbidium on vaginant laminae; sporophytes apical, setae 2–2.5 mm long, smooth, orange-brown, capsules ovoid-cylindric, brown, peristome teeth, 40–45 x 15–18 µm, anomalous, short, undivided and obtuse or irregularly divided, highly papillose, orange-red, spores 24–28 mm, globose, papillose, pale brown (Plate 87 & Fig.45).

Diagnostic characters: *F. neomagofukui* is characterised by its vaginant laminae of upper leaves of perichaetial plants with weak limbidium, peristome teeth anomalous, short, 0.7–1.0 mm high, irregularly divided or not, distally highly papillose and spores 24–28 mm in diameter. Vegetative plants of *F. neomagofukui* hardly differ from those of *F. diversifolius* Mitt., but the fertile characters differ from *F. diversifolius*, like vaginant laminae of upper leaves of perichaetial plants with distinct limbidium, peristome teeth bryoides type, 1.8–2.1 mm, spirally thickened

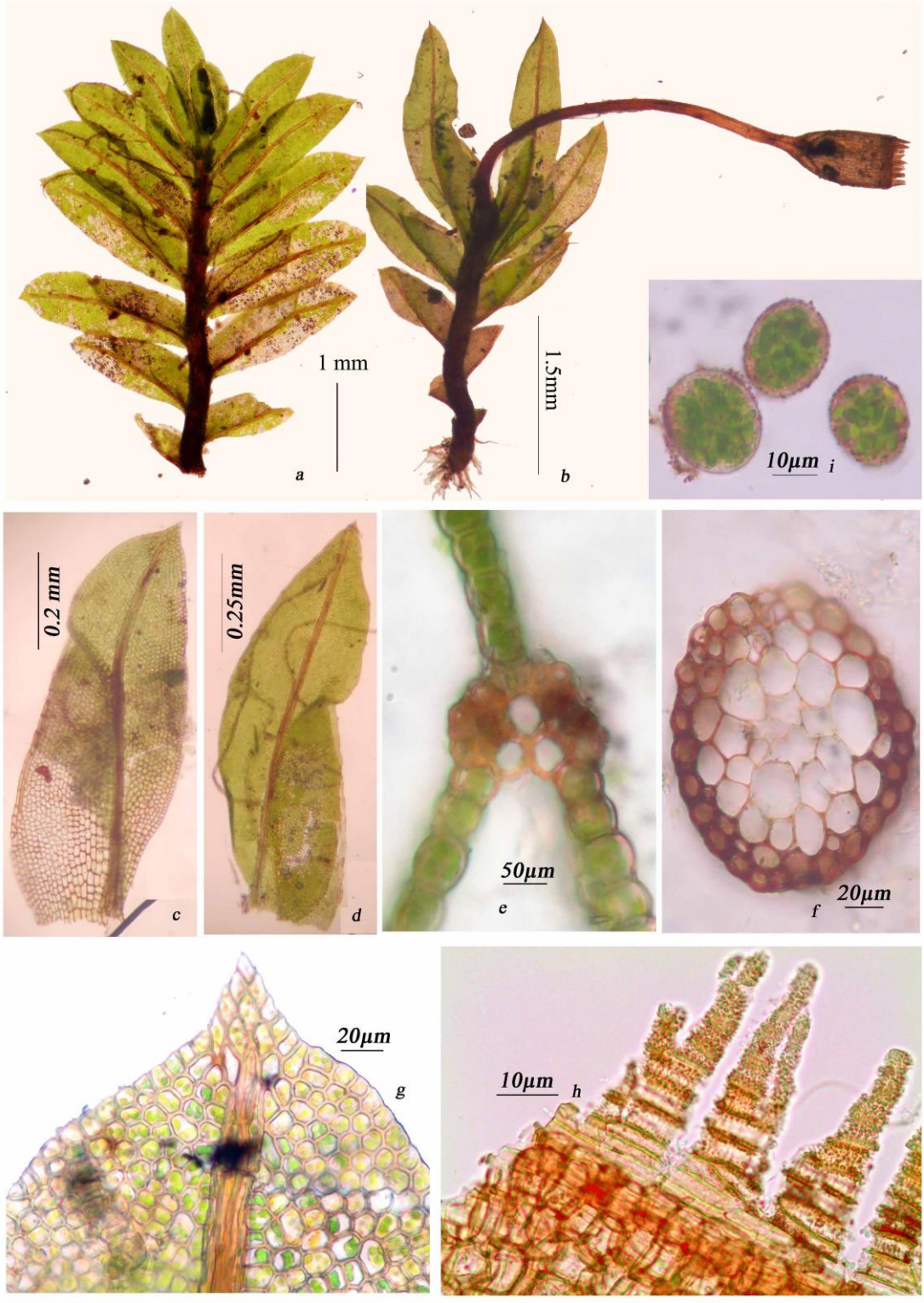


Plate 87. *Fissidens neomagofukui* Z. Iwats. & Tad. Suzuki, a. vegetative plant, b. sporophytic plant, c.leaf, d. perichaetial leaf, e.cross section of leaf. f. cross section of stem, g. leaf apex, h. peristome teeth, i. spore (Photo courtesy to Dr. Dulip Daniels, photo from Daniels and Kariyappa 9789).

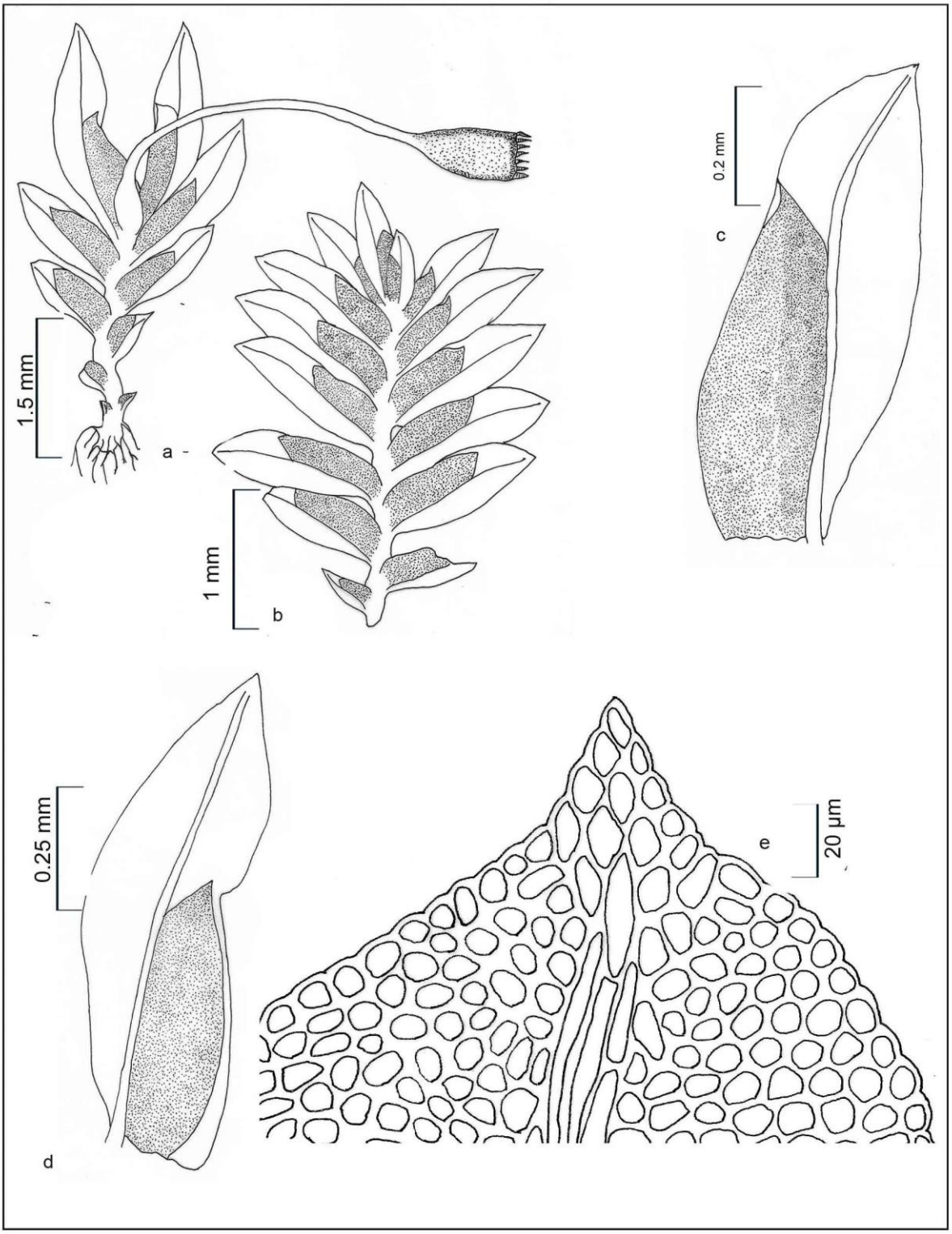


Fig. 45. *Fissidens neomagofukui* Z. Iwats. & Tad. Suzuki. a. fertile plant with sporophyte, b. vegetative plant, c&d. vegetative leaves, e. leaf apex.

distally, not papillose and spores smaller, 18–22 mm in diameter Sporophytes of these two species, on the other hand, are easily distinguished by their peristomes.

Habitat and General Ecology: Corticolous, the species collected from Japan is on the bark of *Ginkgo biloba* L. and the species collected from India is on the bark *Terminalia paniculata* Roth., in the moist deciduous forest at an altitude of 180–820 m.

Distribution: Japan and India (Western Ghats of Tamil Nadu (Coimbatore) (Daniels et al., 2017; Iwatsuki & Suzuki, 2002) (Map 50A&50B).

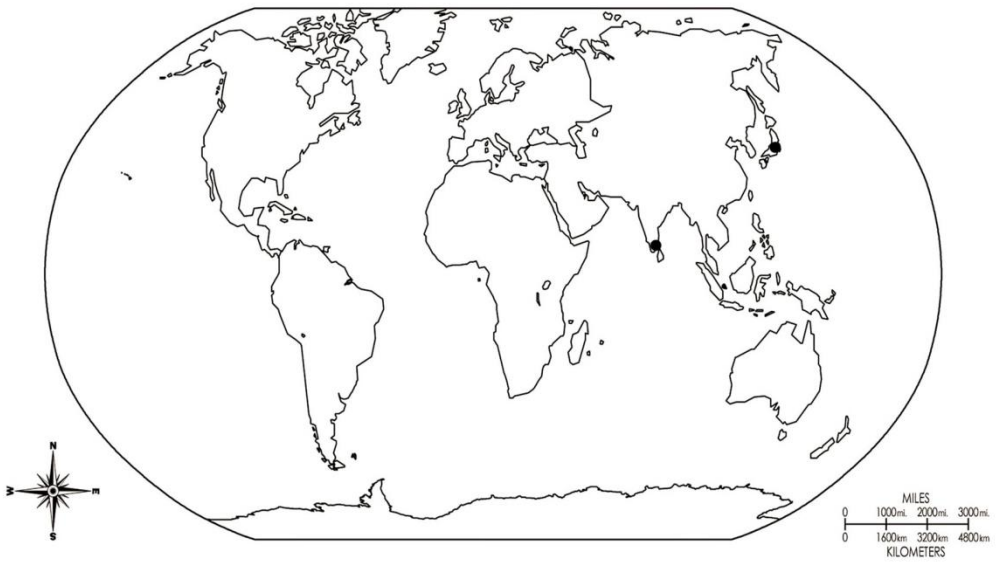
Specimen examined: Western Ghats: Tamil Nadu, Coimbatore District, Anamalais, Valparai, Topslip, on the way to Ambuli, *ca* 820 m, 25.9.2014, A.E.D. Daniels & K.C. Kariyappa 9789 p.p. (SCCN).

Etymology: The specific epithet *neomagofukui* is in honour of 'T. Magohuku' who collected the type specimen of this species from Japan.

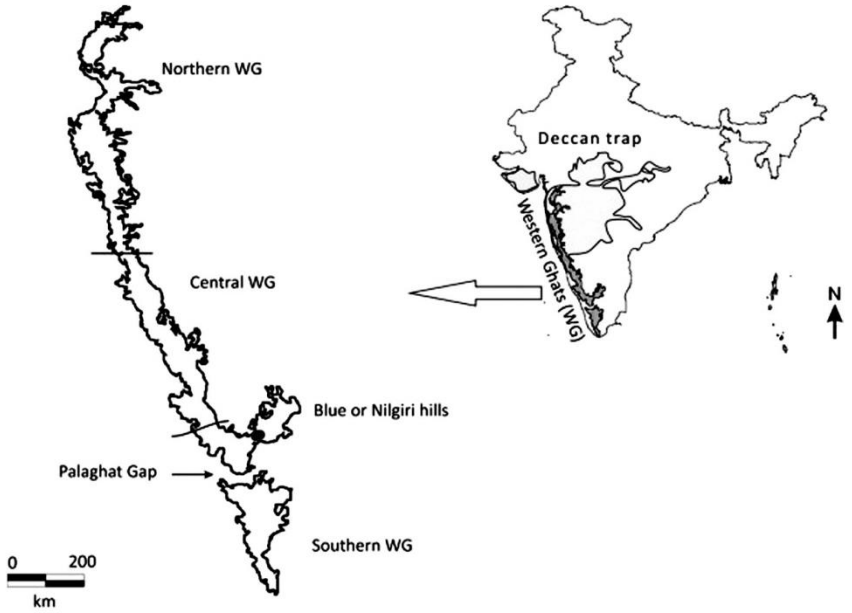
Fissidens orishae Gangulee, Nova Hedwigia, 8; 140. 1964; Gangulee, Moss. E. India & Adj. 1: 499. 1971; Lal, Checklist Indian Moss. 62. 2005; Daniels & Daniel, Bryof. South. W. Ghats, 47. 2013; Manju *et al*., Tropical Bryol. Res. Rep. 7: 12. 2008b.

Type: India, Orissa, (Eastern Ghats), Ganjam, Gangulee 3727 (CAL!).

Plants growing in loose tough, yellowish green; axillary hyaline nodules not differentiated; rhizoids smooth, brownish; stem 1.5 - 3 x 1.2 - 1.6 mm, 6 - 9 pairs of leaves; leaves oblong lingulate, 1.2 – 1.5 x 0.3 – 0.4 mm, 4 times long as wide, apex broadly acute, margin subentire; limbidium very short, incomplete one or two rows of elongated cells at vaginant laminae base, uniseriate; dorsal lamina narrowing down and joints to the costa at base, dorsal lamina and apical lamina uniseriate; costa strong, percurrent or ending 3 or 4 cells below apex, bryoides type; laminal



Map 50A. World distribution of ***Fissidens neomagofukui*** *Z. Iwats. & Tad. Suzuki*



Map 50B. Distribution of ***Fissidens neomagofukui*** *Z. Iwats. & Tad. Suzuki in Western Ghats*

cells mamillose, rounded quadrate to hexagonal, 7.0 – 8.5 µm in diameter; gemmae not observed (Plate 88 & Fig.46).

Fertile parts not observed.

Diagnostic characters: *F. orishae* is well characterised by 6-9 pairs of leaves, subentire leaves, very short and incomplete limbidium, mamillose and rounded quadrate to hexagonal laminal cells. This species is allied to *F. kurzii* in leaf shape and costa percurrent or ending below apex but differs in the pluripapillose laminal cells and absence of limbidium on vegetative leaves of *F. kurzii*.

Note: Gangulee (1971) reported this species as endemic to Northern India. Daniels and Daniel (2013) reported this species from Tamil Nadu as a new record to Western Ghats.

Habitat and General Ecology: On bark of large trees in evergreen and moist deciduous forests.

Distribution: This is an endemic species to India and reported from Orissa, West Bengal and Kerala (present collection) (Gangulee, 1971) (Map 51A&51B).

Specimens examined: India, Kerala, Wayanad district (Kuruva dweep, $11^{0}82'184''$ N, $76^{0}08'792''$ E, 900m), 25.09.2013, Manjula (ZGC 860A); Idukki district (Anamudi Shola NP, 1900m), 06.02.2008, Sreenivasan 106603a (CALI); Orissa, (Eastern Ghats), Ganjam, Gangulee 3727 (CAL!), Midnapore, (5 miles from Midnapore), 03.11.1958, Anon. (3123 V) (CAL!),

Etymology: The specific epithet *orishae* derived from the name of its type locality 'Orissa' in India.

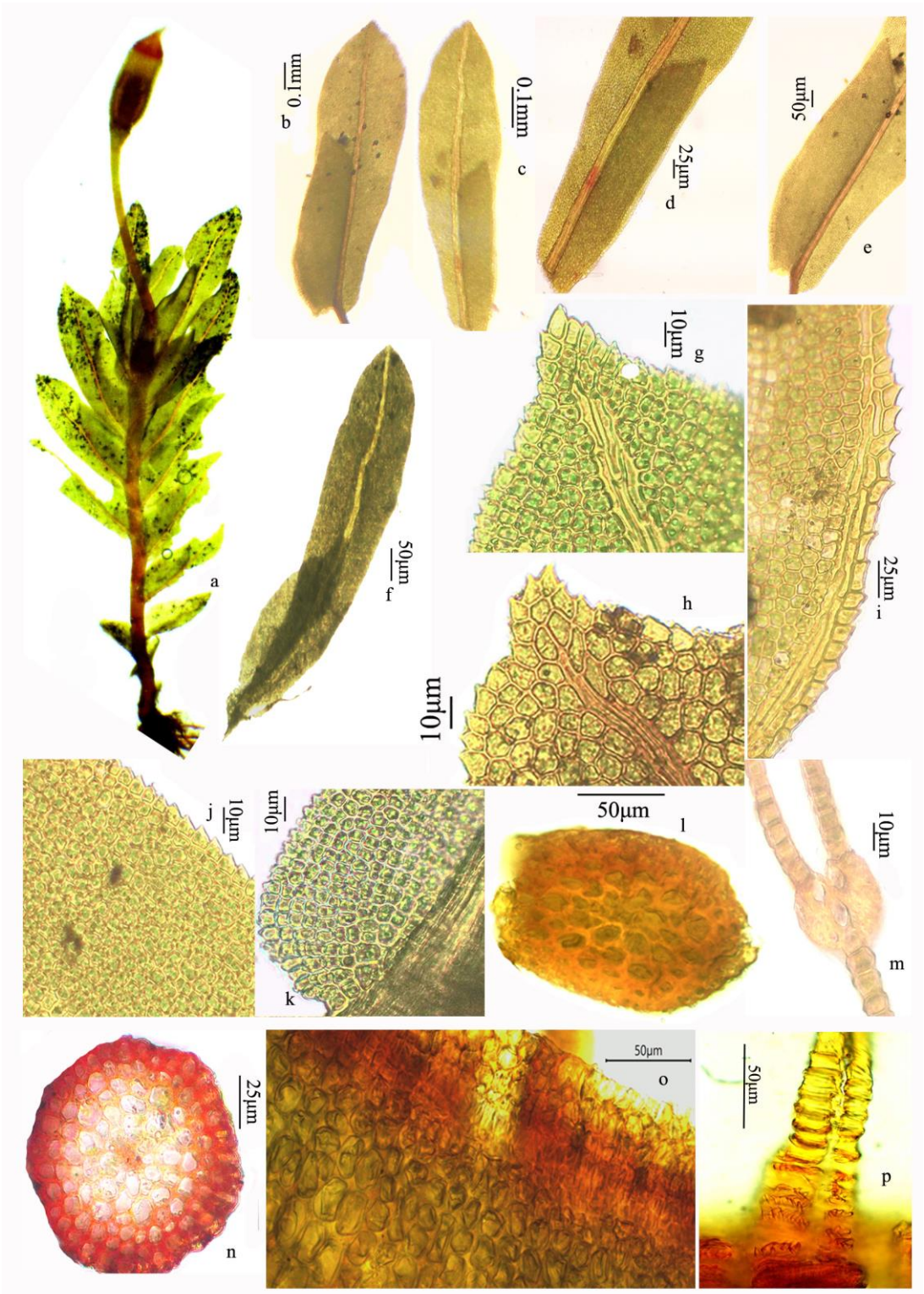


Plate 88. *Fissidens orishae* Gangulee, a. single plant, b&c. vegetative leaf, d&e. vaginant laminae, f. perichaetial leaf, g&h. leaf apex, i. vaginant laminae margin, j. dorsal lamina margin, k. base of dorsal lamina, l. stem T.S., m. leaf T.S., n. seta T.S., o. exothecial cells, p. peristome.

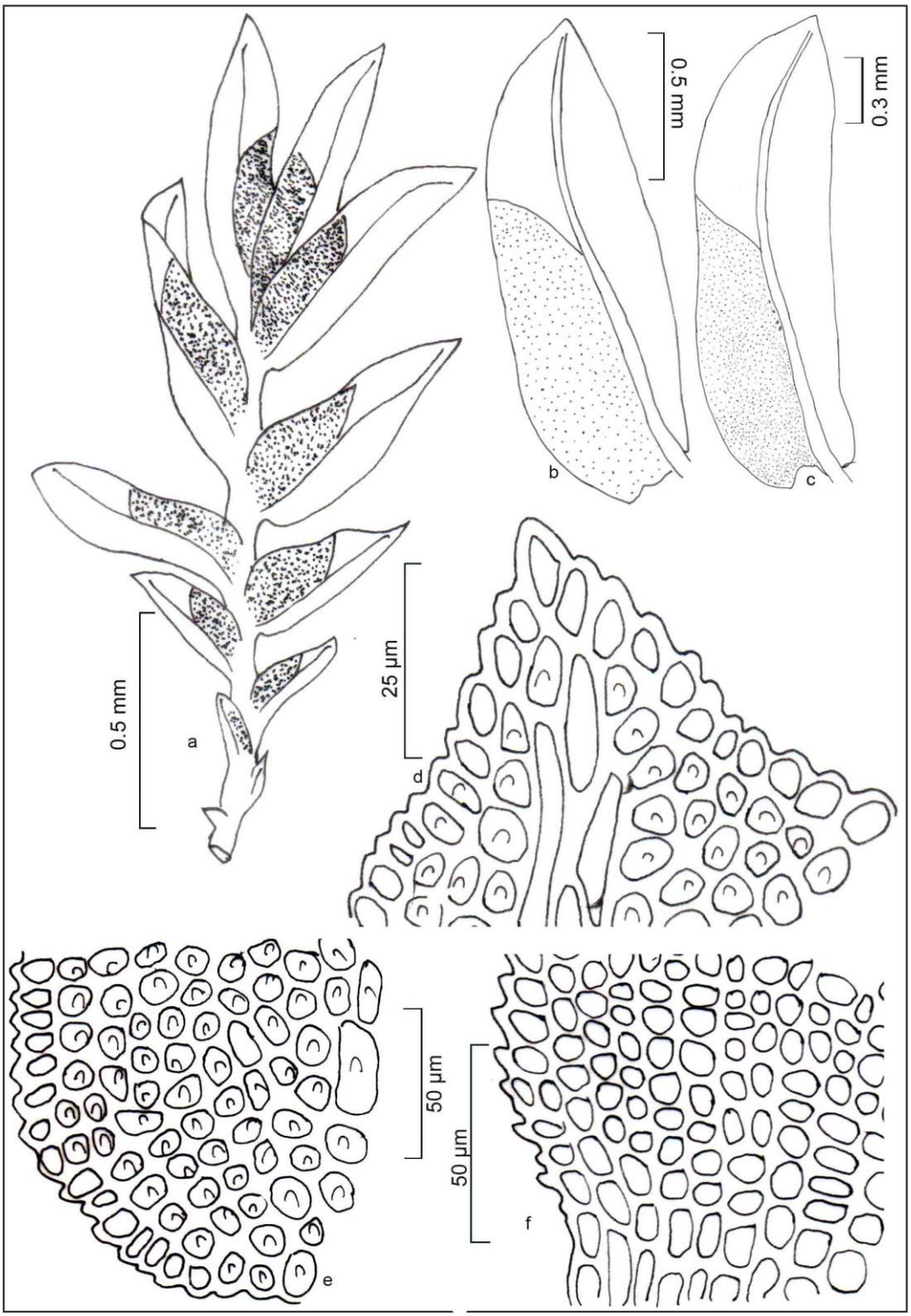
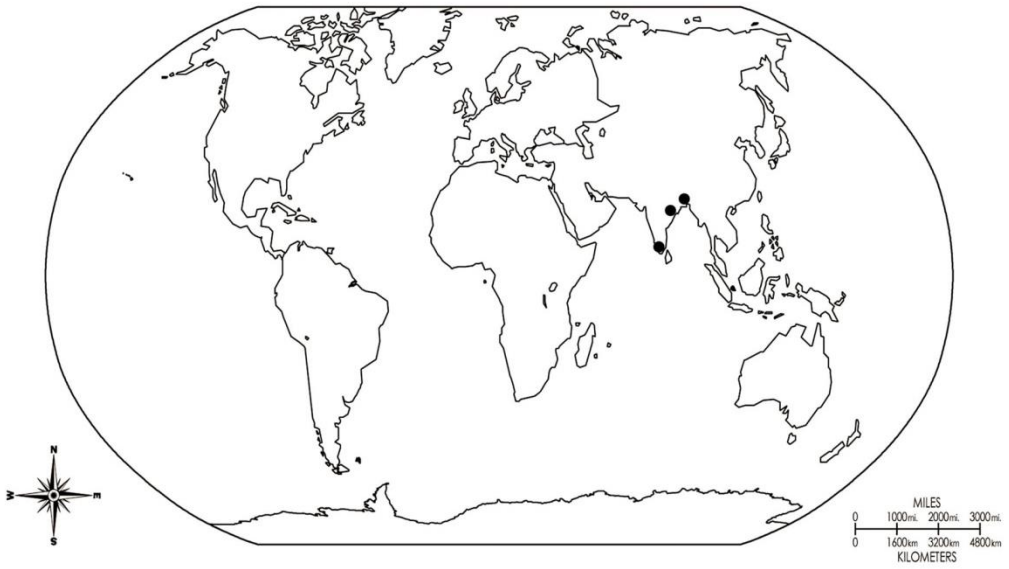
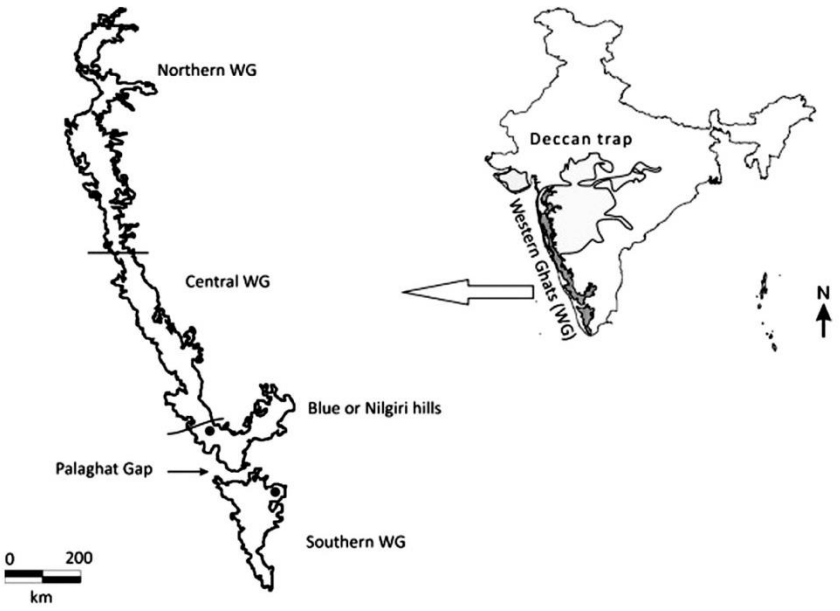


Fig. 46. *Fissidens orishae* Gangulee, a. vegetative plant, b&c. vegetative leaves, d. leaf apex, e. dorsal laminal cells near insertion, f. vaginant laminae base



Map 51A. World distribution of ***Fissidens orishae*** *Gangulee*



Map 51B. Distribution of ***Fissidens orishae*** *Gangulee in Western Ghats*

Fissidens pallidinervis Mitt., J. Linn. Soc., Bot. 12: 592. 1869; Gangulee, Moss. E. India & Adj. 1: 515. 1971; Li & Iwatsuki, Moss Fl. of China 2: 48. 2001; Pursell, Fissidentaceae Fl. Neo. Mono. 101: 147. 2007; Bruggeman-Nannenga & Arts, J. Bryol. 32: 194. 2010.

Type: Peru, Andes Peruvianae, Tarapoto, ad rivulum Marono-yacu (2000 ped.), R.Spruce 536. Holotype (NY), Isotype (BM!).

Fissidens minutus Thwaites & Mitt. in Mitt., J. Linn. Soc. Bot. 13: 323. 1873; *F. garberi* Lesq. & James, Proc. Am. Acad. Arts 14: 137. 1879; *F. mateoensis* Broth. in Herzog, Biblioth. Bot. 87: 27. 1916; *F. foreauanus* Card. in Dixon & P.de la Varde, Rev. Bryol. 49: 323. 1922; *F. chungii* Thér., Ann. Crypt. Exot. 5: 167. 1932; *F. pusillissimus* Steere. Ann. Bryol. 10: 116. 1937 [1938].

Plants epiphytic, yellowish green in herbarium, leaf tip curls when dry; vegetative plants 2.50-6x 0.70-1.50 mm, 5-19 pairs of leaves; stem light green and slightly wavy in cross section with 0.10-0.14 mm diameter, central strand not differentiated, two or three rows of outer small, thick walled cells with 4.70-15.80 long, inner three or four rows of large, thin walled cells with 15-24.80 µm long; rhizoids narrow, smooth; leaves alternate, overlapping towards apex, oblong lanceolate, 0.60-1.04 x 0.19-0.30 mm, 3 times long as wide, margin serrated throughout, leaf apex widely acute; limbidium present only at vaginant laminae base, mostly in perichaetial leaves, 2–4 rows of ruminant slightly elongated cells also in some mature upper leaves; vaginant laminae slightly open, unistratose, reaching more than half of leaf length, 0.14-0.21 mm wide at base; dorsal lamina base narrow, slightly round, not decurrent, apical lamina and dorsal lamina unistratose, apical lamina slightly asymmetrical; costa percurrent, ends 2-5 cells below apex, yellowish green, bryoides type; laminal cells small, compactly arranged, irregularly hexagonal, chlorophyllous, pluripapillose, cells at base of vaginant laminae slightly elongated, marginal cells triangular; mid dorsal laminal cells convex, 10.50-13.20 x 6.65-8.70 µm; apical cells 7.90-8.50 x 4.70-6.40 µm; mid vaginant laminal cells 10.90–11.30 x 8.10–8.50 µm, convex; basal cells 9.70-15.30 x 6.40-6.90 µm.

Fertile plants; perigonia not found, perichaetia terminal, innovations from apical part is seen in some plants after archegonial development, plants 4-4.60 x 1.30-1.50 mm, 5-8 pairs of leaves, 1.32-1.40 x 0.22-0.28 mm, archegonia 0.19-0.21 mm long; sporophyte not found (Plate 89,90 & Fig.47).

Diagnostic characters: *F. pallidinervis* Mitt. is characterised by its oblong leaf with serrate margin, pluripapillose laminal cells, short limbidium restricted to the vaginant laminae base of upper leaves of perichaetial stem.

Note: Papillosity of cells of *F. pallidinervis* Mitt. are similar to *F. ceylonensis* Dozy & Molk. and *F. hollianus* Dozy & Molk. But *F. ceylonensis* Dozy & Molk. have slightly excurrent costae and intramarginal limbidium on all laminae. *F. hollianus* Dozy & Molk. have limbidium on vaginant laminae of all leaves. But in *F. pallidinervis* Mitt., limbidium restricted to vaginant laminae base of fertile leaves and one or two leaves below.

Habitat and General Ecology: Epiphytic on bark, logs, twigs and branches of large trees especially some evergreen trees like *Albizia saman* (Jacq.) F. Muelll. along with *Calymperes erosum* Muell. Hal., *Cyathodium cavernarum* Kunze and Lejeuneaceae members like *Lejeunea tuberculosa* Steph. Thick growth of algae is noticed. Common in open land, evergreen and semi evergreen forests from low to high altitude areas. Rarely on termite mount (Pursell, 2007; Bruggeman-Nannenga & Arts, 2010)

Distribution: India (Kerala (Present study), Maharashtra, Goa, Tamil Nadu (Dabhade, 1998; Magdum *et al*., 2017; Gangulee, 1971); Brazil, Central America (Belize, Costa Rica, Guatemala, Honduras, El Salvador, Nicaragua, Panama), China, East Nepal, Florida, Indochina, Kenya, Louisiana, Malawi, Malaysia, Mexico, South America, Sri Lanka, Tanzania, Uganda, West Indies (Bruggeman-Nannenga & Arts, 2010; Foreau, 1961 as *Fissidens minutus*; Gangulee, 1971; Li & Iwatsuki, 2001; O'Shea, 2006; Pursell, 2007). The present report of this species from Kozhikode district is a new record for Kerala and Goa. (Map 52A&52B).

Plate 89. *Fissidens pallidinervis* Mitt. habit & habitats; a-c. on bark of trees, d. on lianas.

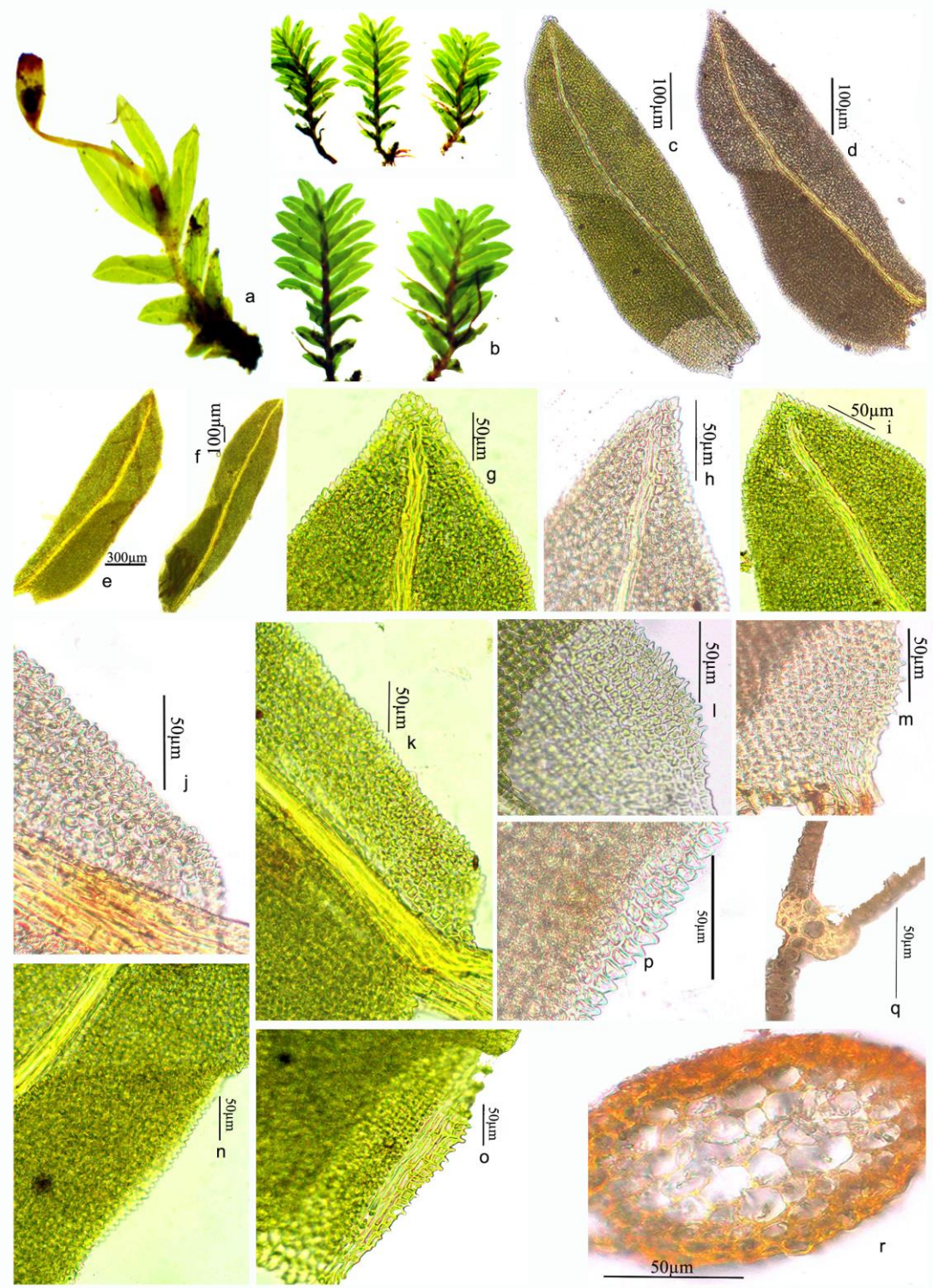


Plate 90. *Fissidens pallidinervis* Mitt., a. habit with sporophyte, b. sterile plants, c-e. vegetative leaves, f. perichaetial leaf, g-i. leaf apices, j&k. dorsal lamina near insertion, l&m. vaginant laminae base, n. vaginant laminae apex, o. limbidium on perichaetial vaginant laminae, p. leaf margin, q. leaf T.S., r. stem T.S. (a,b,e-g, i,k,n,o from ZGC1174; c,d,h,j,l,m,p-r ZGC6391).

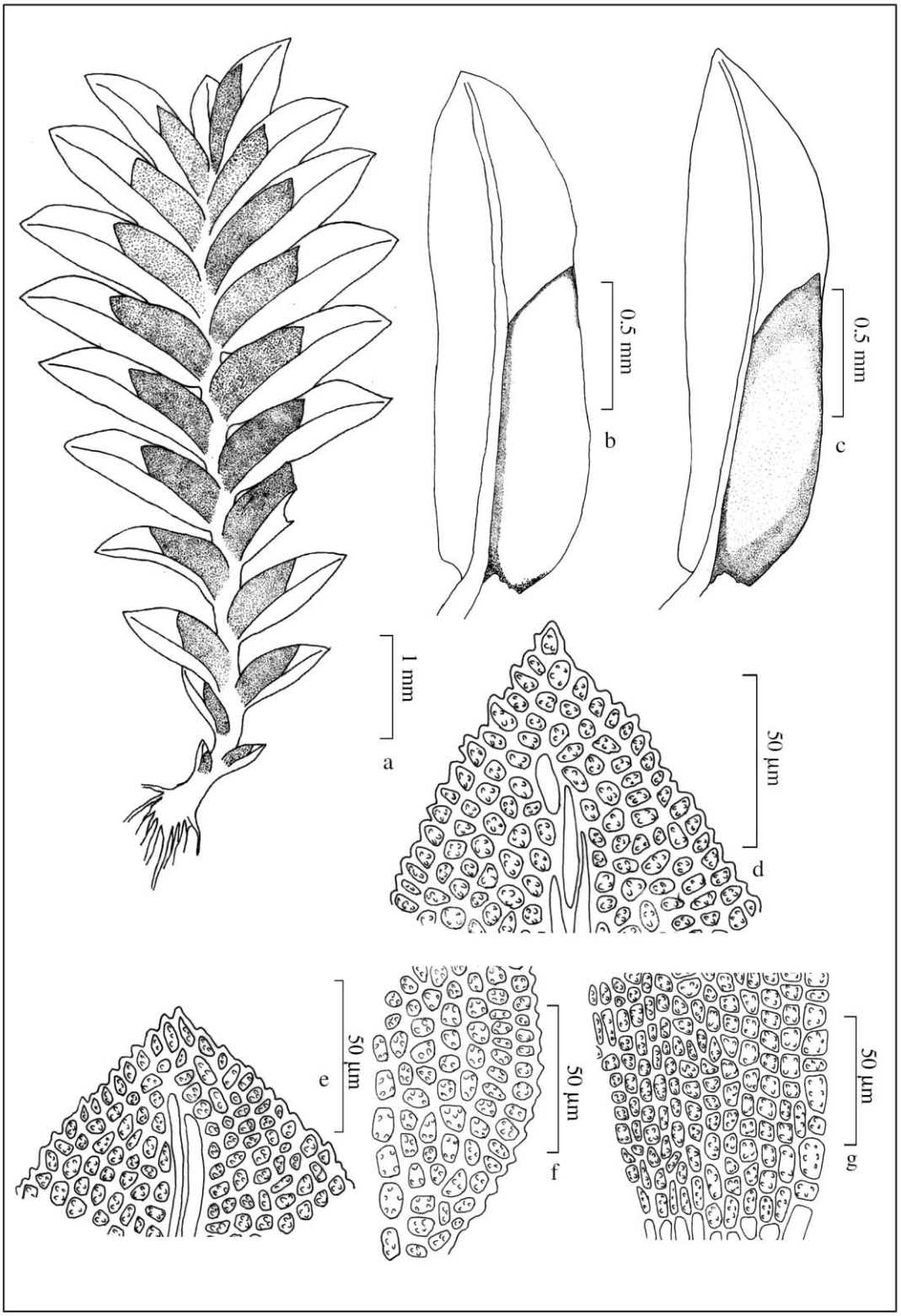
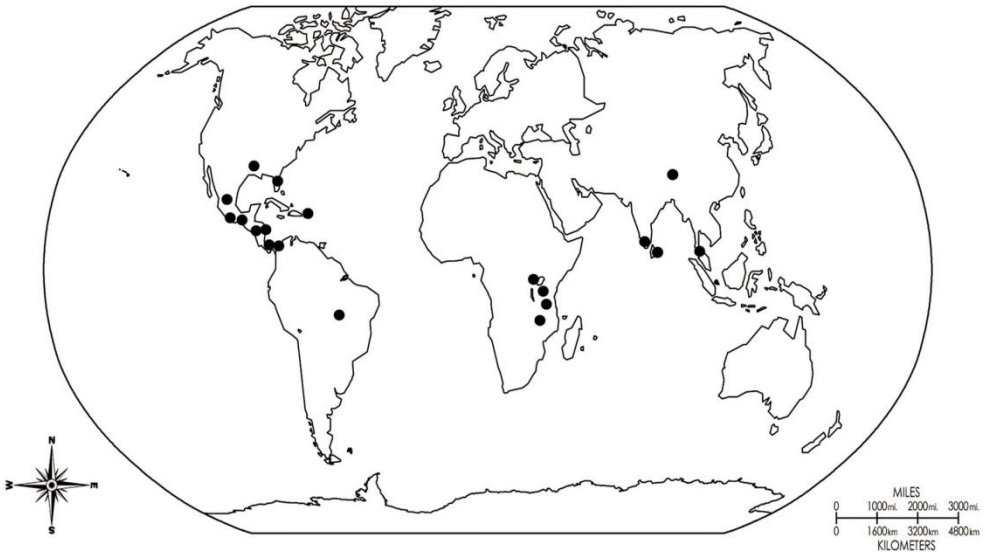
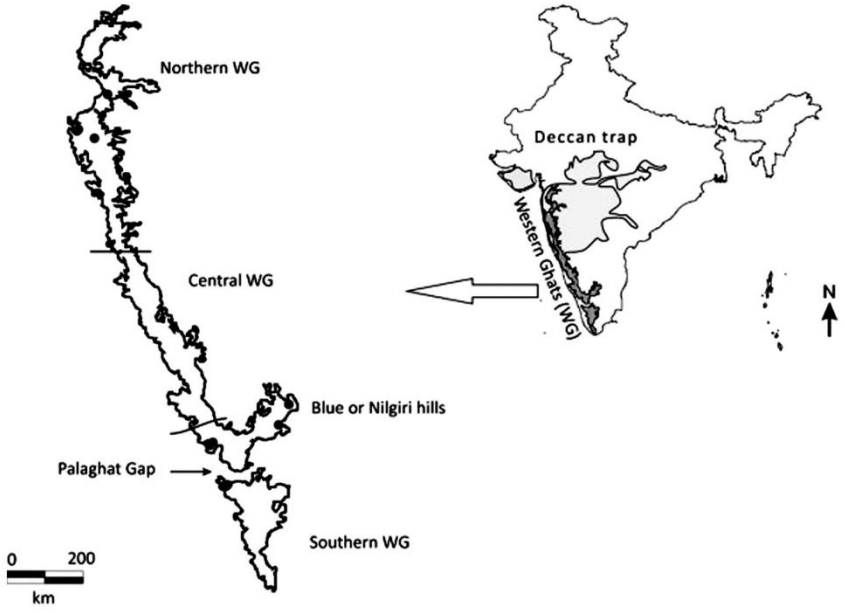


Fig. 47. *Fissidens pallidinervis* Mitt., a. vegetative plant, b&c. vegetative leaf, d&e. leaf apex with costa, f. dorsal lamina base near insertion, g. vaginant laminae base.



Map 52A. World distribution of ***Fissidens pallidinervis*** *Mitt.*



Map 52B. Distribution of ***Fissidens pallidinervis*** *Mitt. in Western Ghats*

Specimens examined: India, Kerala; Kerala, Kasaragod district, Dharmasastha kavu, Cheemeni (254m), 01.09.2017, Chandini & Deepa (ZGC 10259, ZGC 10260); Edayilakad kavu, Trikaripur (), 01.09.2017, Chandini & Deepa (ZGC 10243, ZGC 10244), (Parappa, 100m), 19.09.2002, K.P. Rajesh (87009) (CALI!); Kannur district, Aralam WLS, Valayamchal (57m), 09.01.2015, Manjula (ZGC 4014, ZGC 4016), 24.09.2016, Chandini (ZGC 10434), Chullikandam (98m), 25.09.2016, Chandini (ZGC 10443), Uruppukunnu (645m), 23.09.2016, Chandini (ZGC 10420, ZGC 10424), (Ambalappara, $11^0$93'77.5" N, $65^0$93'86.1" E, 1549m), 07.04.2016, Chandini (ZGC 4172), (Meenmutty water fall, $11^0$56'65.5" N, $75^0$52'90" E, 800m), 18.09.2015, Manjula (ZGC 15631a), (way to meenmutty water fall from tower, $11^0$56'65.5" N, $75^0$52'90" E, 740m), 16.09.2015, Manjula (ZGC 15638a), (Pottamplavu, $11^0$56,00.3" N, $75^0$50'86.2", 450m), 16.09.2015, Manjula (ZGC 15622), (Valayamchal, $11^0$55'24.1" N, $75^0$47'54" E, 50m), 18.09.2015, Manjula (ZGC 15684), (Uruppukunnu $11^0$57'05.6" N, $75^0$49'58.5" E, 750m), 17.09.2015, Manjula (ZGC 15672), (Valumukku), 18.09.2015, Manjula (ZGC 15640), Mangattu paramba (Neeliyarkottam kavu, $12^0$07'31" N, $75^0$17'47" E, 37m), 15.07.2016, Chandini (ZGC 16091, ZGC 16090); Kozhikode district, Malabar WLS, Urakkuzhi (976m), 14.11.2014, Manjula (ZGC 3783, ZGC 3786, ZGC 3787, ZGC 3788); 14.11.2014, Prajitha (12882) (MBG!); Idukki district, Vagamon (Mottakkunnu $9^0$34'49" N, $76^0$58'27" E, 1087m), 24.10.2015, Manjula (ZGC 15787), Idukki district, Kothamangalam, Pattayam kuzhi, Meenuliyan para (914m), 24.07.2015, Manjula (ZGC 15063, ZGC 15071), Pooyamkutty (250m), 23.07.2015, Manjula (ZGC 15042), Panamkuzhi, Thalakkod (130m), 25.07.2015, Manjula (ZGC 15095), Kozhikode district, (Arts college campus, $11^0$12'48" N, $75^0$47'55" E, 21m), 13.08.14, Manjula & Chandini (ZGC 1174), 27.07.2016 (Manjula & Chandini (ZGC 15996, ZGC 15997), 04.10.2015, Manjula & Deepa (ZGC 16051, ZGC 16053), 24.08.2011, Manju (ZGC 16161, ZGC 6387C, ZGC 6391, ZGC 15996), Malabar WLS (Kakkayam, Thattitta para, $11^0$34'05" N, $75^0$54'23" E, 720m), 14.11.2014, Manjula (ZGC 3906a), (Kakayam, Ambalappara, $11^0$34'26" N, $75^0$54'19" E, 700m), 26.09.2012, Prajitha (8514) (MBG!), (Peruvannamuzhi, $11^0$35'31" N, $75^0$51'38" E, 159m), 11.08.2016, Vinjusha (ZGC 16110), Kuttyady churam (Pakkramthalam

churam, $11^0$43’42” N, $75^0$48’40” E, 665m), 23.07.2016, Manjula (ZGC 15955), Thrissur district (Peechi-Vazhani WLS, 88m), 10.12.2016, Chandini & Mufeed (ZGC 10493); Karnataka; Kargal (1880ft), 19.09.2014, Manjula & Deepa (ZGC 3609B); Kodachadri (1343m), 18.09.2014, Manjula & Deepa (ZGC 3607, ZGC 3602), Santhi falls, Kemmanagundi (4460ft), 20.09.2014, Manjula & Deepa (ZGC 3647); Goa, Cancona, (Cotigao Wildlife Sanctuary, 88 m), 15.08.2015 Manjula & Deepa (ZGC 15120, ZGC 15126), Goa; Baghavan Mahavir NP (464m), 16.08.2015, Manjula & Deepa (ZGC 15135, ZGC 15140(2), ZGC 15148, ZGC 15149, ZGC 15164), Maharashtra, Nashik, Brahmagiri, Near Godavari origin (997m), 16.09.2017, Manjula (ZGC 7753); Musci Amazonici et Andini, 1867, W. Mitten (536) (Isotype; BM!).

Etymology: The epithet *pallidinervis* is derived from *pallidus* (pale) + *nervis* (nerve) which reflects the pale coloured costa of this species.

Fissidens pellucidus Hornsch., Linnaea 15: 146. 1841; Dixon, J. Indian Bot., 2: 179. 1921; Bartram, Fieldiana: Botany 16: 23. 1949; Li & Iwatzuki, Moss Fl. China 2: 53. 2001; Pursell, Fl. Neotrop. Monogr. 101: 1. 204. 2007; Manju *et al.,* Tropical Bryol. Res. Rep. 7: 12. 2008b; Bruggeman-Nannenga & Arts, J. Bryol. 32: 195. 2010.

Type: Suriname: Weigelt s.n. Neotype (designated by Pursell, 1994b): Brazil, Sa. Catharina, Itaj ahy, Erdboden im Walde, Ule 67 (H-BR).

Fissidens subcrenatus Schimp. in Muell. Hal., Syn. Musc. Frond. 2: 531. 1851; *F. laxus* Sull. & Lesq., Proc. Amer. Acad. Arts 4: 276. 1859; *F. ripensis* Mitt., Trans. Linn. Soc. London 23: 55. 6 f. 15. 1860; *F. rufulus* Sull., Proc. Am. Acard. Arts 5: 275. 1862 [1861]; *F. flexinervis* Mitt. J. Linn. Soc. Bot. 12: 588. 1869; *F. crassinervis* Thwaites & Mitt., J. Linn. Soc. Bot. 13:323. 1873; *F. cryptarum* Muell. Hal., Linnaea 39: 352. 1875; *F. holstii* Broth., Bot. Jahrb. Syst. 20: 181. 1894; *F. mittenii* Par., Ind. Bryol. 477. 1894; *F. calabariae* Muell. Hal. *ex* Deusen, Kongl. Svenska Vetensk. Acad. Handl., n.s. 28(2): 10. A-e; 2 f. 7. 1895; *F. grandiretis* Renauld & Cardot in Renauld, Prodr. Fl. Bryol. Madagascar: 115, 1898; *F. pellucidens* Hornsch. *ex* Ule, Hedwigia 38 (Beibl.) 57.1899; *F. disperses* Cardot,

Rev. Bryol. 36: 17. 1909; *F. pyrenocystis* Cardot, Rev. Bryol. 37. 121. 1910; *F. immutatus* Dixon, J. Indian Bot. 2: 179. 1921; *F. amblyotis* Dixon, Bull. Torrey Bot. Club 51: 229. 3f. 16. 1924; *F. propinguus* P. de la Varde, Bull. Soc. Bot. France 72: 352. 3. 1925; *F. subpellucidus* Broth., Akad, wiss. Wein. Math-Naturwiss. Kl., Denkschr. 83: 274. 1927; *F. crispidioides* Broth., Mitt. Inst. Allg. Bot. Hamburg 7(2): 115. 1928; *F. linderi* P. de la Varde & Thér., rev. Bryol., n.s. 3: 44. 1930; *F. taeniocladus* P. de la Varde, Rev. Bryol., n.s. 4: 64. 3 f. 1. 1931; *F. portorisensis* E. Britton *ex* Grout, Bryologist 44. 142. 1941; *F. ghanae* Bizot, Rev. Bryol. Lichénol. 40: 105. Pl. 3: c. 1974; *F. palvadeaui* Bizot, Rev. Bryol. Lichénol. 40: 106. Pl. 3: a. 1974; *F.cremersii* Bizot & Onr. in Bizot, Rev. Bryol. Liche´nol. 42: 846, 1976; *F. pictus* Bizot & Pócs, Fol. Hist.-Nat. Mus. Matr. 4: 30. 1976 [1977]; *F. subpictus* Bizot & Pócs, Fol. Hist.-Nat. Mus. Matr. 4: 30. 1976[1977].

Plants small, growing in loose tufts, stem simple, leaves curls in herbarium; yellowish orange stem, central strand weakly differentiated, 0.10–0.40 mm, vegetative stem 4-7 x 0.20-0.70 mm, 10-16 pairs of leaves; rhizoids reddish, smooth, axillary nodules absent; leaves small, lanceolate with acute to acuminate apex, margin serrate, leaves not overlapping, 0.64-0.74 x 0.16-0.18 mm, 5 times long as wide; limbidium absent, but few scanty elongated cells present in perichaetial leaves, vaginant laminae ± half open, small, reaching less than half the length of apical leaf, unistratose, basal vaginant cells near costa slightly elongated, dorsal lamina base round, reaching the insertion, not decurrent, dorsal and apical lamina unistratose; costa prominent, percurrent to slightly excurrent, bryoides type, rarely bifid at end; laminal cells often guttulate, mid dorsal laminal cells irregularly rectangular, plane to slightly convex, smooth 9.70-12.88 x 10.08-13.05 µm; mid vaginant laminal cells linearly oval to rectangular, 10.10-13.93 x 13.11-15.58 µm, slightly convex; gemmae not found.

Fertile parts; perigonia not found; perichaetia terminal, perichaetial branch similar to vegetative stem, perichaetial leaf slightly large; archegonium 0.18-0.24 µm long; sporophyte not observed (Plate 91,92 & Fig.48).

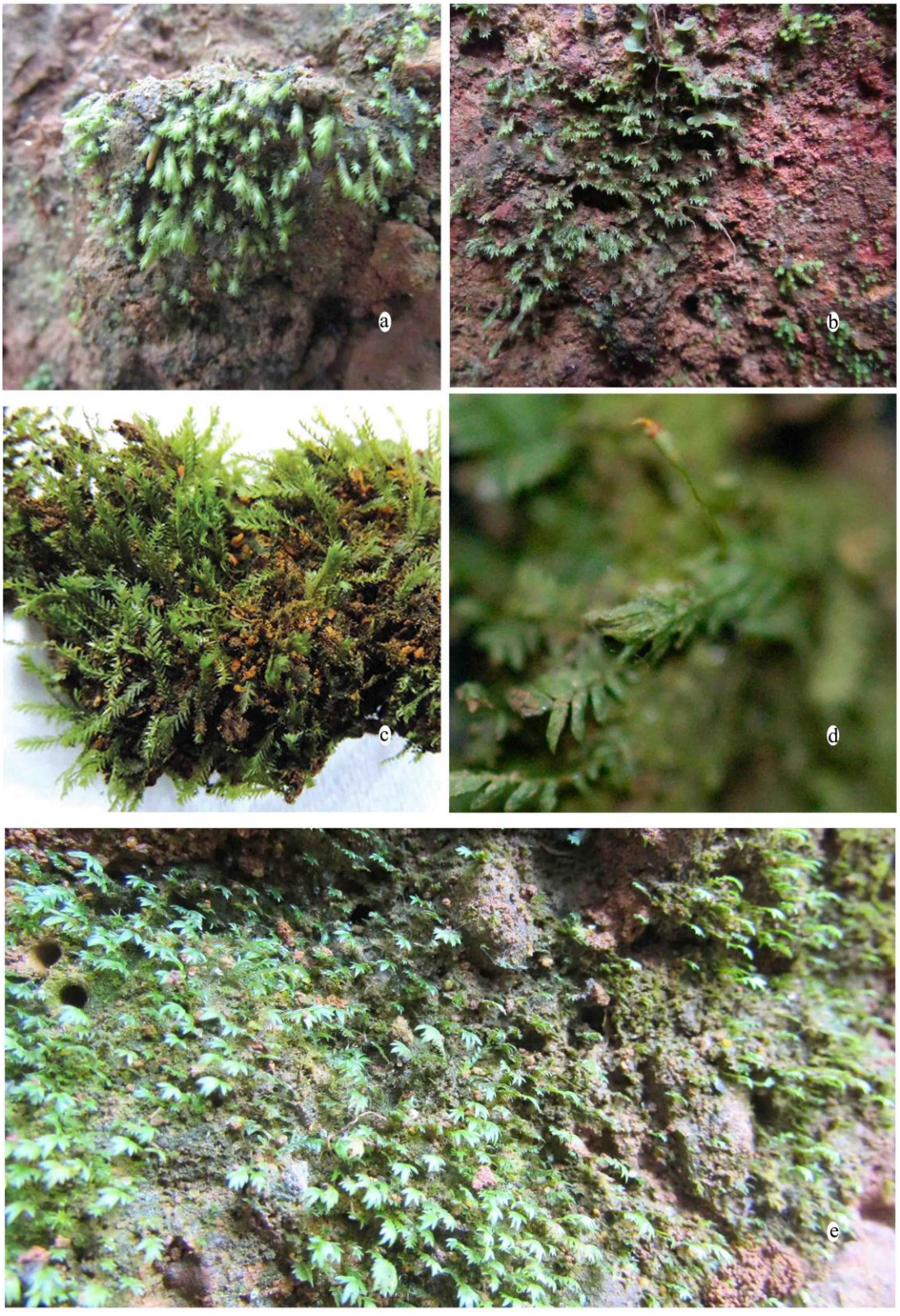


Plate 91. *Fissidens pellucidus* Hornsch. habit & habitats; a&b. on laterite land cuttings, c&d. enlarged microscopic view of the plant, e. on laterite soil in land cuttings

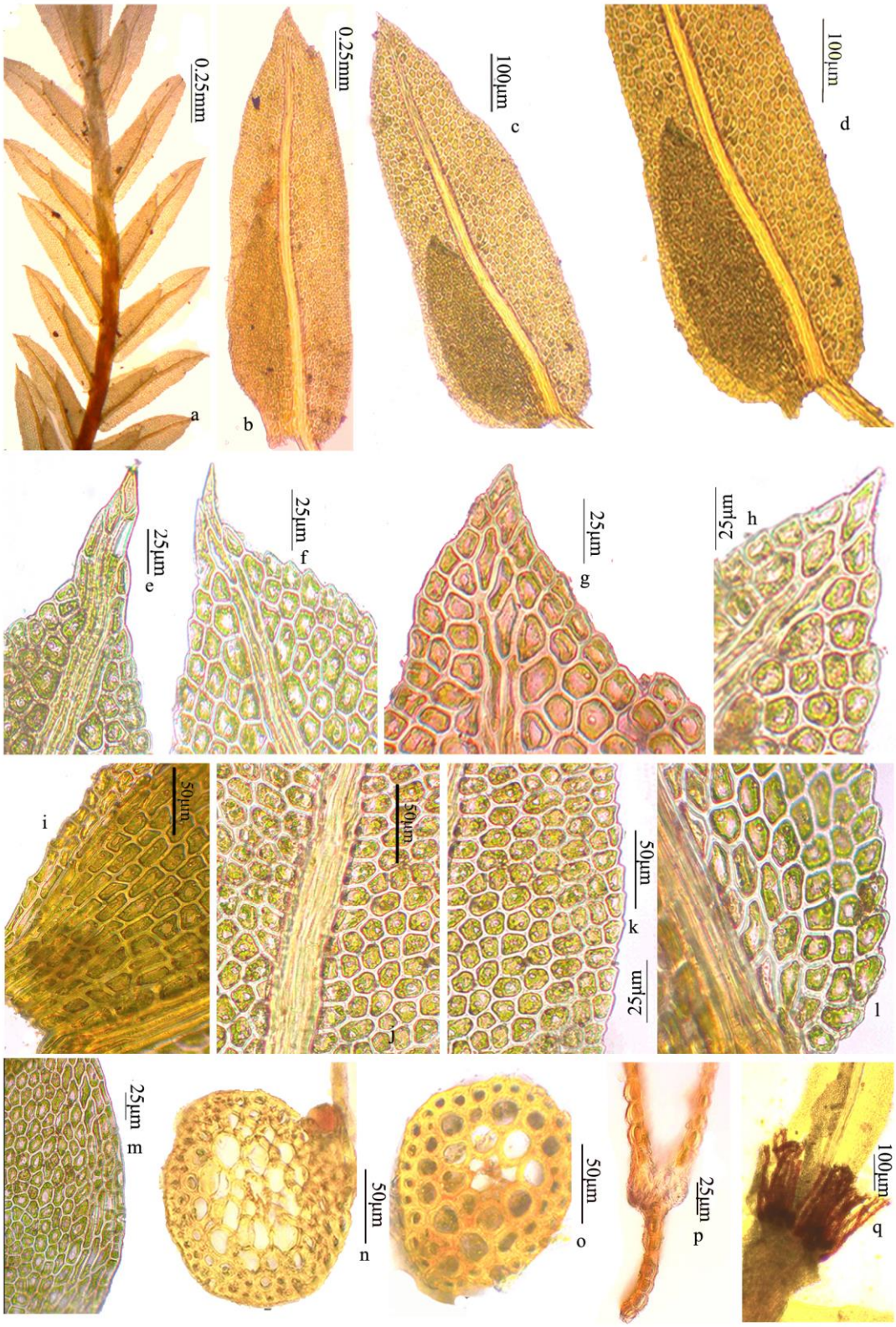


Plate 92. *Fissidens pellucidus* Hornsch., a. vegetative plant, b&c. vegetative leaves, d. vaginant laminae, e-h. leaf apex, i. vaginant laminae base, j. mid laminal cells, k. leaf margin, l. dorsal lamina base near insertion, m. vaginant laminae base of perichaetial leaf, n&o. stem T.S., p. leaf T.S., q. perichaetium

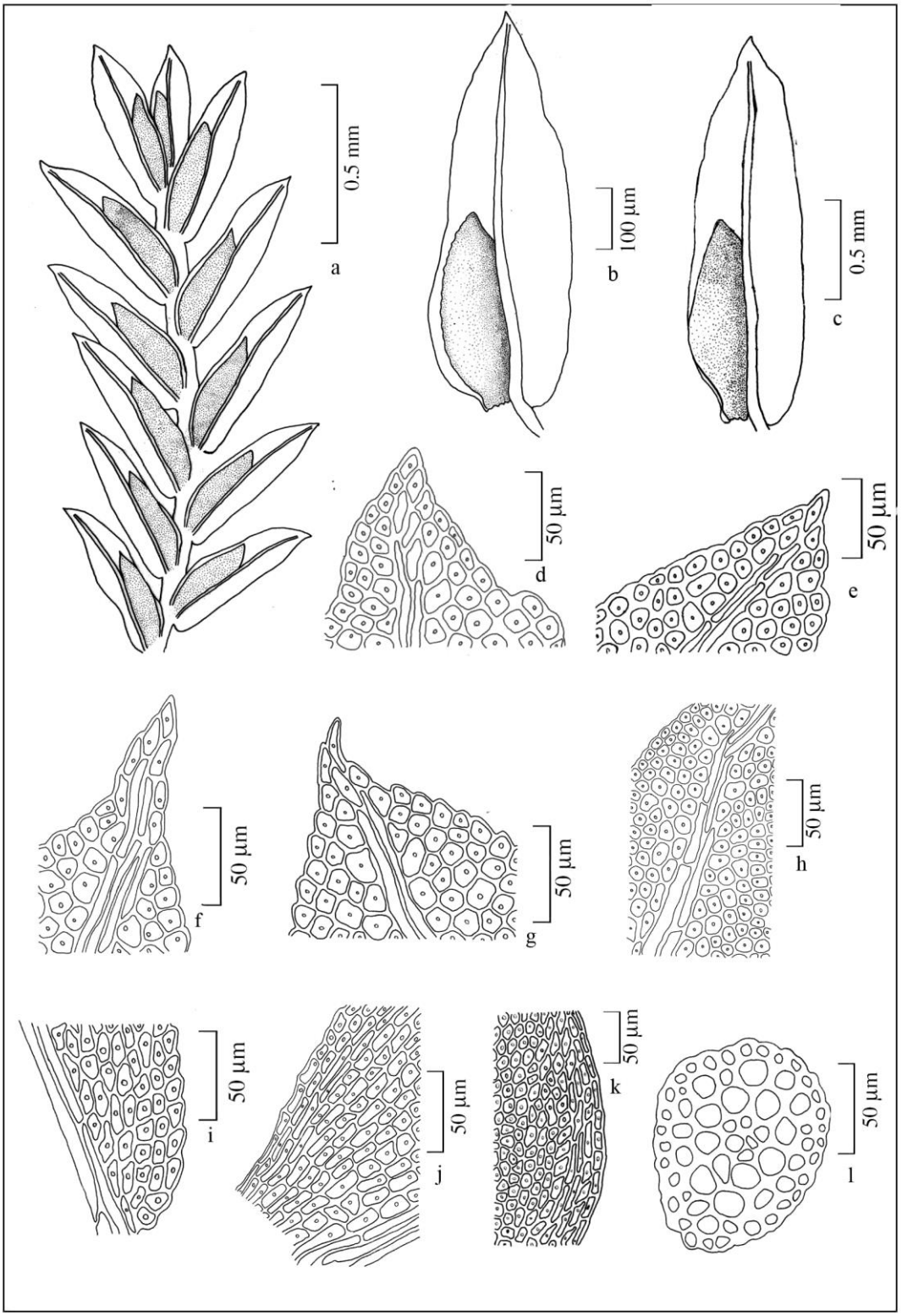


Fig. 48. *Fissidens pellucidus* Hornsch., a. vegetative plant, b&c. vegetative leaves, d-g. leaf apex with costa, h. laminal cells with costa, i. dorsal lamina base, j. vaginant laminae base, k. perichaetial vaginant laminae base with elongated marginal cells, l. C.S. of stem.

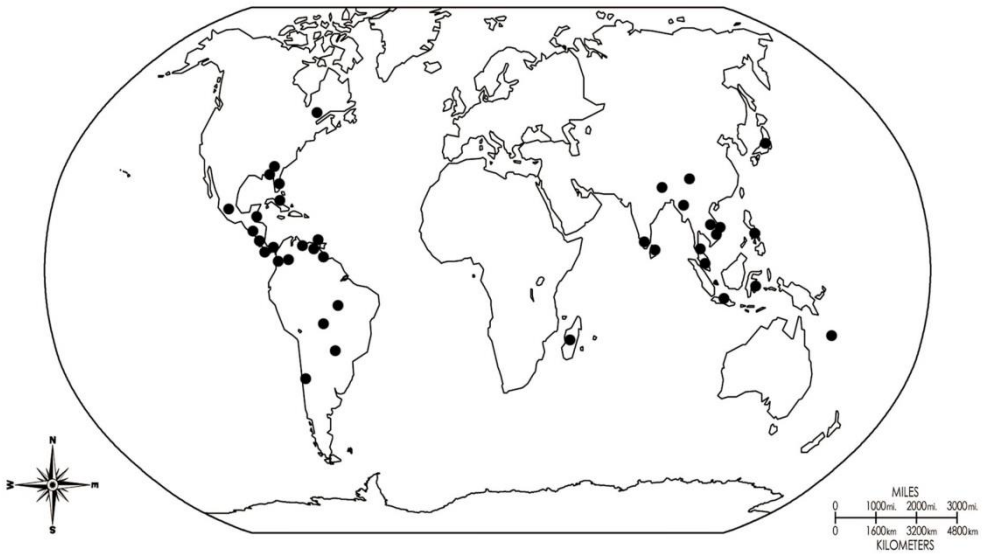
Diagnostic characters: *F. pellucidus* Hornsch. is characterised by its thin simple stem, lanceolate and elimbate leaves, compactly arranged polygonal cells with clear and small guttula at centre, vaginant laminae open. Structure of guttula is similar to papillae of *F. macrosporus* Dixon but it differs in leaf size, shape and sporophyte characters.

Note: The leaf shape of *F. pellucidus* Hornsch. is variable. In type specimen, leaves are narrow with excurrent costa and base of dorsal lamina wedge-shaped. However, in many specimens the leaves are broader mostly with percurrent costa (rarely excurrent) and wider rounded bases of the dorsal lamina (Li & Iwatsuki, 2001). Some of our present collections also shows slightly excurrent costa and wedge-shaped dorsal lamina base. This species is reported from Karnataka as *F. crassinervis* var. *laxus* (Sull. & Lesq.) A. Eddy

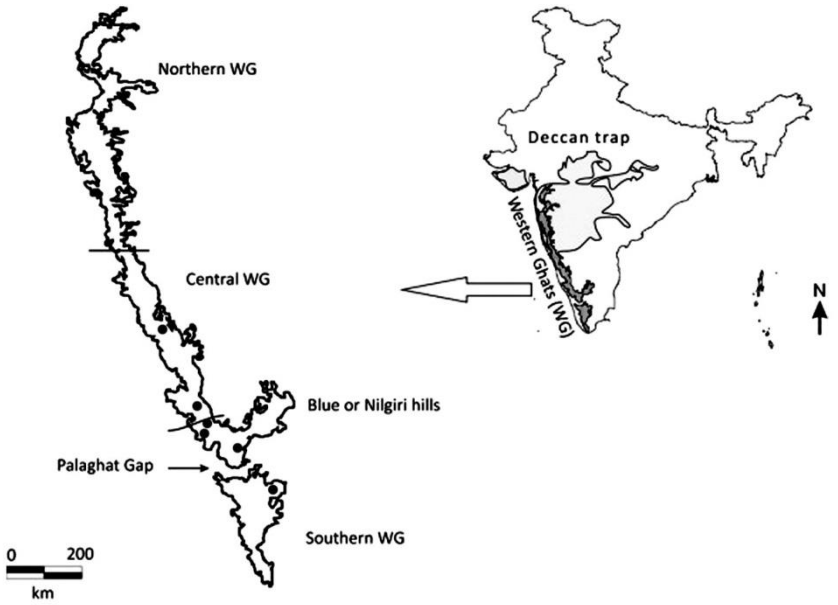
Habitat and General Ecology: On soil, land cuttings and large & small rocks. Common species in all the altitudinal ranges in between msl to 1300 m along with other bryophytes such as *Hyophila involuta* (Hook.) A. Jaeger, *Garckea flexuosa* (Griff.) Margad. & Nork., *Phillonotis hastata* (Duby) Wijk & Margad., *Fissidens flaccidus* Mitt. and *F. crispulus* Brid. It is found in all vegetation types except in shola forests, but the frequency of occurrence is high in low altitude areas.

Distribution: India (Kerala, Goa, Karnataka as *F. crassinervis* var. *laxus* (Dixon & Pottier de La Varde, 1927 as *F. immutatus*; Frahm *et al*., 2013; Schwarz, 2014b; Schwarz (pers.comm., present coll. as *F.pellucidus*) Manju *et al.*, 2008b, 2009a); Belize, Bolivia, Brazil, Caribbean, Chile, China, Colombia, Costa Rica, Ecuador, Fiji, French Guiana, Florida, Georgia, Guatemala, Honduras, Indonesia, Japan, Java, Louisiana, Madagascar, Malaysia, Mexico, Myanmar, Nepal, Panama, Paraguay, Philippines, Singapore, Sri Lanka, Sumatra, Suriname, Taiwan, Trinidad, Thailand, Vietnam, Venezuela, Vanuatu (Breen, 1963; Crosby *et al.*, 1983; Li & Iwatzuki, 2001; Möller & Pursell, 2003; Tan & Iwatsuki 1991 & 1996; Wijk *et al.*, 1959-1969). The present collection is a new record to Goa. (Map 53A&53B).

Specimens examined: India, Karnataka; Uduppi district (Hebri, $13^{0}45'876''$ N, $74^{0}99'247''$ E, 76m), 26.09.2013, Rajilesh (ZGC 851B, ZGC 855B), (Jog fall, 464m), 26.09.2013, Rajilesh (ZGC 850B), Karnataka; Kilagar (1345m), 18.09.2014, Manjula & Deepa (ZGC 3608), Way to Kalathagiri fall (3180ft), 20.09.2014, Manjula & Deepa (ZGC 3639), Kumaraparvatha (1010m), 02.05.2015, Mufeed (ZGC 4274); Tamil Nadu, (Maramalai, 340m), 14.01.14 Manjula (ZGC 973, ZGC 974, ZGC 978B); Kerala, Kasaragod district, Kanada kavu, Kayoor (153m), 01.09.2017, Chandini & Deepa (ZGC 10262); Kannur district, Aralam WLS (Valayamchal, $11^{0}55'24.1''$ N, $75^{0}47'54''$ E, 50m) K.P.Rajesh (87043) (CALI!), (Uruppukunnu $11^{0}57'05.6''$ N, $75^{0}49'58.5''$ E, 750m), Manju (99712) (CALI!), Veripara (850m), 22.01.2017, Vijisha (ZGC 16354); Theyyottukavu (50m), 23.08.2002, K.P. Rajesh (84686) (CALI!); Kozhikode district, (Pannikkode), 11.09.2014, Rajilesh (ZGC 689, ZGC 691), (Mavoor), Manjula (ZGC 688), (Vellarimala, $11^{0}49'64''$ N, $76^{0}14'21''$ E, 998m) 18.07.2013, Manjula (ZGC 617, ZGC 618B, ZGC 619, ZGC 620, ZGC 818B, ZGC 681B), Kakkayam churam (), 14.11.2014, Manjula (ZGC 3792); Wayanad district (Periya, $11^{0}83'56''$ N, $75^{0}85'63''$ E, 744m), 06.10.2013, Manju (ZGC 891, ZGC 901, ZGC 902A), Wayanad district, Near Hair Pin area (550m), 09.09.2004, Manju C.N. (99635) (CALI!); Malappuram district (Manoor, 16m), Chandini (ZGC 802) Kakkancherry, 05.09.2013. Manjula (ZGC 520, ZGC 522); Ernakulam district, Idukki road (115m), 24.07.2015, Manjula (ZGC 15086); Pathanamthitta district, Ranni, Way to Erimeli fro Plapally (29.01.2017), Manjula (ZGC 16362); Tamil Nadu, Mahendragiri (450m), 07.09.1996, A.E.D. Daniels (110B) (SCCN); Goa, Cancona, (Cotigao Wildlife Sanctuary, 88 m), 15.08.2015 Manjula & Deepa (ZGC 15125b); (Zuari river), 04.01.1971, A.H. Norkett (15843C) (CAL!).



Map 53A. World distribution of ***Fissidens pellucidus*** *Hornsch.*



Map 53B. Distribution of ***Fissidens pellucidus*** *Hornsch. in Western Ghats*

Fissidens polysetulus Muell. Hal. *ex* Nork. & Gangulee, Moss. E. India 1(2): 525. F. 248. 1971; Lal, Checklist Indian Moss. 63. 2005; Daniels *et al.*, Bryofl. Indira Gandhi N.P. Anamalai hills, India. 69. F. 27. 2018.

Type: India, Darjeeling, Sikkim, Kurz 2192 (BM).

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 laneolate, 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, mamillose, obscure, up to 10 µm long; gemmae not found.

Fertile parts; 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 (Plate 93).

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 mamillose 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.

Note: Manju *et al.,* 2011 reported this species from Kakkavayal RF in Kerala which is confirmed as *F. crispulus* during the present study.

Habitat and General Ecology: On soil in homestead and evergreen forest plantations of in medium altitude area.

Distribution: Endemic to India (Sikkim, West Bengal, Western Ghats of Tamil Nadu) (Gangulee, 1971; Daniels *et al.*, 2018) (Map 54A&54B).

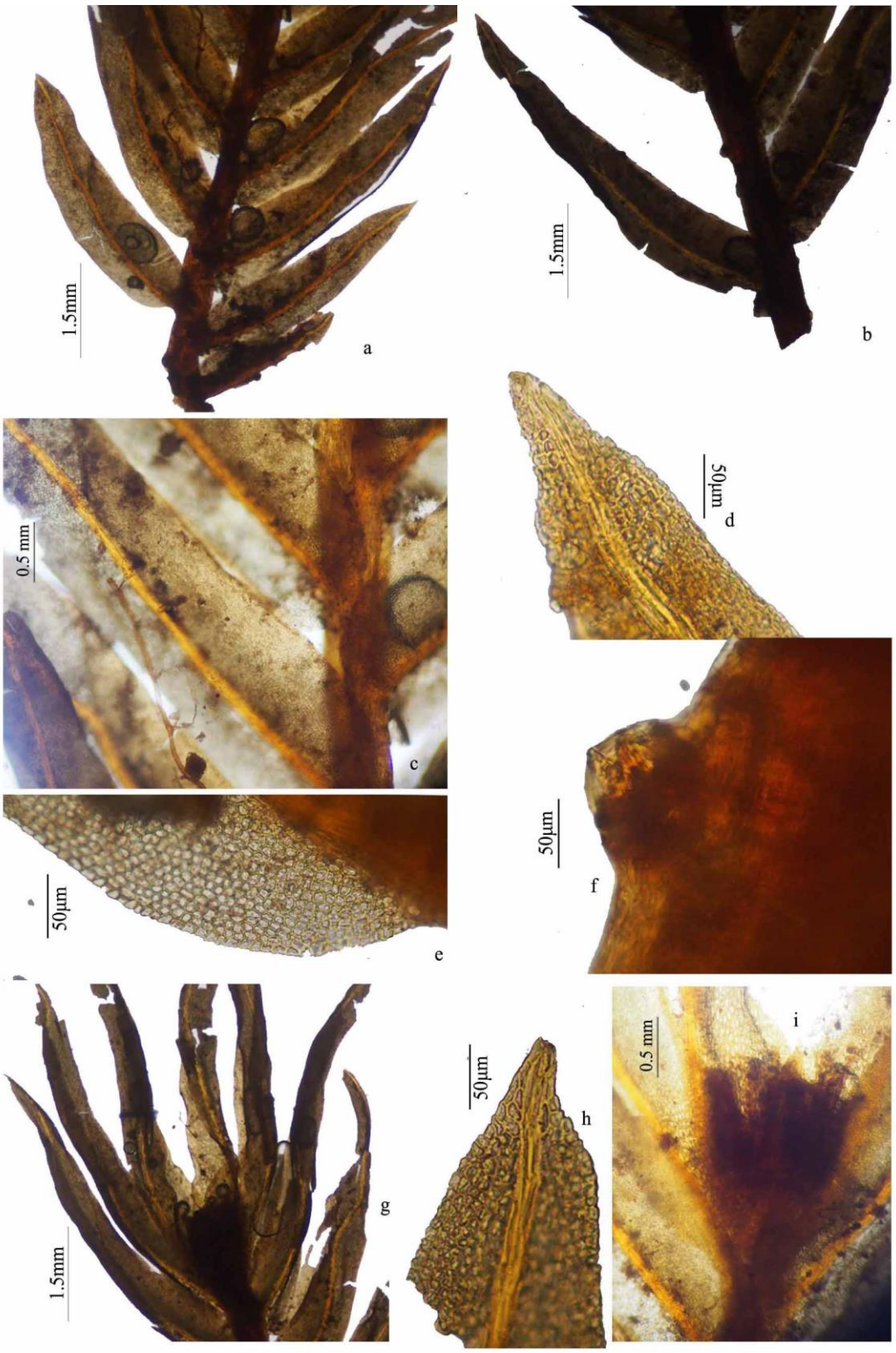
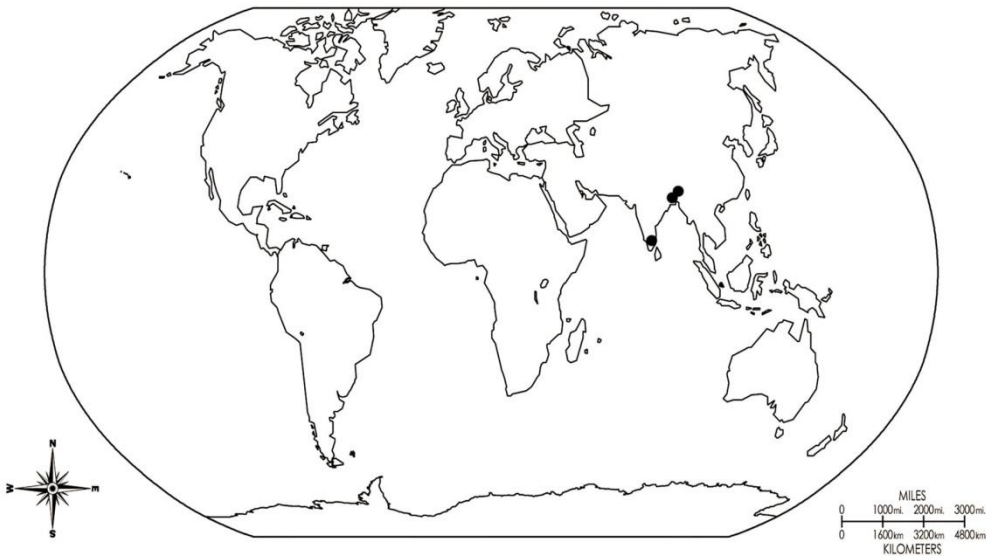
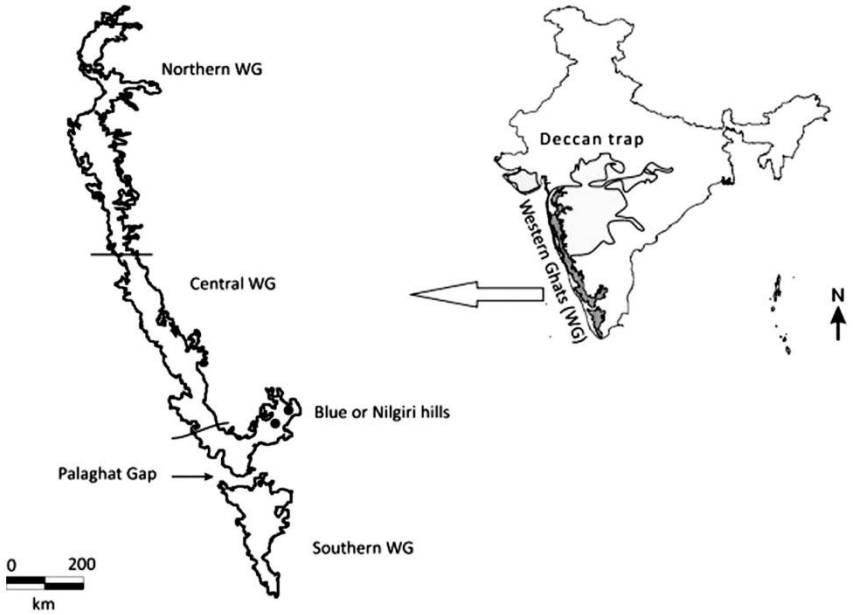


Plate 93. *Fissidens polysetulus* Kurz, a&b. vagetative leaves, c. vaginant laminae base, d. leaf apex, e. dorsal lamina base near insertion, f. axillary hyaline stem nodule, g. perichaetial branch, h. perichaetial leaf apex, i. Perichaetium (Photos from Kurz 2192 CAL!).



Map 54A. World distribution of ***Fissidens polysetulus*** *Müll. Hal. ex Nork. & Gangulee*



Map 54B. Distribution of ***Fissidens polysetulus*** *Müll. Hal. ex Nork. & Gangulee in Western Ghats*

Specimens Examined: India, Tamil Nadu, Coimbatore, Anamalais, Valparai, Anali estate (ca 820 m) 13.08.2012, A.E.D. Daniels, 8915 (SCCN!); Sikkim (Darjeeling, 6000ft), S. Kurz (Kurz 2192) (CAL!)

Fissidens pokhrensis Nork. *ex* S.S. Kumar, Misc. Bryol. Lichenol. 8: 120. f. 2. 1979; Chopra & Kumar, Moss. W. Himalayas. 51 t. 50. 1981; Lal, Checklist Indian Moss. 62. 2005: Daniels & Kariyappa, Curr. Sci. 93(7): 980. 2007; Daniels & Daniel, Bryo. South. W. Ghat. 48. 2013.

Type: T: Norkett 12192 (2); India. Himachal-Pradesh, Simla, 2300 m (Holotype: BM!).

Plants 1.3-2.3 mm long; leaves 5-8 pairs, curls when dry, 0.6-1.2 x 0.15-0.20 mm, ovate-lingulate, apex acute, margin not entire; limbidium present only on perichaetial leaf base; vaginant laminae reaching half the length of leaf, open, unequal; costa prominent, ending below apex; laminal cells quadrate hexagonal, pluripappillose, apical cells 4-8 x 3-6 µm, middle cells 6-10 x 4-8 µm, basal cells 8-12 x 6-10 µm; gemmae not found.

Fertile parts, perigonium and perichaetium absent; sporophyte apical, seta around 1.8 mm, capsule 0.6 x 0.18 mm, peristome teeth around 72 x 15 mm, spores 14.41-16.2 µm, globose (Plate 94 & Fig.49).

Diagnostic characters: *F. pokhrensis* is characterised by small plants with ovate-lingulate leaves, semilimbidium present only on perichaetial leaf vaginant laminae base, pluripapillose laminal cells and open unequal vaginant laminae. This species is similar *F. pallidinervis* Mitt. in pluripapillose laminal cells, limbidium restricted to vaginant laminae of perichaetial leaves. It varies from this species in the small plants and

Habitat and General Ecology: On rocky patches and on land cuttings in degraded evergeen Forests in low altitude.

Distribution: This is an endemic species to India distributed in Western Himalayas and Western Ghats of Tamil Nadu (Daniels & Daniel 2013) (Map 55A&55B).

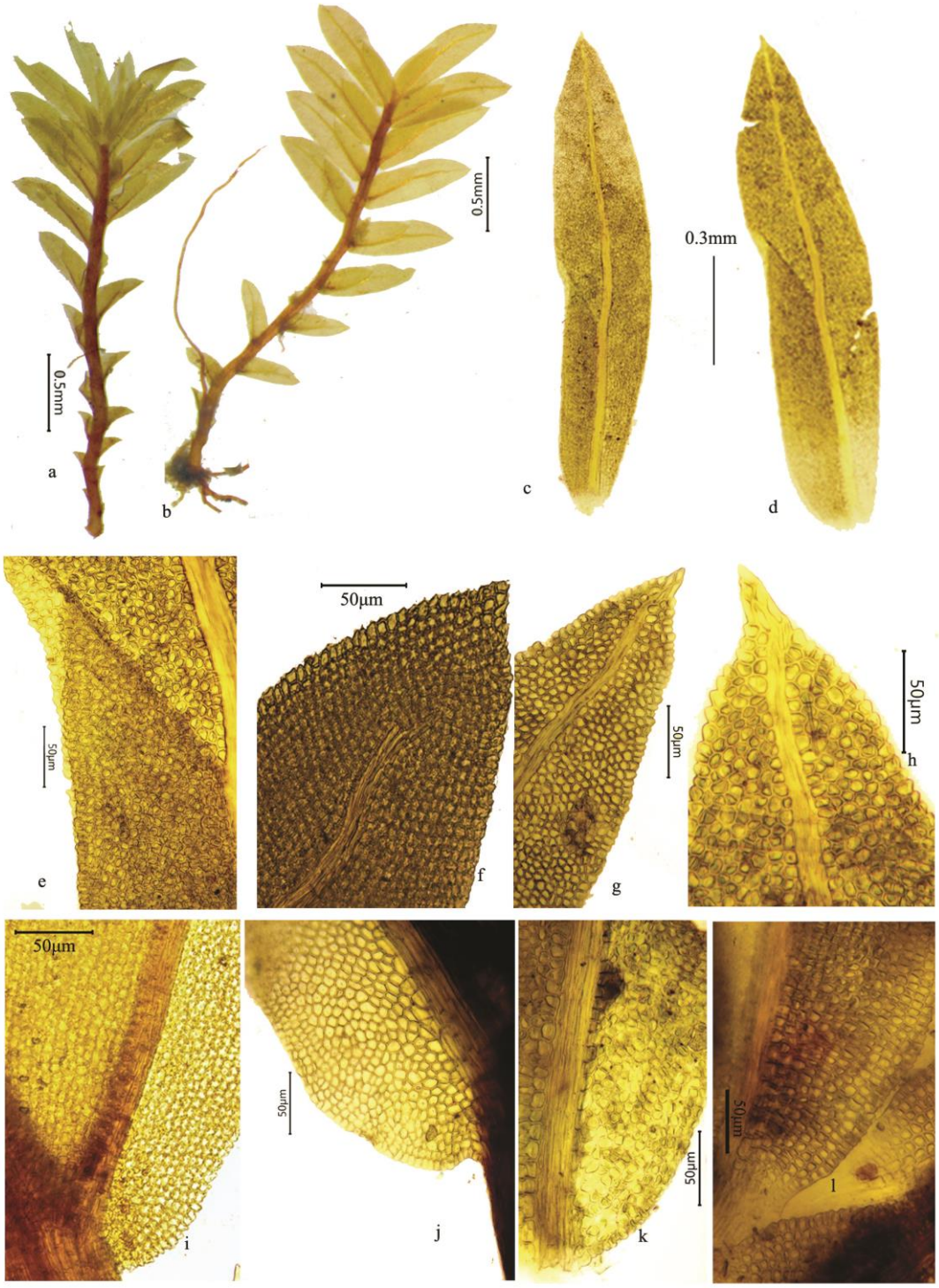


Plate 94. *Fissidens pokhrensis* Nork. *ex* S.S. Kumar, a&b. habit, c&d. vegetative leaves, e. vaginant laminae apex, f-h. leaf apex, i-k. dorsal lamina base near insertion, l.vaginant laminae base (photos from Norkett 12192 BM!)

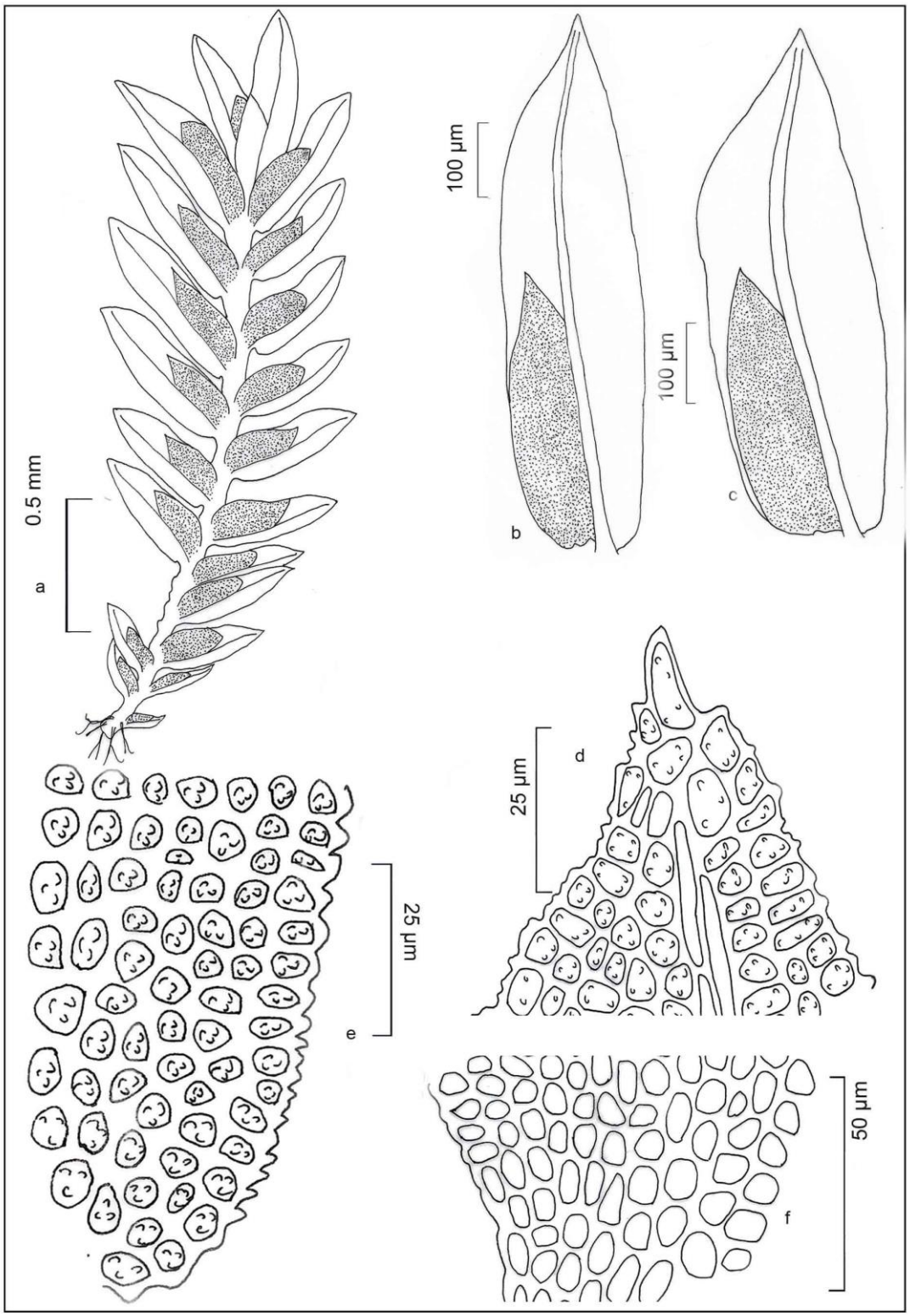
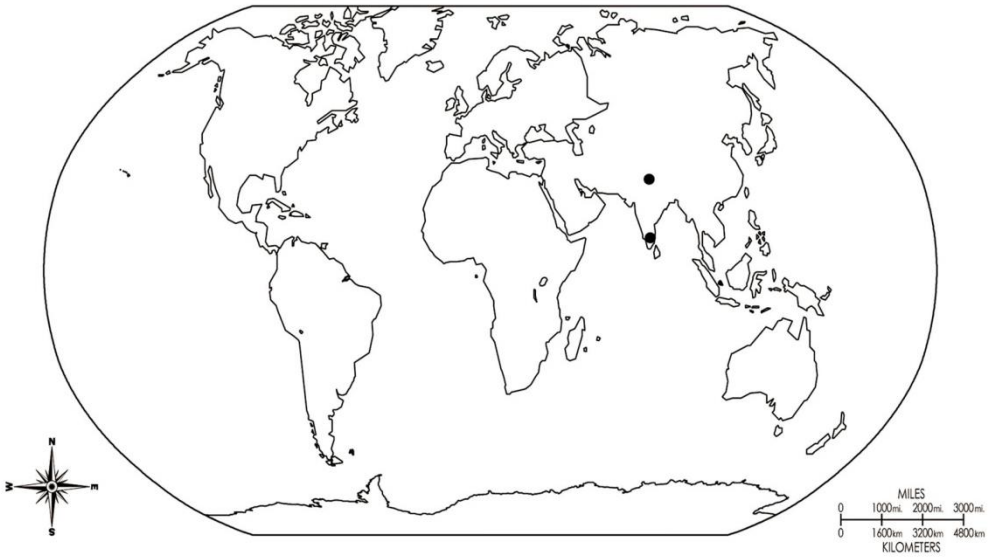
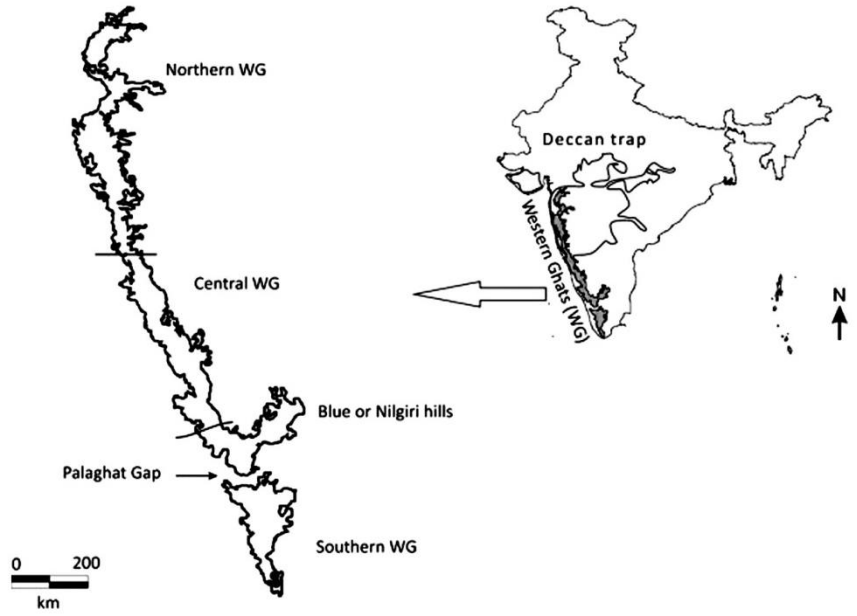


Fig. 49. *Fissidens pokhrensis* Nork. *ex* S.S. Kumar, a. vegetative plant, b&c. vegetative leaves, d. leaf apex, e. dorsal lamina base near insertion, f. vaginant laminae base.



Map 55A. World distribution of ***Fissidens pokhrensis*** *Nork. ex S.S. Kumar*



Map 55B. Distribution of ***Fissidens pokhrensis*** *Nork. ex S.S. Kumar in Western Ghats*

Specimens examined: India, Tamil Nadu, Kanyakumari District (Ashambu, 360-430m), 05.11.2005, Leena (28 SCCN 2211!); Himachal-Pradesh, Simla, 2300 m, A.H. Norkett (12192 (2)) (BM!); Uttarakhand, Nainital, (2-3 miles from Nainital), 28.09.70, A.H. Norkett (14452A, 14461A) (BM!).

Fissidens pulchellus Mitt., J. Proc. Linn. Soc., Bot., Suppl. 2: 140. 1859; Bruehl, Rec. Bot. Surv. India 13(1): 18. 1931; Gangulee, Moss. E. India & Adj. 1: 524. 1971; Iwatsuki & Suzuki, J. Bryol. 27: 241. 2005; Lal, Checklist Indian Moss. 63. 2005; Daniels & Kariyappa, Curr. Sci. 93(7): 981. 2007 (as *F. pulchellus* and *F. subpulchellus*); Daniels & Daniel in Nath & Asthana, Curr. Trends Bryol.: 235. 2007; Manju *et al.*, Tropical Bryol. Res. Rep. 7: 12. 2008b*;* Daniels, Archive Bryol. 65: 56. 2010; Daniels & Daniel, Bryof. South. W. Ghats. 48. 2013.

Type: India (W. Bengal), Darjeeling, Tongloo ca.2800m, J.D.Hooker s.n. (BM!).

F. subpulchellus Nork., Mosses E. India 2: 521. f. 246. 1971.

Plant dull green in herbarium, tip curls when dry; axillary hyaline nodules not differentiated; rhizoids brownish, smooth, axillary and basal; stem 3-5 x 1-1.5mm, 7-9 pairs of leaves; leaves oblong lanceolate, apex apiculate, margin denticulate with sharp cells, 0.82-1.01 x 0.68-0.93 mm, 2 times long as wide; limbidium absent; vaginant laminae open, joining below margin, uniseriate 7.40-7.67 x 4.51-5.39 µm; dorsal laminae round, slightly decurrent or not, dorsal lamina and apical lamina uniseriate; costa excurrent in short apiculus or ending at the apex, bryoides type; laminal cells compactly arranged, irregularly quadrate to hexagonal, one or two conical papillae in each cell, juxta costal cells slightly elongated; gemmae not formed (Plate 95 & Fig.50).

Fertile parts not observed.

Diagnostic characters: *F. pulchellus* Mitt. is characterised by denticulate margin with sharp cells, open vaginant laminae, one or two papillose laminal cells and slightly elongated juxta costal cells. This species shows similarities with *F. longtonianus* in leaf margin and longitudinal perforations of peristome while laminal

cells of *F. longtonianus* are smooth, whereas those of *F. pulchellus* are papillose. The setae of *F. pulchellus* are longer and capsule is exserted than those of *F. longtonianus* in which setae are short and capsule is emergent. The spores of *F. longtonianus* are larger than those of *F. pulchellus.*

Note: Gangulee (1971) reported *F. subpulchellus* Nork. as a separate species from *F. pulchellus* Mitt. because of the denticulate leaf margin, less distinct cell papillosity, perforated peristome teeth and smooth spores. In the protologue of *F. subpulchellus* Nork. described its peristome as not split but perforated with unequal limbs. Iwatsuki and Suzuki (2005) synonimised *F. subpulchellus* under *F. pulchellus* based on the presence of papillae which is clear in cross section and undivided or perforated peristome of *F. subpulchellus* which are similar to *F. pulchellus*.

Habitat and General Ecology: On land cuttings in evergreen and shola forests from low to high altitudes.

Distribution: India (Arunachal Pradesh (as *F. subpulchellus*), Darjeeling, Kerala, Tamil Nadu (Daniels, 2010; Daniels & Daniel, 2013; Daniels & Kariyappa 2007; Gangulee, 1971; Iwatzuki & Suzuki, 2005; Manju *et al.*, 2008b); East Nepal (Iwatzuki & Suzuki, 2005). (Map 56A&56B)

Specimens examined: India, Kerala, Kannur district, Aralam WLS, Paripputhodu (150m), 06.02.2003, Manju 87597/b (CALI!); Ambalappara (1110 m), K.P. Rajesh 99823 (CALI!),); Wayanad district, Muthanga WLS, 02.11.2017, Chandini (ZGC 10860); Holotype of *F. subpulchellus* Nork. Summit of Bapu, (Abor hills) (alt: 6240 ft), 31.01.1912, I.H.Burkill (36563 BM!, CAL!).

Etymology: The term *pulchellus* denotes the evenly denticulate leaf margin of this species.

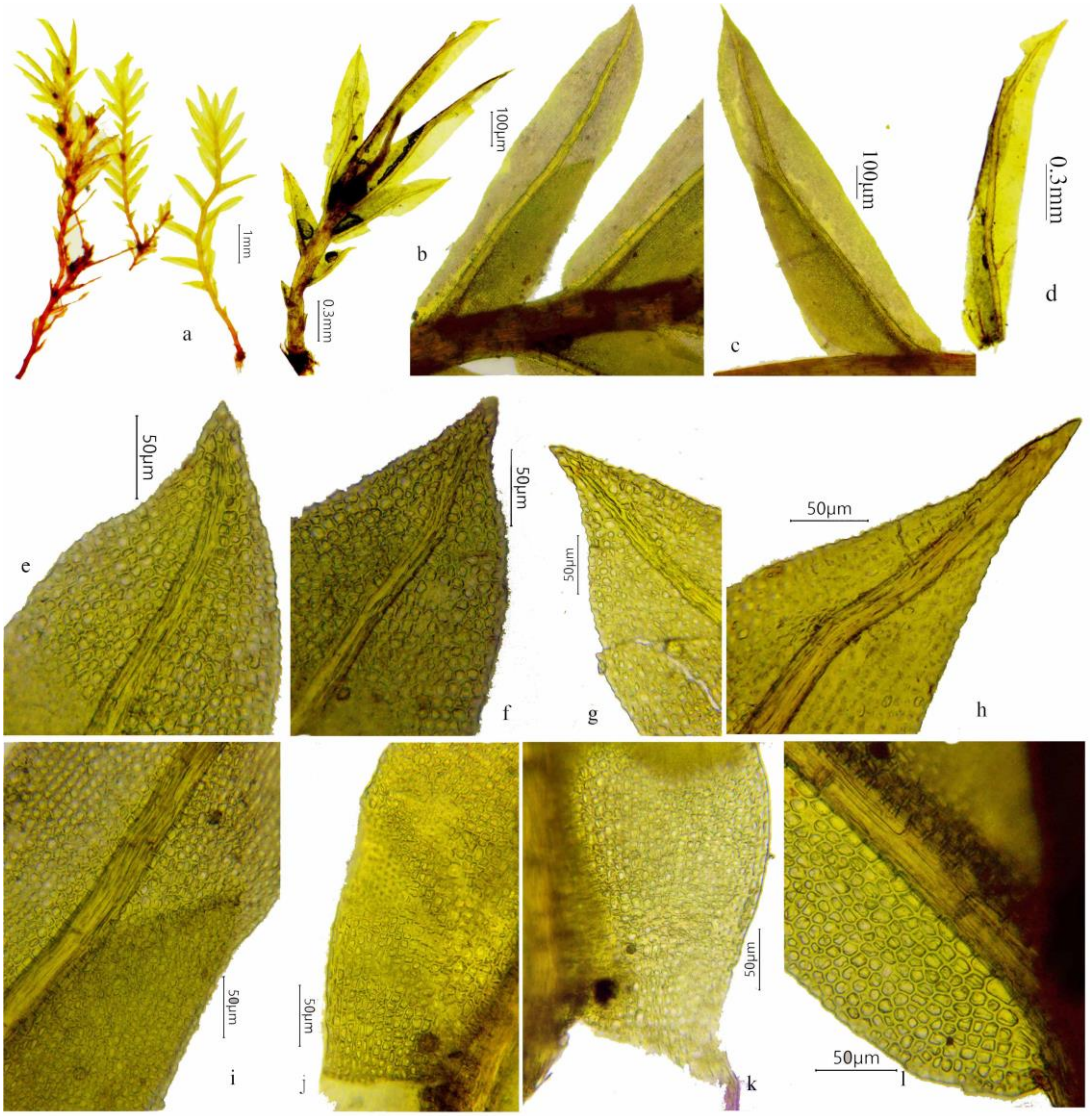


Plate 95. *Fissidens pulchellus* Mitt., a. Vegetative plant, b&c. vegetative leaves, d. perichaetial leaf, e-h. leaf apex, i. vaginant laminae apex, j&k. vaginant laminae base, l. dorsal lamina base near insertion (photo from Burkill 36563 BM!)

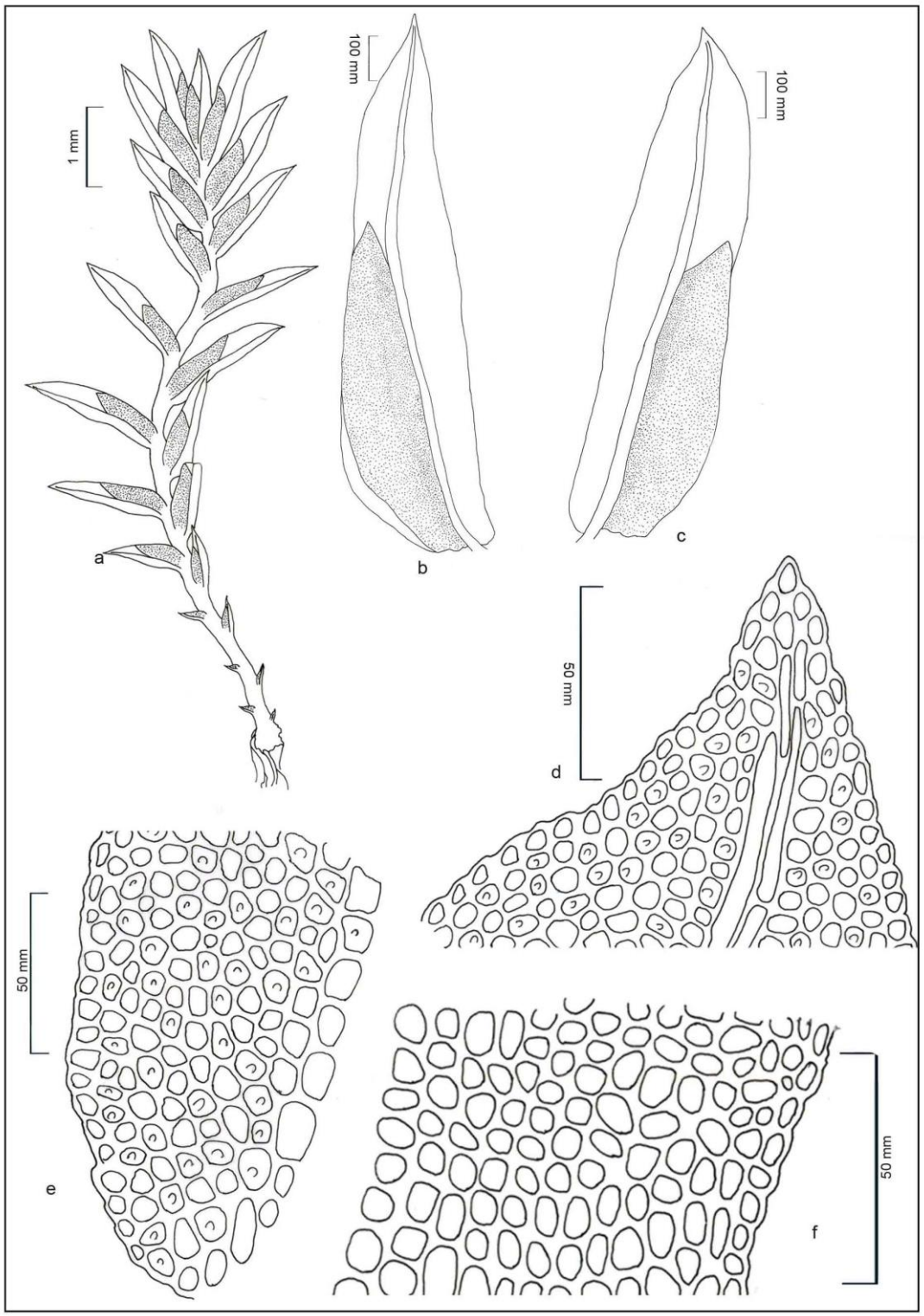
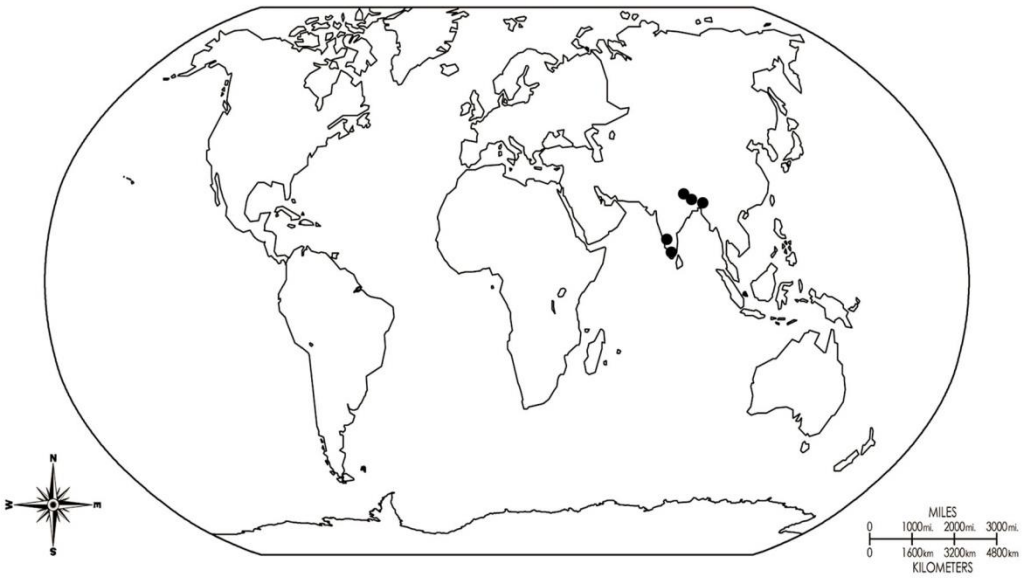
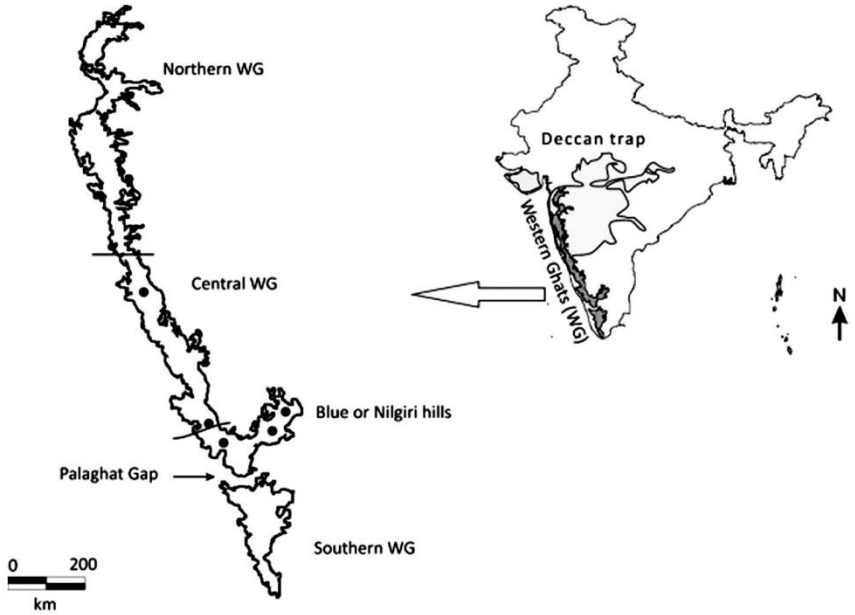


Fig. 50. *Fissidens pulchellus* Mitt., a. vegetative plant, b&c. vegetative leaves, d. leaf apex, e. dorsal lamina base near insertion, f. vaginant laminae base



Map 56A. World distribution of ***Fissidens pulchellus*** *Mitt.*



Map 56B. Distribution of ***Fissidens pulchellus*** *Mitt. in Western Ghats*

Fissidens ranchiensis Gangulee, Bull. Bot. Soc. Bengal 11: 68. f. 7. 1957[1959]; Gangulee, Moss. E. India & Adj. 1(2): 495. F. 230. 1971; Lal, Checklist Indian Moss. 63. 2005; Daniels & Daniel, Bryo. South. W. Ghat. 48. 2013.

Type: India, Bihar, Chotanagpur, Ranchi, Gangulee 2460I (CAL!).

Plants 2.0-2.5 mm long, caespitose, green; rhizoids basal, smooth; axillary hyaline nodules absent; leaves 4-10 pairs, alternate, curled but not contorted when dry, 0.2-0.6 x 0.01-0.03 mm, ovate lingulate, corrugate at margin, apically symmetric, leaf apex acute or ends in short apiculus formed by cells of costae; limbidium on vaginant laminae base of perichaetial leaf only, completely absent in vegetative leaves, one rowed or rarely two rowed, smooth, elongate, pellucid cells; vaginant laminae open, equal or not; dorsal lamina narrowing towards base; costa stout, ending below apex; laminal cells rounded hexagonal, mammillose, apical cells 4-10 x 2-6 µm, median cells 5-10 x 3-6 µm, basal cells 6-10 x 3-6 µm; gemmae not found.

Fertile parts, perigonium and perichaetium not found, seta 2.0-2.5 mm long, capsule 0.8-1.0 x 0.4-0.6 mm, brown, peristome teeth spirally thickened, spores 25-30 µm, globose, smooth (Plate 96 & Fig.51).

Diagnostic characters: *F. ranchiensis* Gangulee is characterised by small plants, ovate lingulate leaves, rounded hexagonal mammillose laminal cells and open vaginant laminae.

Habitat and General Ecology: On bark of trees and on large rocks in moist deciduous forest with an altitudinal range of 500-750 m.

Distribution: India (Bihar, Madhyapradesh, Maharashtra, Tamil Nadu, West Bengal (Daniels & Daniel 2013; Gangulee, 1971; Lal, 2005) and Nepal (Gangulee, 1971) (Map 57A&57B).

Specimens examined: India, Kerala, Shenduruny WLS, 27.08.2009. Felix, R. 539 (SCCN!); Jharkhand; Ranchi (650m), 01.11.56, Anon. (2460I) (CAL!).

Etymology: The specific epithet is after the type locality.

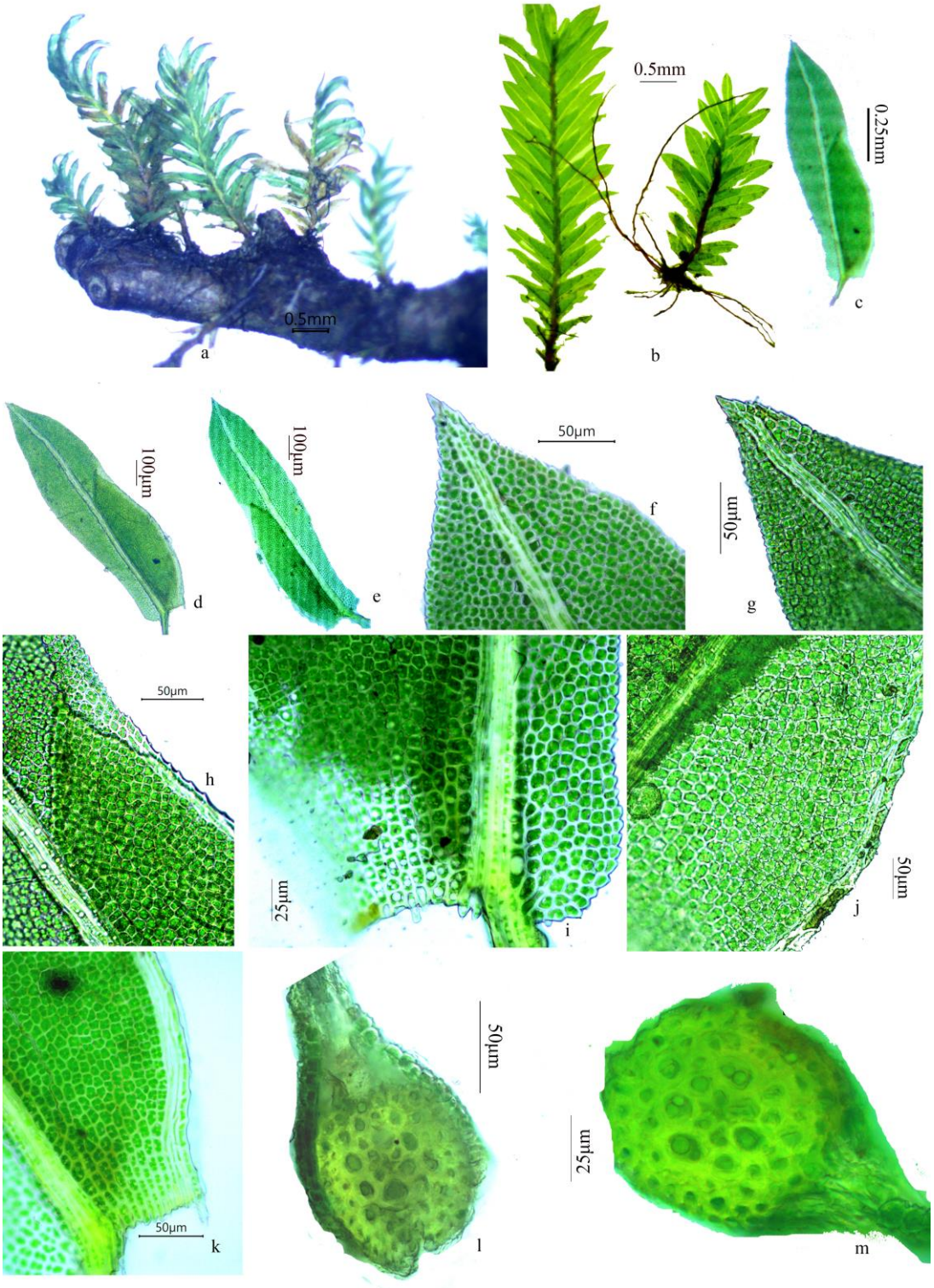


Plate 96. *Fissidens ranchiensis* Gangulee, a. habit, b. vegetative plants, c-e. vegetative leaves,f&g. leaf apex, h. vaginant laminae apex, i. leaf base, j. vaginant laminae cells, k. vaginant laminae base, l&m. stem T.S.

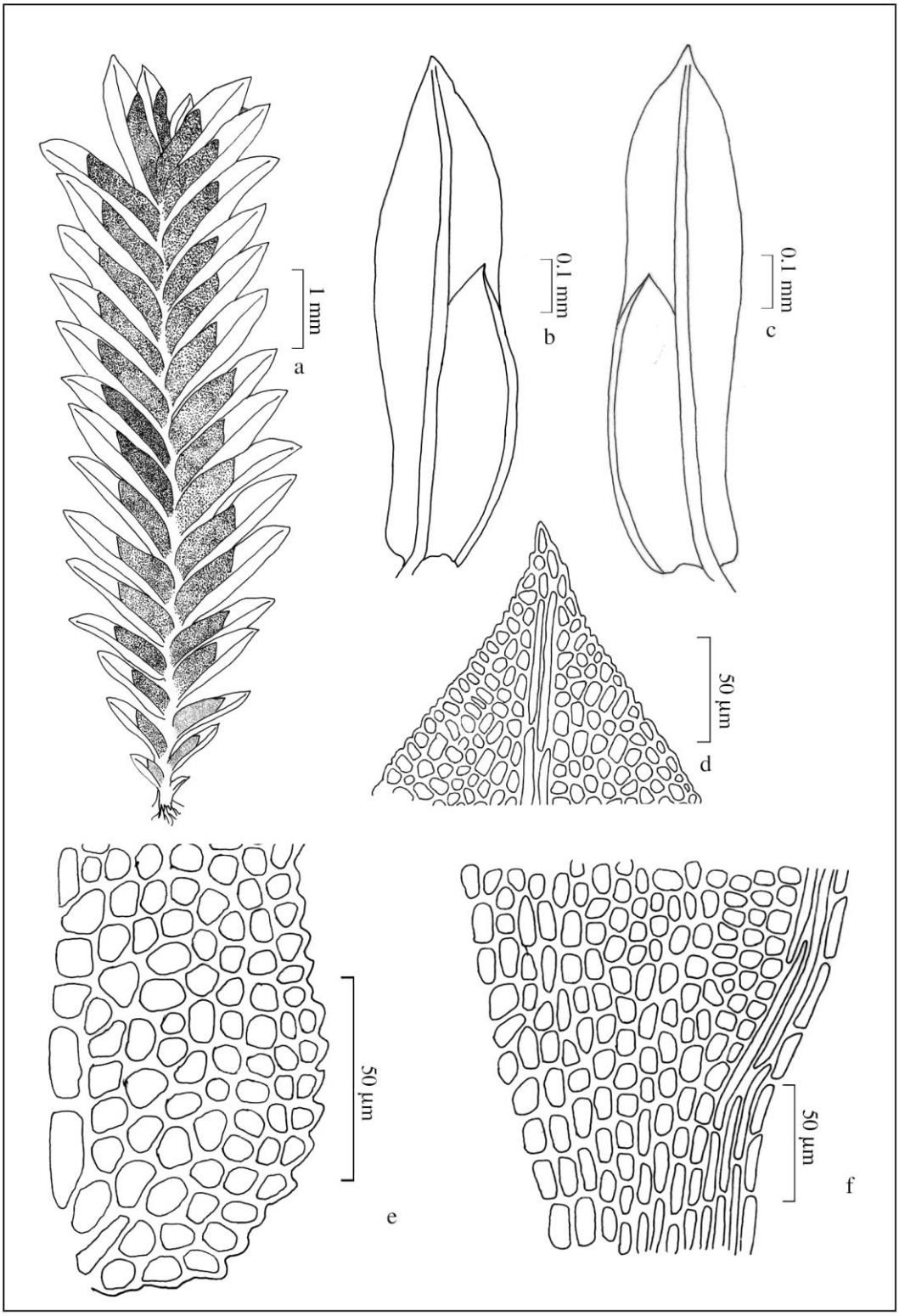
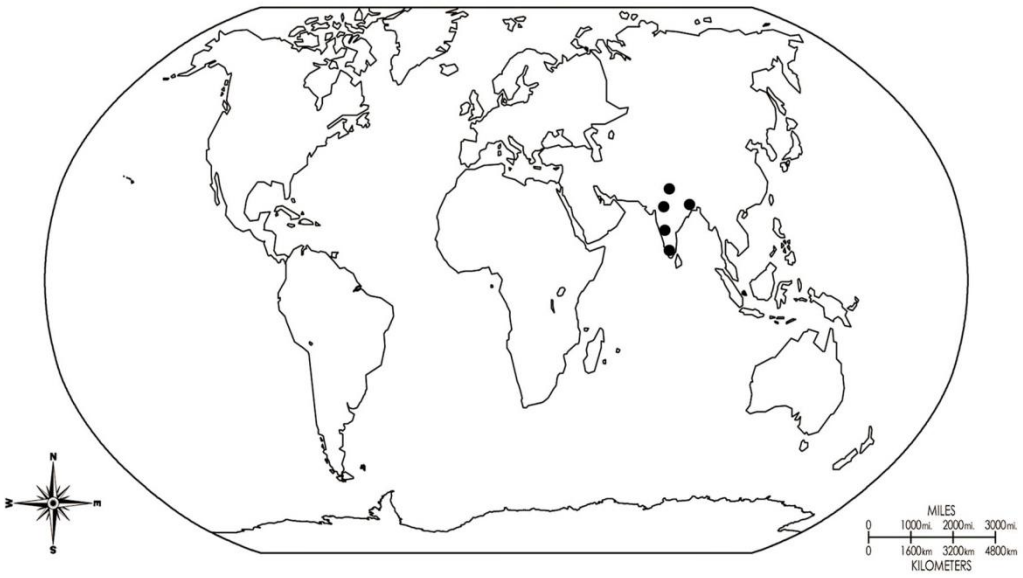
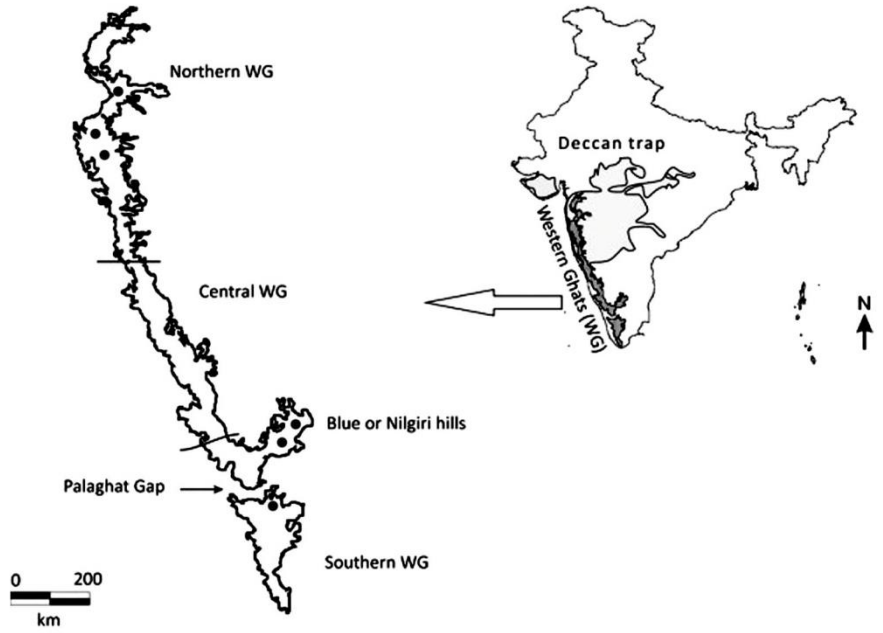


Fig. 51. *Fissidens ranchiensis* Gangulee, a. vegetative plant, b&c. vegetative leaves, d. leaf apex, e. dorsal lamina base near insertion, f. vaginant laminae base.



Map 57A. World distribution of ***Fissidens ranchiensis*** *Gangulee*



Map 57B. Distribution of ***Fissidens ranchiensis*** *Gangulee in Western Ghats*

Fissidens sedgwickii Broth & Dixon, J. Bot. 48: 305. 507 f. 1. 1910; Schwarz & Frahm, Polish Bot. J. 58(2): 519. 2013.

Type: India, Maharashtra (Mahabaleshwar, Dhobis' waterfall) Sedgwick 51. (BM!)

Plants strong, rigid, stem mostly unbranched, perigonial branches common from sterile plants; rhizoids basal, smooth; sterile plants 12.0-13.0 x 0.2 mm, cortical cells thick walled, central strand not differentiated; leaves 1.3-1.5 x 0.25-0.29 mm, leaves lanceolate, stiff and strong, base broad, narrows towards apex, margin entire, apex acute to widely acute; limbidium on vaginant laminae base, ends before reaching vaginant laminae apex; costa stout, reaching leaf apex, vaginant laminae reaching more than 1/2 or 3/5 of leaf length, vaginant lamina base broad, open, minor laminae open, bistratose towards costa, unistratose towards margin; dorsal lamina base not round, not decurent, margin smooth, bistratose; laminal cells smooth, thick walled, 8.0-10.0 µm long, cells of vaginant laminae base near costa large, 13.7-15.0 µm long; gemmae not found.

Fertile plants, perigonial branches small, 5-7 pairs of leaves, perigonial leaf small, vaginant laminae base broad, apical lamina and dorsal lamina narrowed; perichaetium terminal, perichaetial leaves 2.0-2.3 mm long, vaginant lamina base slightly modified; sporophyte not seen (Plate 97,98 & Fig.52).

Diagnostic characters: This is an aquatic species and is characterised by strong and rigid plant with lanceolate leaves, bistratose dorsal lamina, smooth cells and limbidium restricted to vaginant laminae base. This species is similar to *F. grandifrons* in leaf shape and leaf apex while the leaves are elimbate and cell wall of laminal cells in *F. sedgwickii* is more thickened than *F. grandifrons* which has elimbate leaves.

Habitat and General Ecology: On submerged rocks in flowing water in evergreen forests.

Distribution: India (Karnataka, Kerala (present collection), Maharashtra (Dabhade, 1998; Lal, 2005; Frahm *et al.*, 2013*;* Magdum *et al*., 2017; Schwarz & Frahm, 2013; Schwarz, 2014b; Sedgwick, 1910); Thailand (Crosby, *et.al*., 1999). The present collection is a new record for Kerala (Map 58A&58B).

Plate: 97. *Fissidens sedgwicki* Broth. & Dixon, (aquatic; photo taken using Nikon SLR camera from lab)

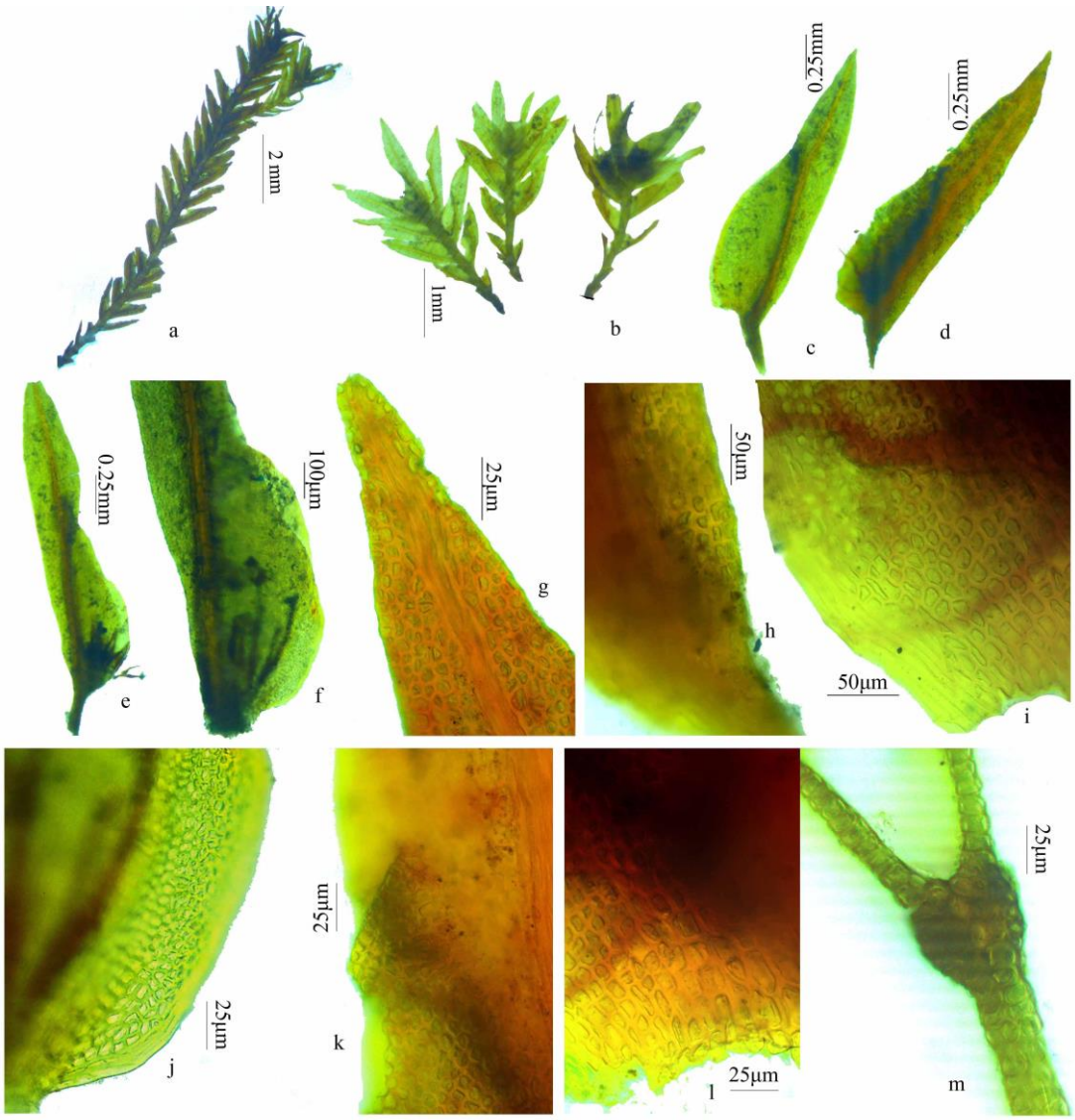


Plate 98. *Fissidens sedgwickii* Broth. & Dixon, a. vegetative plant, b. fertile branches, c&d. vegetative leaves, e&f. perichaetial leaves, g. leaf apex, h. dorsal lamina base near insertion, i,j&l. vaginant laminae base, k. vaginant laminae apex, m. leaf T.S. (photo from Sedgwick 51 BM!)

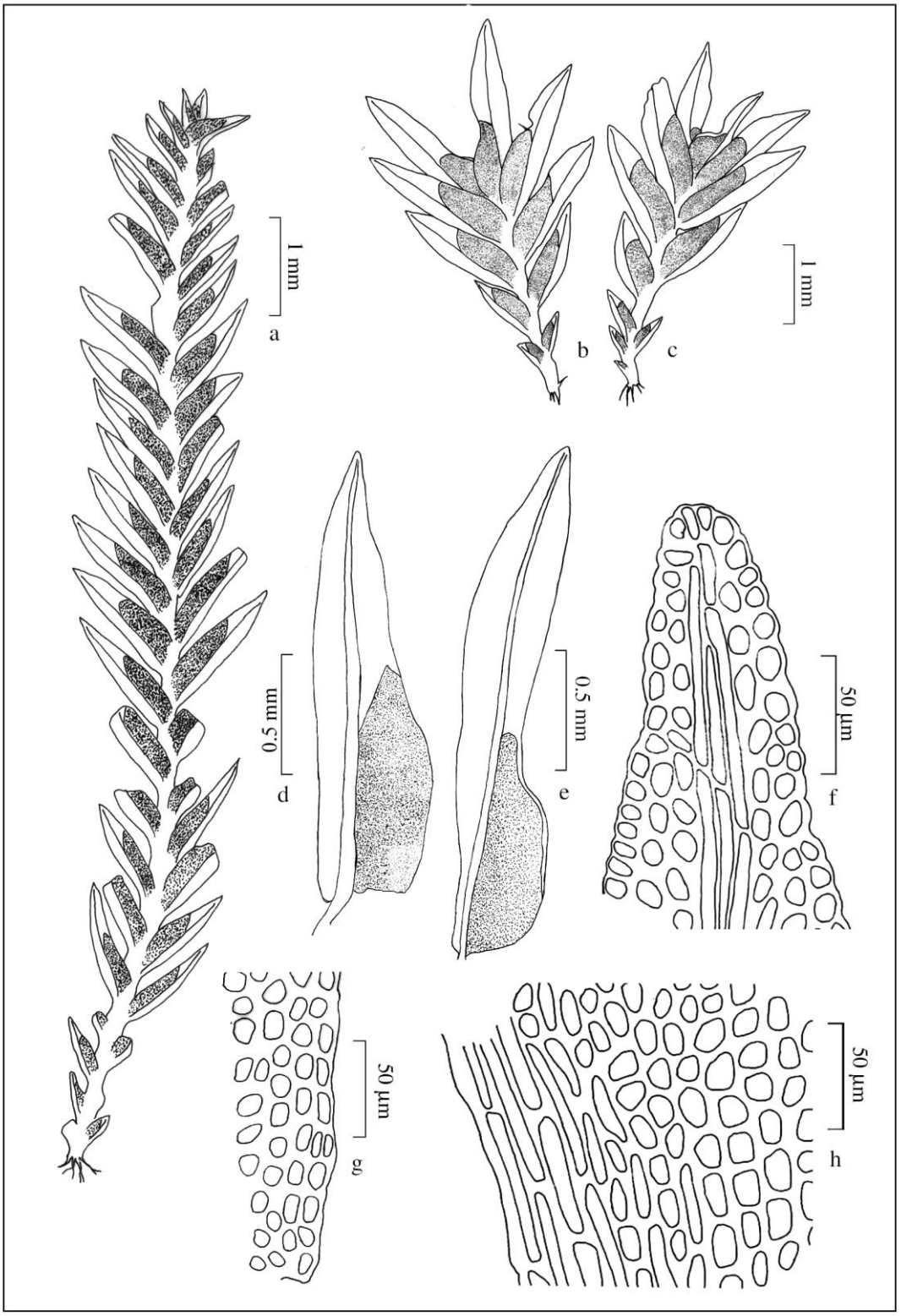
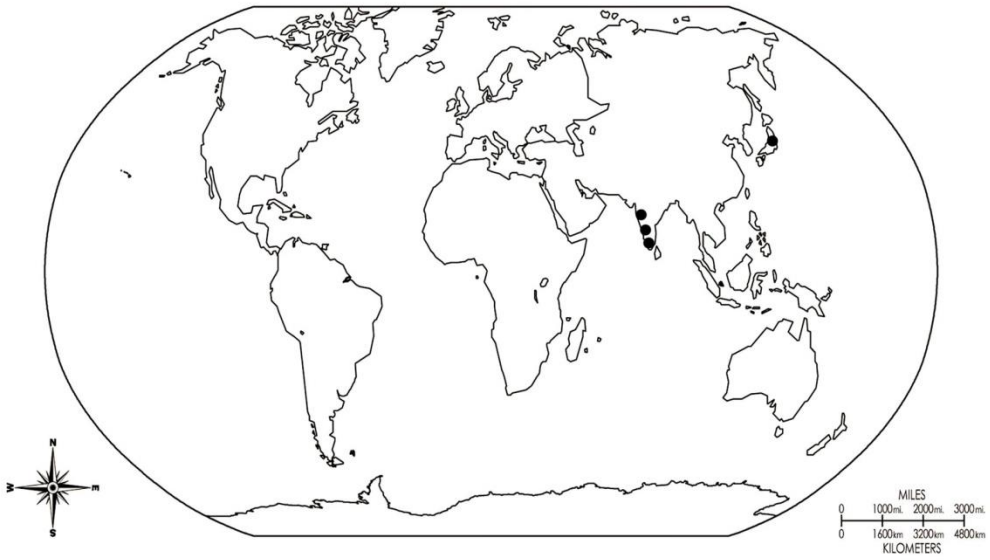
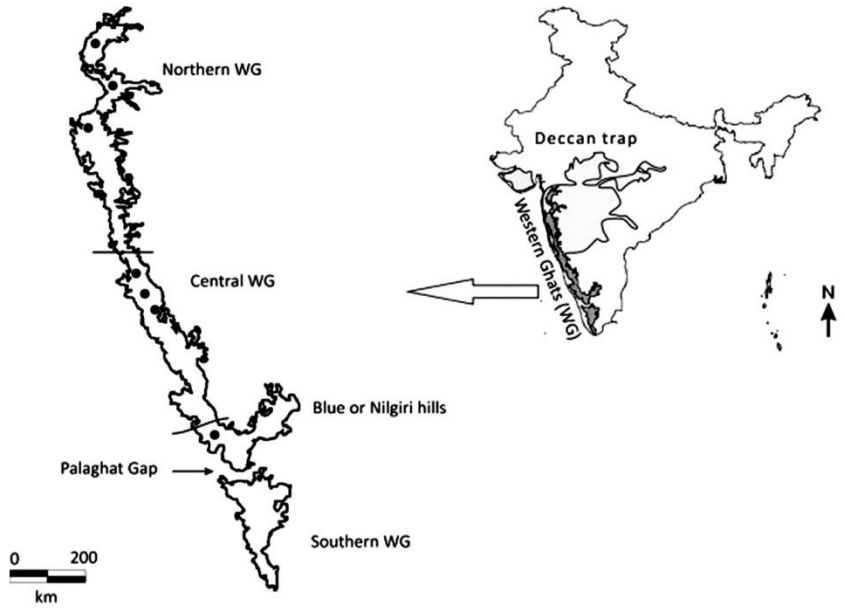


Fig. 52. *Fissidens sedgwickii* Broth. & Dixon, a. vegetative plant, b&c. perigonial plants, d. vegetative leaf, e. perigonial leaf, f. leaf apex with costa, g. dorsal lamina base, h. vaginant laminae base with limbidium.



Map 58A. World distribution of ***Fissidens sedgwickii*** **Broth. & Dixon**



Map 58B. Distribution of ***Fissidens sedgwickii*** **Broth. & Dixon in Western Ghats**

Specimens examined: India, Kerala, Kannur district (Aralam WLS, Meenmutti, $11^0$56'65.5" N, $75^0$52'90" E, 800m), 17.09.2015, Manjula (ZGC 15648), Kerala, Kannur district, Aralam WLS, Ambalapara (864m), 06.04.2016, Chandini (ZGC 4315); Kozhikode district, Thusharagiri, II water fall (), 14.111.2017, Chandini (ZGC 10851); Maharashtra (Mahabaleshwar, Dhobis' waterfall) Sedgwick 51. (BM!).

Etymology: The specific epithet is in honour of 'L.J. Sedgwick' who collected the type specimen of this species from Mahabaleshwar.

Fissidens serratus Muell. Hal., Bot. Zeitung (Berlin) 5: 804, 1847; Iwatsuki & Suzuki, J. Hattori Lab. 51: 395. 1982; Eddy, A Handb. Malay. Mosses 1: 90. 1988; Li & Iwatzuki, Moss Fl. China 2: 58. 2001; Manju *et al*., Tropical Bryol. Res. Rep. 7: 12. 2008b; Pursell, Fl. Neotrop. Monogr. 101: 185. 2007; Bruggeman-Nannenga & Arts, J. Bryol. 32: 201.2010.

Type: Indonesia: Java, Tjivodjas, Fleischer s.n. (neotype FH).

Conomitrium serratum (Muell. Hal.) Muell. Hal., Syn. 2: 527, 1851; *Fissidens dimorphus* Muell. Hal., Syn. Musc. Frond. 2: 533. 1851; *F. tenellus* Hook. f. & Wilson, Fl. Nov.-Zel. 2: 62. pl. 83: f. 6. 1854; *Conomitrium perpusillum* Muell. Hal. & Hampe, Linnaea 28: 214. 1856; *C. pseudoserratum* Muell. Hal., Bot. Zeitung (Berlin) 17: 197. 1859; *C. wilsoni* Muell. Hal., Bot. Zeit. 17: 197, 1859; *Fissidens wilsonii* Muell. Hal., Bot. Zeitung (Berlin) 17: 197. 1859; *F. australiensis* A.Jaeger, Enum. Fissident. 24. 1869; *F. pseudoserratus* (Muell. Hal.) A.Jaeger, Enum. Fissident. 24. 1869; *F. papillosus* Sande Lac., Verh. Kon. Akad. Wetensch., Afd. Natuurk. 13: 1. 1A. 1872; *F. donnellii* Austin, Bot. Gaz. 4: 151. 1879; *Conomitrium trachelymum* Sull., Linnaea 42: 466. 1879; *C. puiggarii* Geh. & Hampe, Vidensk. Meddel. Dansk Naturhist. Foren. Kjøbenhavn 4, 1: 161. 1879; *F. tenerrimus* Muell. Hal. in Broth., Acta Soc. Sci. Fenn 19: 10. 1893; *F. dimorphus* Muell. Hal. Hedwigia 38(Beibl.): 57. 1899; *Conomitrium trichopodium* Muell. Hal. Hedwigia 39: 243. 1900; *Fissidens iporanganus* Besch. & Geh., Rev. Bryol. 28: 63. 1901; *F. trichopodius* (Muell. Hal.) Broth., Nat. Pflanzenfam. I(3): 357. 1901; *F. crenatoserrulatus* Cardot, Rev. Bryol. 36: 70.1909; *F. perangustifolius* Broth. & Paris in Broth., Őfvers. Finska Vetensk.-Soc. Förh. 51A(17): 8. 1909; *F. sparsus* Broth. & Paris in Broth., Őfvers. Finska Vetensk.-Soc. Förh. 53A(11): 10. 1911; *F.*

tocoraniensis Herzog, Biblioth. Bot. 88: 5. 1. 1920; *F. diversiretis* E.B. Bartram, Philipp. J. Sci. 68: 21. f. 22. 1939; *F. vardei* Thé., Mem. Sc. Cub. Hist. Nat. "Felipe Poey" 13: 208. 1939; *F. jamaicensis* Britton *ex* Grout, Bryologist 44: 143. 1941; *F. echinellus* Herzog, Rev. Bryol. Lichénol. 23: 68. 1954; *F. eenii* Bizot, Svensk Bot. Tidskr. 62:473. 1968; *F. subexasperatus* Bizot & Dury *ex* Pócs, Rev. Bryol. Lichénol. 40: 135. 1974; *F. buckii* Pursell, Bryologist 88: 74. 1985;

Plants small, growing in scattered mass along with other mosses and liverworts; rhizoids brownish, smooth; axillary hyaline nodules absent; plants 1-2 x 0.30-1.00 mm long, not branched, light green, four or five pairs of leaves, stem strong, central strand lacking; leaves lanceolate, 0.45-0.65 x 0.10-0.17 mm, five times long as wide, margin highly serrate or dentate, leaf apex acute or narrowly acute; limbidium absent, vaginant laminae 0.26-0.32 mm, reaching ½ or more of leaf length, 78-88 µm wide at base, margin serrate, open, unequal, minor lamina apex towards costa unistratose; dorsal lamina narrows towards leaf insertion, base 1-3 cells wide, 20.70-36.48 µm, margin serrate, base slightly round or not, not decurrent, dorsal lamina and apical lamina unistratose; costa bryoides type, percurrent, rarely short excurrent; laminal cells irregularly quadrate to polygonal, chlorophyllose, moderately thick walled, single conical papillae at centre or mamillose, cells of vaginant laminae near costa slightly large, smooth, 16.32-17.98 x 4.99-6.79 µm; apical laminal cells 10.89-13.04 x 7.03-8.10 µm; gemmae rarely present on leaf, 0.09-0.14 mm long.

Monoicous (rhizautoicous); Perigonia not found; perichaetial plant separate or as proliferating branch from older vegetative plant, attached with rhizoids, 3-5 mm long, 3-5 pairs of leaves; perichaetial leaves large, linear lanceolate, 1.21-1.52 x 0.20-0.24 mm, dorsal lamina joins to costa before leaf insertion; archegonium 90-140 µm; sporophyte 1.71-2.51 mm, setae 1.3-2 mm, smooth; capsule 0.41-0.51 x 0.17-0.30 mm, 15-17 files of rectangular exothecial cells with trigones in upper cells; peristome scariosus type, minute papillae at undivided base, 28.65-33.22 µm wide at base, tooth 0.10-0.17 mm long; calyptra and operculum not found; spore globose, 16.28-16.92 µm (Plate 99 & Fig.53).

Diagnostic characters: *F. serratus* Muell. Hal. is characterised by very small plants with finely serrate to serrulate leaf margin, lanceolate leaf with acute to narrowly acute apex, elimbate, costa usually ending 2-5 cells below apex or

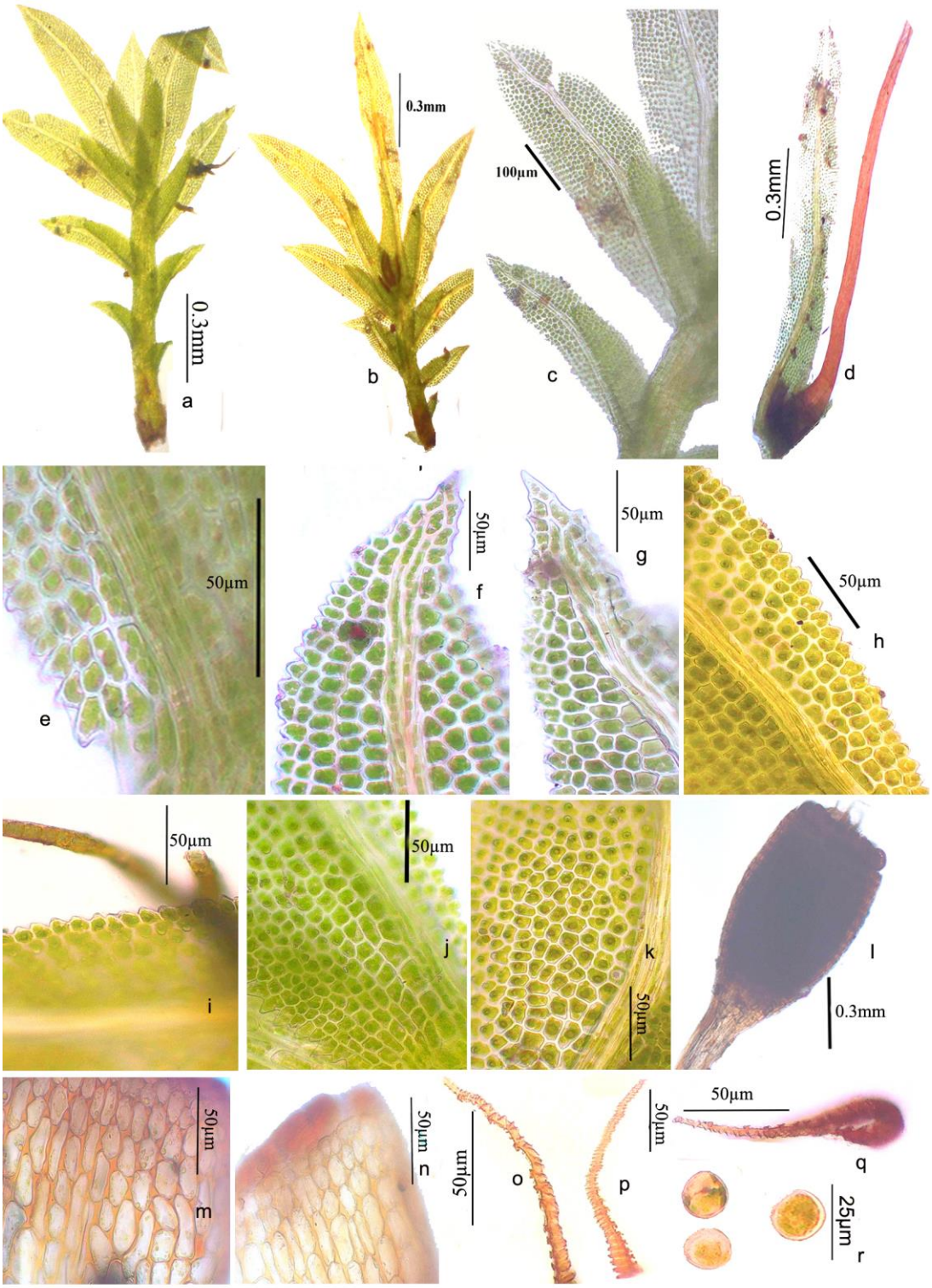


Plate 99. *Fissidens serratus* Müll. Hal., a. vegetative plant, b. perichaetial plant, c. vegetative leaf, d. perichaetial leaf, e. dorsal lamina near insertion, f&g. leaf apex, h. dorsal lamina margin, i. foliar gemmae, j. vaginant laminae base, k. laminal cells, l. capsule, m&n. exothecial cells, o-q. peristome, r. spores.

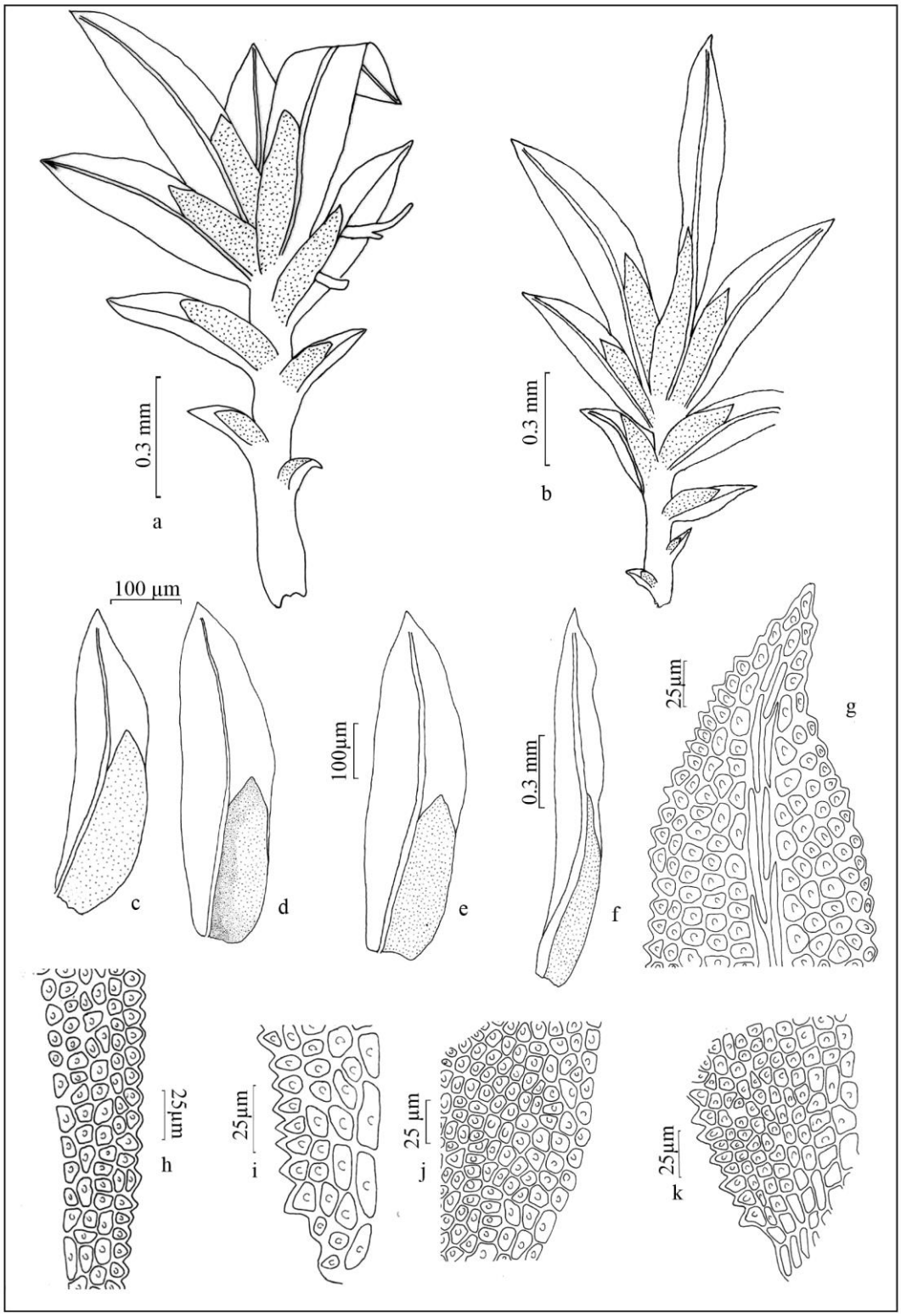


Fig. 53. *Fissidens serratus* Müll. Hal., a. vagetative plant,b. perichaetial plant, c-e. vegetative leaves, f. perichaetial leaves, g. leaf apex, h. laminal cells, i. dorsal lamina base, j&k. vaginant laminae base.

percurrent, thick walled irregularly rectangular or polygonal laminal cells with one distinct papillae in each cell except juxta costal cells and scariosus type peristome.

Note: Bruggeman-Nannenga and Wigginton (2012) commented that *F. serratus* Muell. Hal. is a highly variable species with monomorphic to dimorphic stem, strongly branched; perichaetial leaves with weak, short limbidia on mid vaginant lamina, about 32 columns of exothecial cells and axillary hyaline nodule weakly differentiated. According to Iwatsuki and Suzuki (1982) stem simple or rarely branched with slightly developed axillary hyaline nodule, leaves elimbate and percurrent to shortly excurrent costa. *F. serratus* Muell. Hal. is similar to *F. crenulatus* Mitt. in leaf shape, marginal cell projection and single mamillose laminal cells but plants are very small and vegetative leaves are completely elimbate in *F. serratus.*

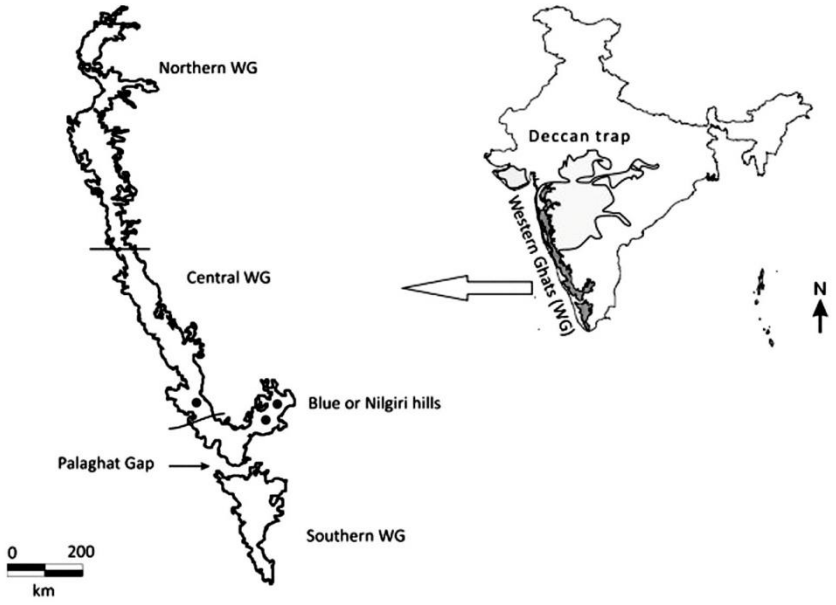
The present collection is more similar with Bruggeman-Nannenga and Wigginton (2012) in usually unbranched monomorphic stem, absence of axillary hyaline nodules, vaginant lamina serrate or weakly limbate in perichaetial leaf and juxtacostal cells of vaginant lamina larger and quadrate to oblong and pellucid cells.

Mueller (1850-1851) listed *F. wilsoni* Mont. as a synonym of *F. serratus* Muell. Hal. Later in 1859 he separated it as a distinct species from *F. serratus* Muell. Hal. According to the description of Mitten (1873) in the type of *F. wilsonii* Mont. from Nilgiri it is clear that *F. wilsonii* Mont. also have distinctly unipapillose laminal cells and shortly excurrent costa. Since these characters are similar to *F. serratus* Muell. Hal., *F. wilsonii* Mont. is considering as a synonym of *F. serratus* Muell. Hal. in the present study.

Habitat and General Ecology: Growing on land cuttings as scattered mass along with other bryophytes such as *Fissidens curvatus* Hornsch., *Asterella khasiana* (Griff.) Grolle and *Fossombronia sp.* in semi evergreen forests. Also found on rocky patches on evergreen forests. The plant prefer shady regions where direct sunlight will not reach.

Distribution: India (Kerala, Tamil Nadu) (Manju *et al.,* 2008b; Mitten, 1859; Mueller, 1853; Karnataka (Schwarz, pers.comm); Argentina, Australia, Belize, Bermuda, Brazil, Caribbean, Central America, China, Colombia, Costa Rica, Ecuador, Fiji, Guatemala, Guyana, Honduras, Indonesia, Jamaica, Japan, Java, Mexico, Paraguay, Philippines, Puerto Rico, Sri Lanka, South America (Brazil,

Map 59A. World distribution of Fissidens serratus Müll. Hal.



Map 59B. Distribution of Fissidens serratus Müll. Hal. in Western Ghats

Chile), Suriname, Venezuela, West Indies, (Iwatsuki & Suzuki 1982, 1996; Li & Iwatzuki, 2001; Mueller & Pursell 2003; Pursell, 2007). The only available report about the collection of this species from Western Ghat is by Mueller (1853, 1859) listed by Daniels (2010) and Manju *et al.* (2008b) (Map 59A&59B).

Specimens examined: India; Tamil Nadu, Coonoor (Way to Dolphin's Nose, 1629 m), 23.12.2015, Manjula & Deepa (ZGC 16011E); Kerala, Kannur district, Aralam WLS, Chavachi(180 m), MCN 87539, 87494 b (CALI); Vietnam (Kreau, 1000m), 30.01.1963, P. Tixier (460), Vietnam (Dafat, Tuyeu Duc), P. Tixier (458), Vietnam (Lang bian), P. Tixier (478) (BM!).

Etymology: The specific epithet *serratus* refers to the finely serrated margin of leaves, especially the vaginant laminae margin.

Fissidens speluncae Broth., Hedwigia 50: 124. 1910; Manjula *et al.*, Acta Bot. Hung. 57(1-2): 165–168. 2015b (as *F. linearis* var. o*bscurirete* (Broth. & Paris) I.G. Stone).

Type: Sri Lanka [Ceylon], in einer Felsenhoehle der Nanu Oya Schucht.

Plants medium sized 2-6 x 1-2 mm wide including leaves, tip curls in herbarium, 7-17 pairs of alternate leaves more crowded towards tip, usually unbranched with yellowish green coloured stem, stem 0.12-0.13 mm in diameter, central strand lacking; rhizoids brown, smooth; hyaline nodules absent; leaves lanceolate 0.86-1.23 x 0.22-0.29 mm, 4 times long as wide, leaf margin not entire due to projections of marginal cells, acute leaf apex and ends in a single costal cell; limbidium on vaginant laminae, four or five rows at vaginant laminae base, reaching the insertion; vaginant laminae open, unequal and reaching 1/2 or 2/3 of apical lamina, 0.12-0.15 mm wide at base, unistratose; dorsal lamina base round, dorsal lamina and apical lamina unistratose; costa prominent, yellowish green coloured, slightly excurrent; quadrate to irregularly hexagonal and compactly arranged laminal cells, pluripapillose, 4-6 papillae in each cells of vaginant laminal cells, four or five

papillae in apical and dorsal laminal cells, juxta costal cells not differentiated, tip cells ± 20 x 5 µm, mid dorsal laminal cells 7.30-8.20 x 3.99-6.66 µm, mid vaginant laminal cells 8.97-15.34 x 6.29-12.49 µm; gemmae not found.

Fertile plants; dioicous, perigonia terminal, plants 2.50-3.40 x 1.25-1.80 mm, perigonial leaves 0.80-0.95 mm long, antheridia 0.17-0.21 mm long; perichaetia terminal, plants 4.73-5.60 x 1.44-1.69 mm, perichaetial leaves 1.16-1.44 mm long, up to 10 rows of limbidium present at base of apical lamina and vaginant laminae base, archegonia 0.19-0.21 mm; sporophyte not found (Plate 100 & Fig.54).

Diagnostic characters: *F. speluncae* Broth.is characterised by slightly excurrent costae, lanceolate leaves with acute apex, 4-6 papillae in vaginant laminae cells, prominent limbidium on perichaetial leaf base. It can be confused with *F. ceylonensis* Dozy & Molk. which, however has intramarginal limbidium and oblong leaves.

Note: It is a very rare species distributed in limited areas. Manjula *et al.* (2015b) reported this species as *F. linearis* var. *obscurirete* (Broth. & Paris) I.G. Stone from Kerala as new record based on the same collection.

Habitat and General Ecology: On soil and land cuttings in evergreen forests and moist deciduous forest. In some collection this species is seen along with *F. walkeri* Broth.

Distribution: Sri Lanka (type), India (Kerala (present collection) (Map 60A&60B).

Specimens examined: India, Kerala, Thiruvananthapuram district (Agasthyamalai Biosphere Reserve, 1300m) 12.12.2013, Rajilesh (ZGC 732A), Malappuram district (Canoli plot, Nilambur, 50m), 24.07.14, Manjula (ZGC 671A), Idukki district (Way to Munnar from Marayoor, Munnar Udumalpet road, 1168m), 05.02.2014, Manjula (ZGC 996), Anamudi Shola NP, Mannavan shola (1700), 12.07.2017, Mufeed (ZGC 7324b); Palakkad district, Silent valley NP, Parathode (845m), 11.01.2018, Chandini & Manju (ZGC 7784)

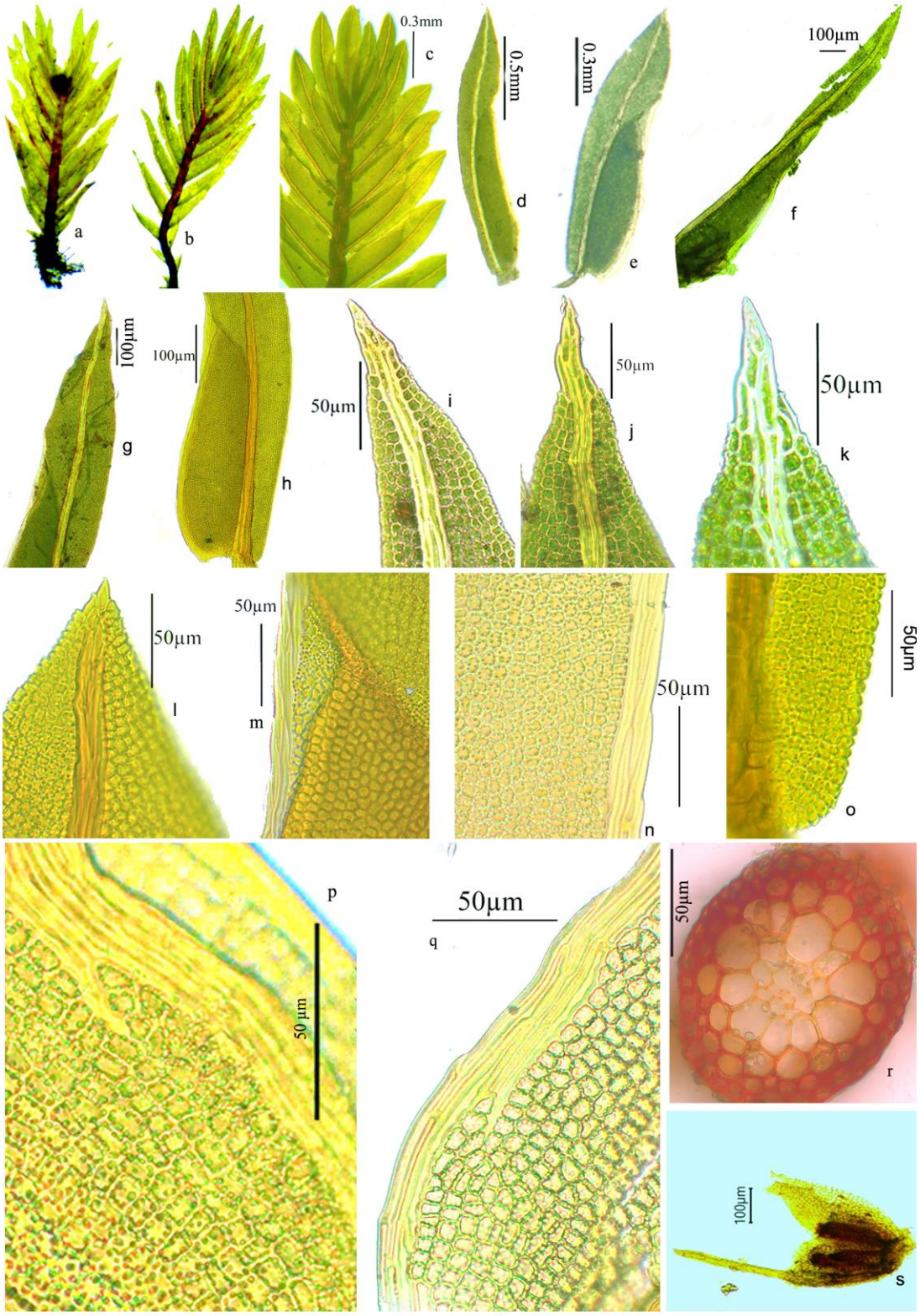


Plate 100. *Fissidens speluncae* Broth., a. fertile plant, b&c. vegetative plants, d&e. vegetative leaves, f. perichaetial leaf, g,i-l. leaf apex, h. vaginant laminae, m. vaginant laminae apex, n,p&q. limbidium on vaginant laminae, o. dorsal lamina near leaf insertion, r. stem T.S., s. perigonium with antheredium (a,b,d,f,g,i,s from ZGC732A; c,e,h,j-r from ZGC996).

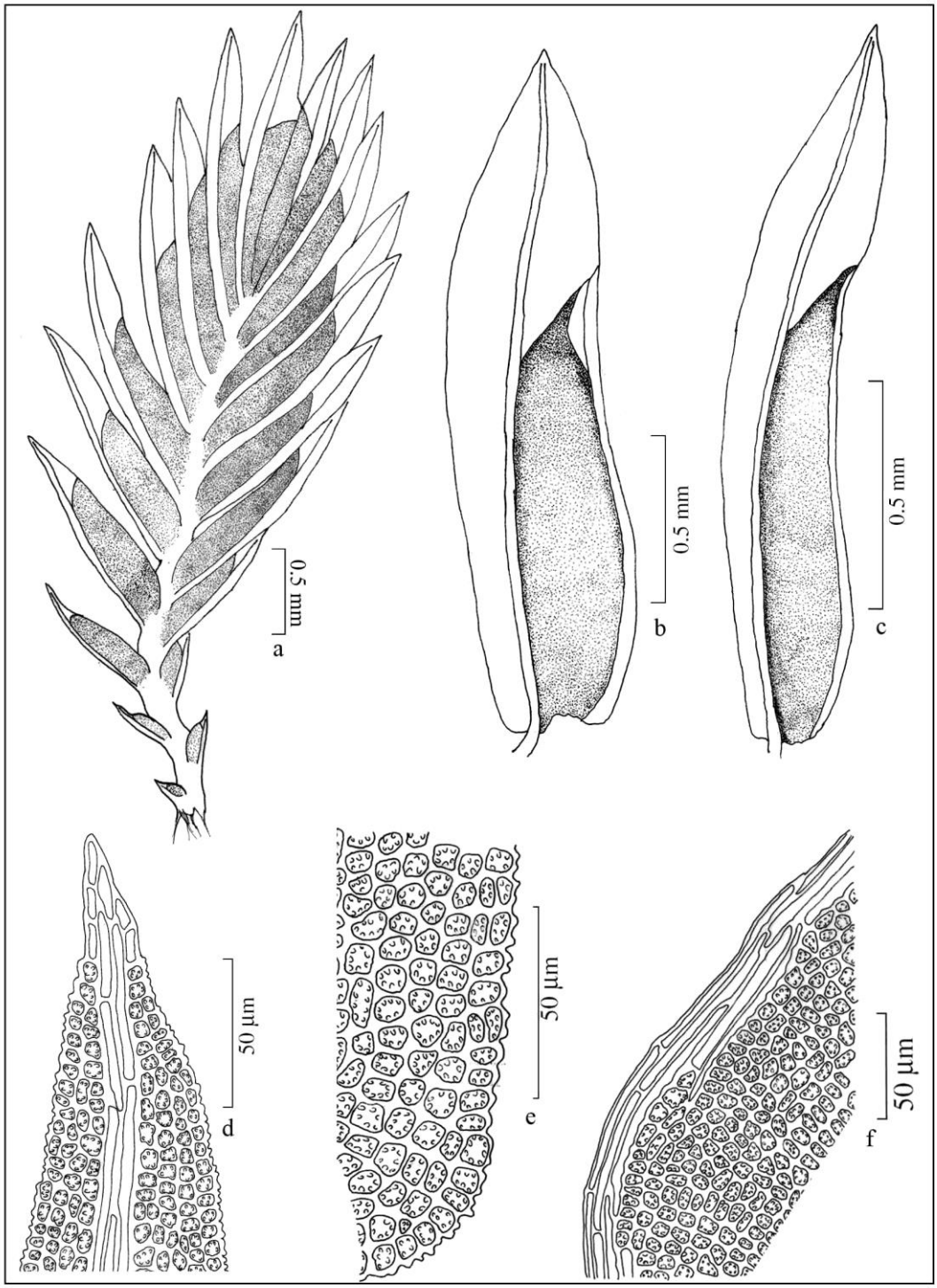
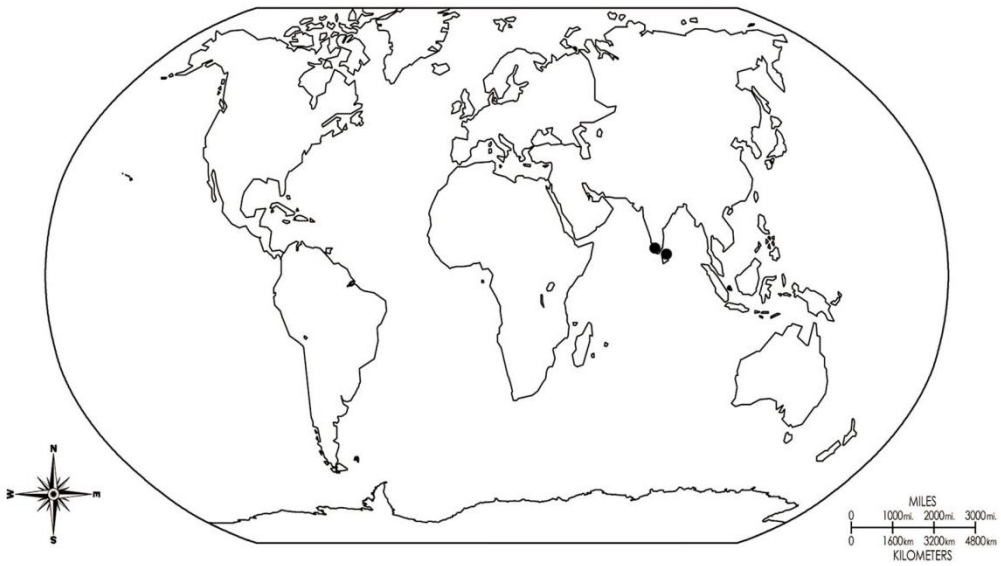
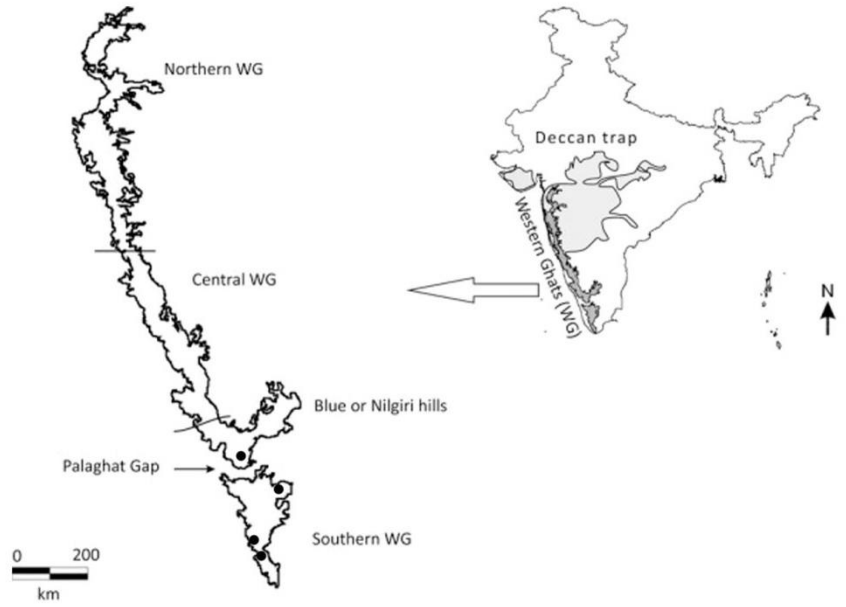


Fig. 54. *Fissidens speluncae* Broth., a. vegetative plant, b&c. vegetative leaves, d. leaf apex with costa, e. dorsal lamina base, f. vaginant laminae base with limbidium.



Map 60A. World distribution of ***Fissidens speluncae*** **Broth.**



Map 60B. Distribution of ***Fissidens speluncae*** **Broth. in Western Ghats**

Fissidens subbryoides Gangulee, Bull. Bot. Soc. Beng. 11: 60. 1957; Li & Iwatsuki, Moss Fl. China 2: 53. 2001; Gangulee, Moss. E. India & Adj. 1: 467. f. 214. 1971; Lal Checklist Indian Moss. 63. 2005; Daniels & Daniel in Nath & Asthana, Curr. Trends Bryol. 234. 2007; Manju, *et. al.*, Tropical Bryol. Res. Rep. 7. 2008b; Daniels, Archive Bryol. 65: 57. 2010; Daniels & Daniel, Bryof. South. W. Ghats. 49. 2013.

Type. India: Assam, Tea Dept. 1194 (Holotype BM!).

Plants small, leafy stems unbranched, 1–4 mm long, 1.5–2.5 mm wide; axillary hyaline nodules weakly differentiated; leaves in 5–12 pairs, linear lanceolate, narrowly acuminate, about 2.7 mm × 0.25 mm, base of dorsal laminae narrow, slightly decurrent; vaginant laminae closed, acute at apex; limbidia weak, composed of narrowly elongated cells all around, 1–2 rows of cells on dorsal and apical laminae, 2–4 rows of cells on the vaginant laminae; costa shortly excurrent; laminal cells smooth, thin-walled, rhomboidal to hexagonal, 7–15 µm long in apical laminae, more elongated at base, especially near costa, where they may be up to 25–40 µm long.

Fertile plants; autoicous. perigonia on short branches from leaf axil at middle of stems; antheridia about 250 µm long. Setae terminal, reddish-brown, up to 6.5 mm long; capsules erect, symmetrical, calyptra smooth (Plate 101,102 & Fig.55).

Diagnostic characters: *F. subbryoides* Gangulee is distinguished by having very narrow leaves with limbidia on all laminae, smooth and elongated laminal cells, costa mostly ends in a single cell. The small sized plant of this species is often confused with *F. biformis* Mitt. But differs in the mamillose cells and comparatively small and somewhat oblique cells of *F. biformis*.

Note: The type of this species was collected by Hampe and written as *F. subbryoides* on sheet. (unpublished). Later Gangulee in 1957 validly published the species in the same name *F. subbryoides*. The species reported by Nair *et al.* (2005) as *F. subbryoides* Gangulee from Kerala is *F. biformis* Mitt., sinceit contains

Plate 101. *Fissidens subbryoides* Gangulee habit & habitats; a. on laterite hillock, b. on small pebbles and rocks, c. enlarged view of the plant, d&e. on land cuttings.

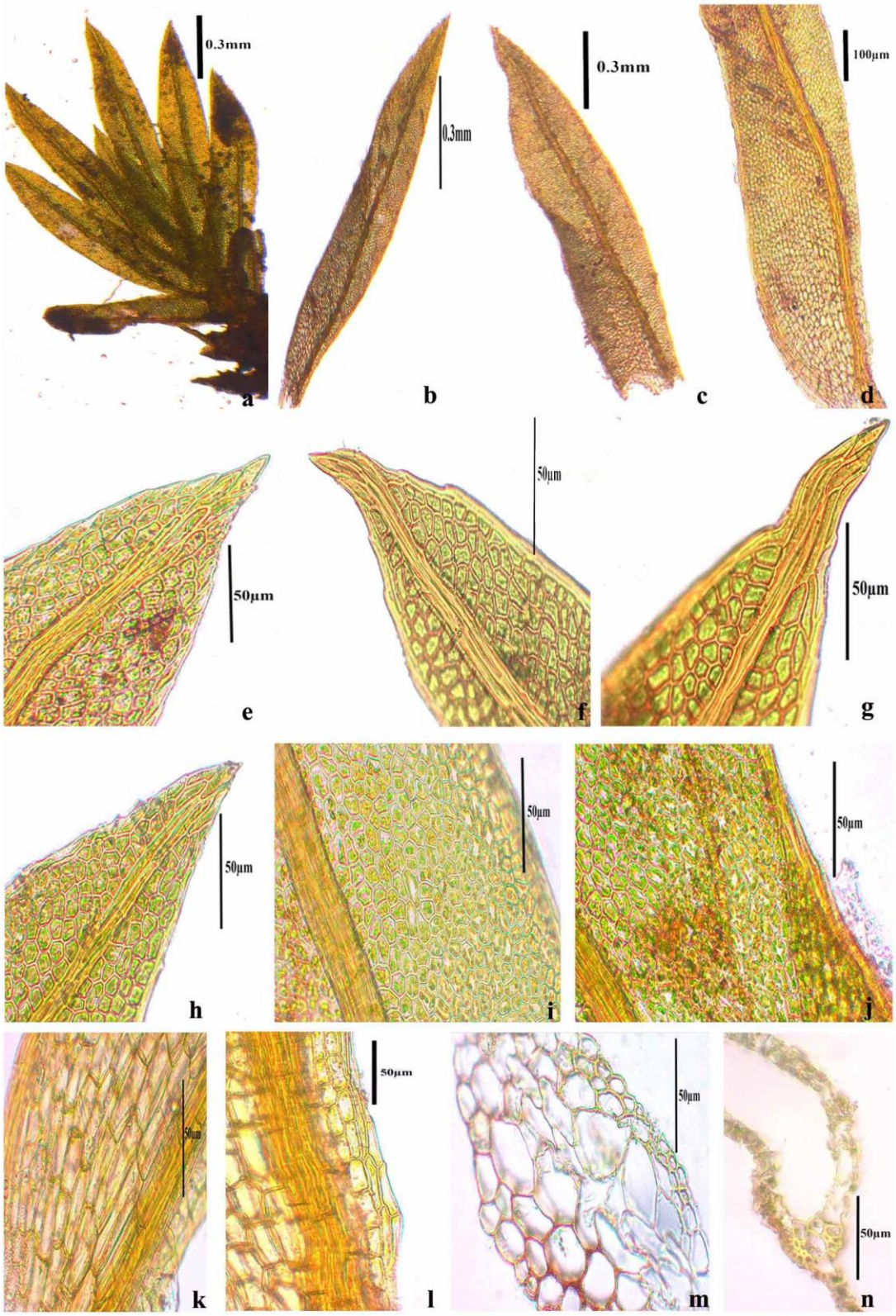


Plate 102. *Fissidens subbryoides* Gangulee, a. vegetative plant, b&c. vegetative leaf, d. vaginant laminae, e-h. leaf apex, i. laminal cells, j. vaginant laminae apex, k. vaginant laminae base, l. dorsal lamina base near insertion, m. stem T.S., n. leaf T.S.

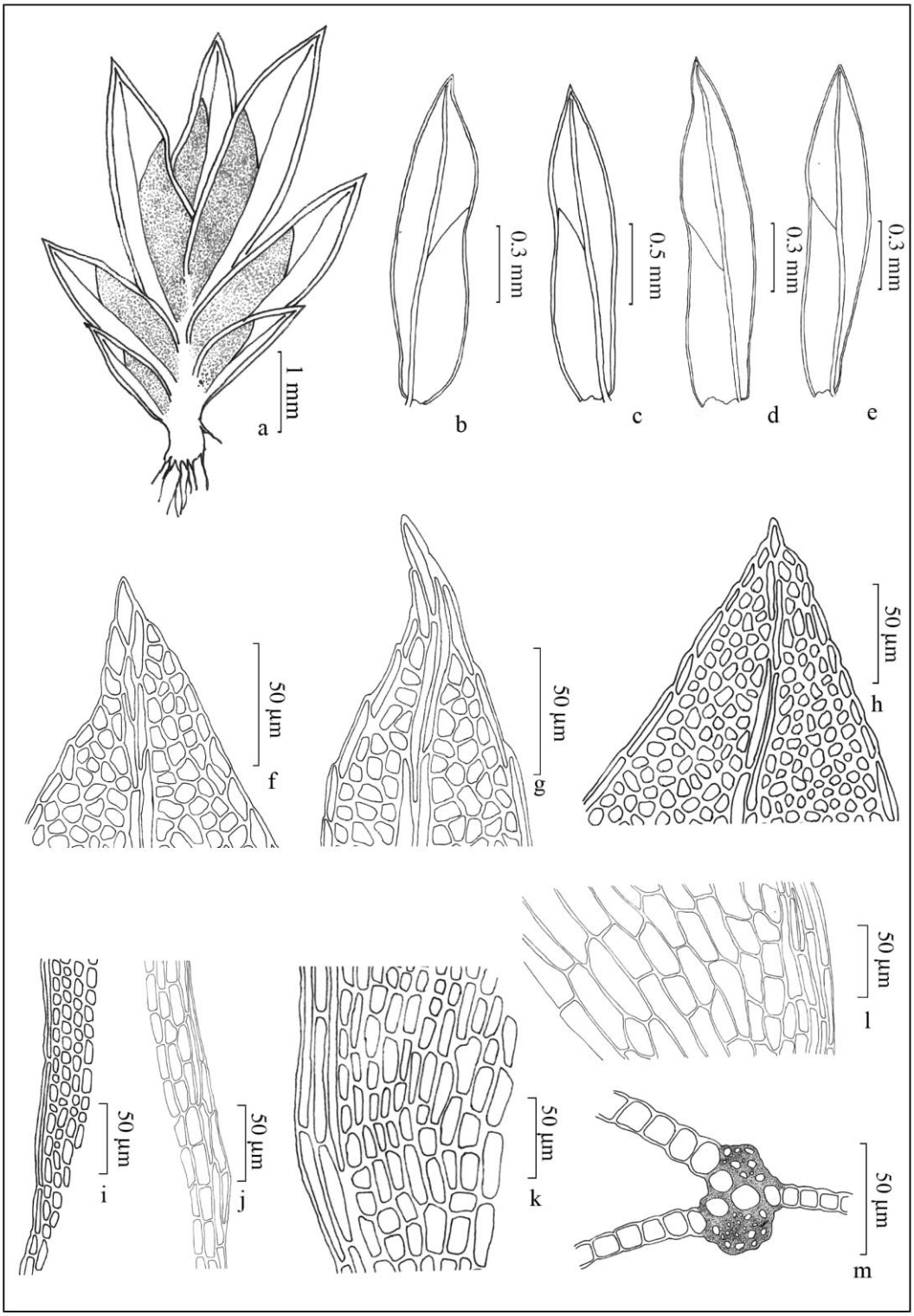


Fig. 55. *Fissidens subbryoides* Gangulee, a. vegetative plant, habit, b-e. vegetative leaves, f-h. leaf apex, i&j. dorsal lamina base near insertion, k&l. vaginant laminae base, m. leaf T.S.

mamillose laminal cells and the cells of *F. subbryoides* Gangelee is smooth and large.

Habitat and General Ecology: On soil, land cuttings and rocks in shaded areas of open lands and semi evergreen forest from low to medium altitude areas.

Distribution: India (Assam, Kerala, Tamil Nadu (Daniels, 2003, 2010, Daniels & Daniel, 2007, 2013; Gangulee, 1971; Lal, 2005; Nair *et al.*, 2005); China, Fiji, Vanuatu (Li & Iwatsuki, 2001) (Map 61A&61B).

Specimens examined: India, Kerala, Malappuram district (Calicut University campus, 40m), 23.09.2007, Manju, C.N. (106379) (CALI!), Nilambur (Nedumkayam forest, 770m), 25.07.2013, Manjula (ZGC 674), Palakkad district (Nelliyampathy churam, 10° 36' 8.352" N 76° 27' 49.6476" E, 900m), 12.07.2014, Manjula (ZGC 1139b), Assam, Tea Dept. Anon. 1194 (Holotype BM!, CAL!).

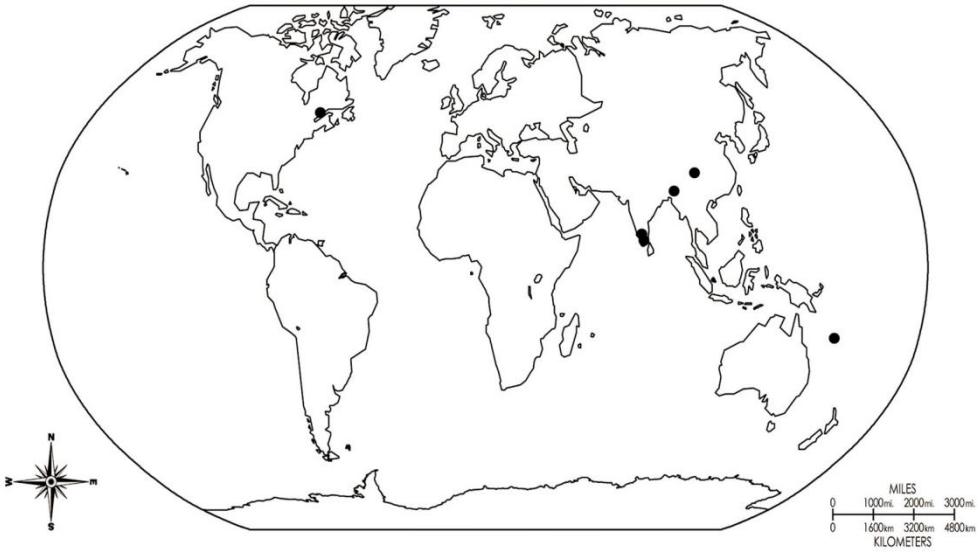
Etymology: The specific epithet *subbryoides* points to the similarity of this species to *F. bryoides* Hedw.

Fissidens subpalmatus Muell. Hal., Linnaea 37: 164. 1871-1873[1872]; Gangulee, Moss. E. India & Adj. 1: 466. 1971; Lal, Checklist Indian Moss. 63. 2005; Daniels & Kariyappa, Curr. Sci. 93(7): 981. 2007; Daniels & Daniel, Bryof. South. W. Ghats. 49. 2013.

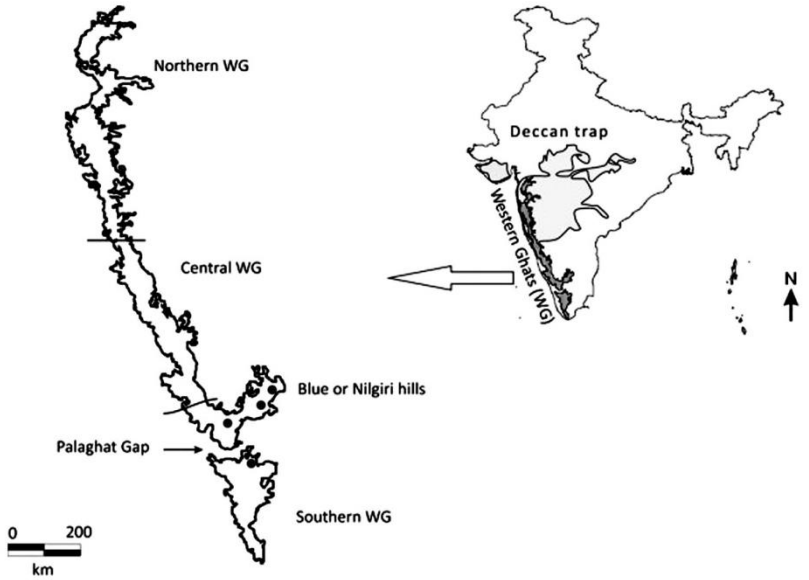
Type: India, W. Bengal, Kurz s. n. (BM!).

Conomitrium subpalmatum (Muell. Hal.) A.Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1874–75: 125 (Gen. Sp. Musc. 2: 41). 1876.

Plants in loose tufts, 4-8 mm long, caespitose; rhizoids smooth, basal; axillary hyaline nodules absent; stem erect, green, central strand not distinct; leaves 11-14 pairs, curled and somewhat contorted when dry, 1.0-1.4 x 0.2-0.3 mm, oblong-lingulate, symmetric above, apex narrowly acuminate; limbidium simple, complete on all laminae, one rowed on apical and dorsal laminae, two or three



Map 61A. World distribution of ***Fissidens subbryoides*** *Gangulee*



Map 61B. Distribution of Fissiens ***Fissidens subbryoides*** *Gangulee in Western Ghats*

rowed on vaginant lamina, uniform, ending below apex, elongated except at leaf apex and at extreme base of dorsal lamina, cartilaginous; vaginant laminae closed, minor lamina apex opens at leaf margin, uniseriate; dorsal lamina base decurrent, apical lamina and dorsal lamina uniseriate; costa excurrent, ends in a single cell, bryoides type; laminal cells distinct, smooth, transparent, rounded hexagonal, apical cells 12-14 x 10-13 µm, median cells 12-15 x 10-13 µm, juxta costal cells large, 18-32 x 8-12 µm; gemmae not found (Plate 103 & Fig.56).

Fertile parts not found.

Diagnostic characters: *F. subpalmatus* Muell. Hal. is characterised by oblong-lingulate leaves, limbidium simple on all laminae, limbidium ending below apex, vaginant laminae closed, costa ends in a single cell and smooth laminal cells. This species is similar to *F. bryoides* in leaf character and limbate leaf margin but differs in the less strong limbidium and apiculate leaf apex of *F. bryoides*.

Habitat and General Ecology: On soil and land cuttings in open lands and disturbed habitats. During the present study this species is reported from evergreen forests of Thusharagiri along with *F. crispulus* Brid. also present on soil and rock in semi evergreen forest in Nadukani churam.

Distribution: India (Bihar, West Bengal, Kerala (present collection), Tamil Nadu and Maharashtra (Gangulee, 1971; Lal, 2005; Daniels & Daniel, 2013); Nepal, (Gangulee, 1971). The present collection is a new record for Kerala (Map 62A&62B).

Specimens examined: India, Kerala, Kozhikode (Thusharagiri (60-200m), $11^0$28’33.168” N, $76^0$0’47.592” E), 22.07.2013, Manjula (ZGC 630b), Malappuram district, (Nadukani churam, 60-750m), 24.07.2013, Manjula (ZGC 661, ZGC 662), Tamil Nadu, Kanyakumari district (Perunchani, ca. 110m), 06.05.2004, Sheeja,V.C. 78 (SCCN!); W. Bengal, Kurz s. n. (BM!), Kolkatta (Barasat), 13.08.1961, Rajani (5214 XIII) (CAL!); Sikkim (Kurseong, 6000ft), April-May 1913, Foreau (53b) (BM!).

Etymology: The specific epithet *subpalmatus* reflects the elongated palmate appearance of the leaf.

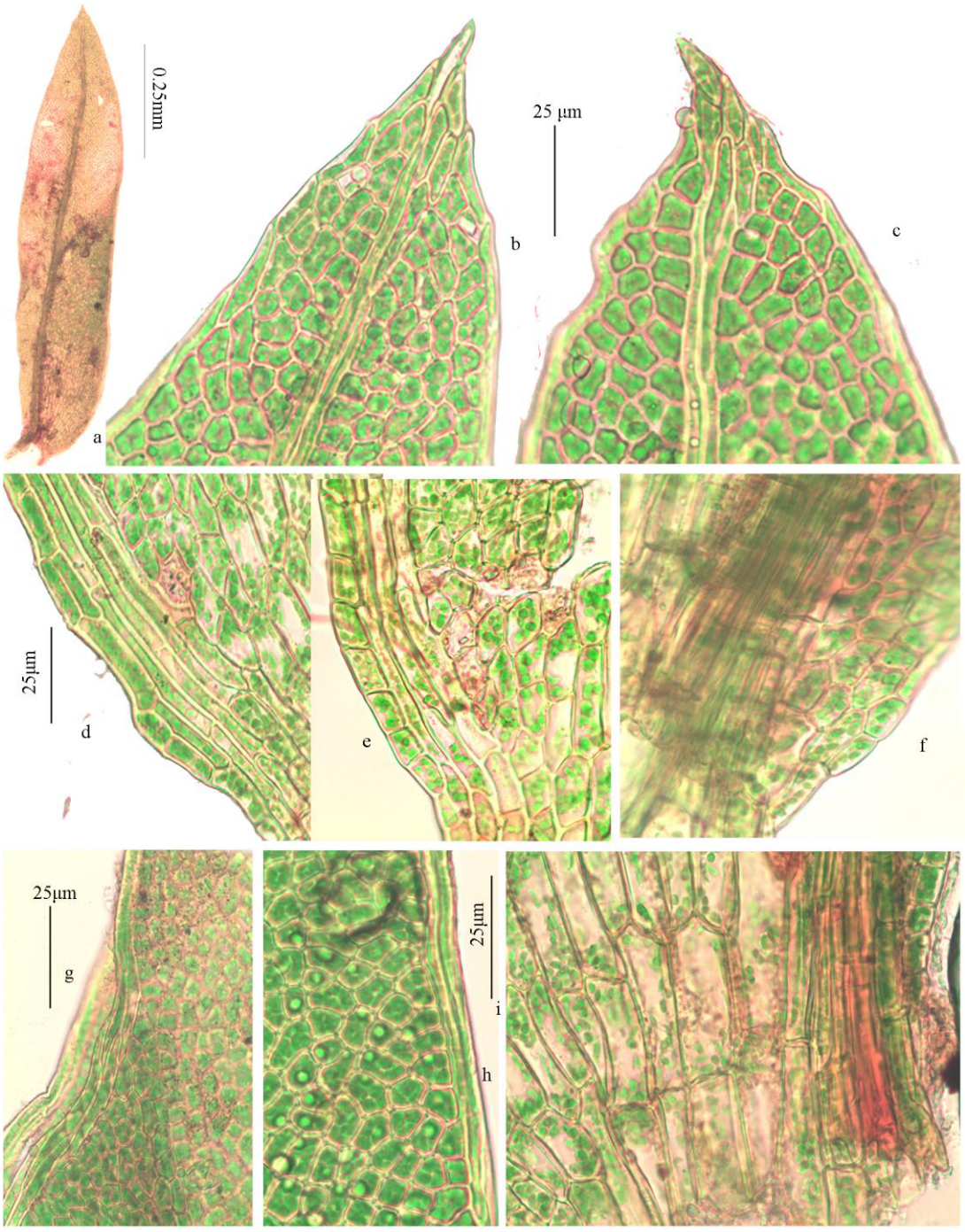


Plate 103. *Fissidens subpalmatus* Möll. Hal., a. vegetative leaf, b&c.. leaf apex, d,e&i. vaginant laminae base, f. dorsal lamina base, g. vaginant laminae apex, h. laminal cells (h&c; d-f; g&h same size)

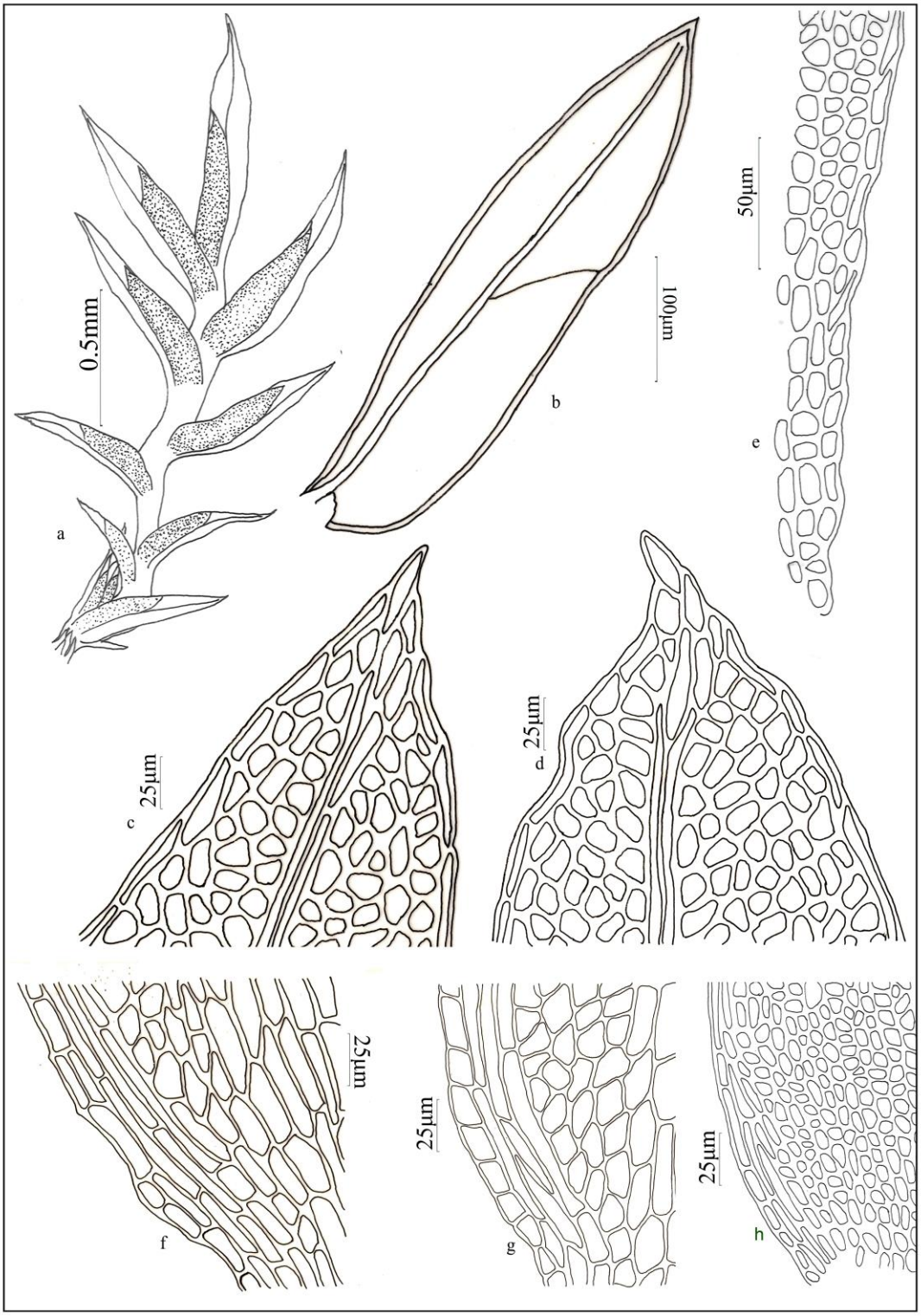
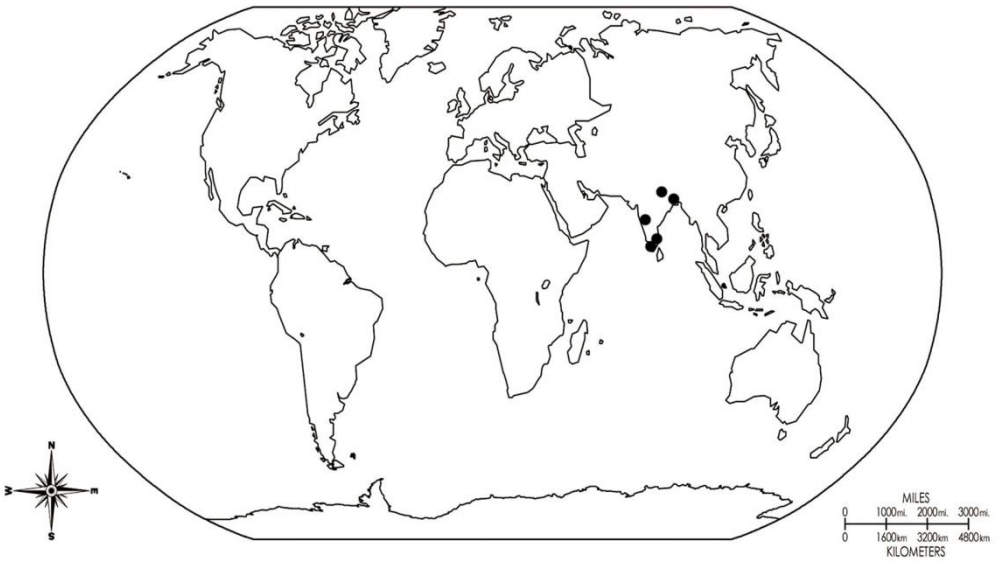
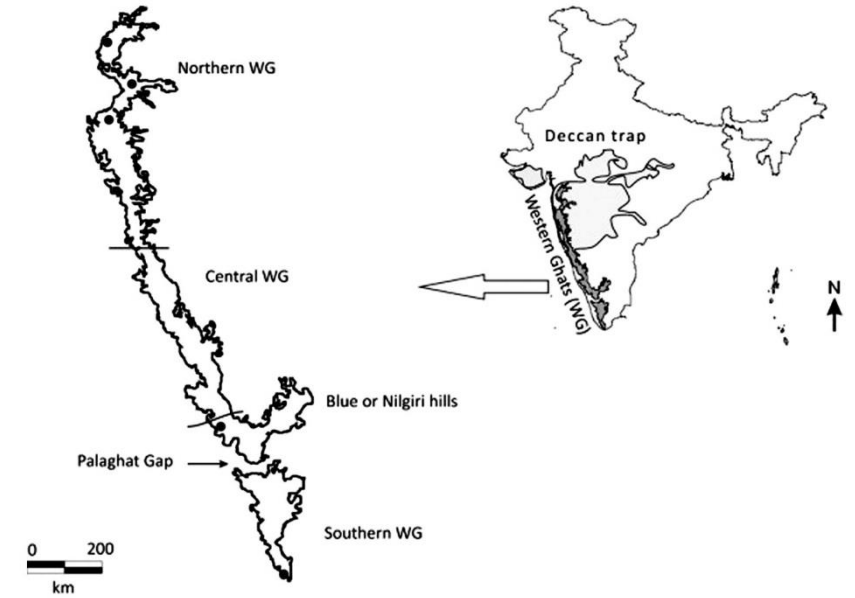


Fig. 56. *Fissidens subpalmatus* Müll.Hal., a. vegetative plant, b. vegetative leaf, c&d. leaf apex, e. dorsal lamina base near insertion, f-h. vaginant laminae base.



Map 62A. World distribution of ***Fissidens subpalmatus*** *Müll.Hal.*



Map 62B. Distribution of ***Fissidens subpalmatus*** *Müll.Hal. in Western Ghats*

Fissidens walkeri Broth., Rec. Bot. Surv. India 1(12): 315. 1899; Dixon, J. Indian Bot. 2: 177. 1921.

Type: Karnataka; Sirsi, Earth-bank of stream, Anmod (3265).

Plants not forming mats but growing in groups; rhizoids smooth, dark brown; axillary hyaline nodule absent; small plants, 3-5.00 x 0.19-0.20 mm, pinnate, stem light green, central strand weakly differentiated or not differentiated; leaves dark green, curls in herbarium, alternate, 8-15 pairs of leaves, slightly overlapping; leaves lanceolate, 0.70-0.93 x 0.16-0.20 mm, 5 times long as wide, margin serrate, tip acute; limbidium three or four rows of incomplete cartilaginous cells only at the base of vaginant laminae; vaginant laminae slightly open,0.44-0.53 mm long, 0.10-0.14 mm wide at base, uniseriate; dorsal lamina base slightly narrows at insertion, 29.38-33.90 µm wide, 3 or 4 cells wide at base, dorsal lamina and apical lamina uniseriate; costa strong, pale green, slightly excurrent or reaching at the apex; laminal cells irregularly polygonal or round, arranged with intercellular spaces; mid dorsal laminal cells 9.82-14.29 x 6.76-10.22 µm; mid vaginant laminal cells 8.39-13.76 x 8.54-11.29 µm; juxta costal cells slightly large, single mamillose, 11.3-13.56 x 6.78-9.04 µm; small linear gemmae of four or five cells present on leaf margin (Plate 104a&b,105& Fig.57).

Fertile plants not found.

Diagnostic characters: *F. walkeri* Broth. is characterised by lanceolate leaves with acute apex, highly serrate margin, slightly open limbidium and single conical mammillose laminal cells. It is similar to *F. crenulatus* Mitt. in its mammillose laminal cells and nature of limbidium but differs in leaf apex and margin of the leaf. Dixon and Potier de la Varde (1930) and Foreau (1961) reported one variety of *F. walkeri* as *F. walkeri* var. *elimbatus* from Tamil Nadu. But this variety is not collected after 1961 and excluded from the present study.

Habitat and General Ecology: On large and small rocks and twigs in evergreen and semi evergreen forests. It is moderately common species in the Western Ghats of Kerala.

Distribution: *F. walkeri* Broth. is an endemic species to South India. Reported from Tamil Nadu (Daniels, 2004, 2010; Dixon & Potier de la Varde, 1930; Foreau, 1961), Karnataka (Brotherus, 1899 (Type) & Dixon, 1921; Schwarz, 2014b), Kerala, Goa (present collection) and Maharashtra (Dabhade, 1998). The present collection is a new record to Kerala and Goa. (Map 63A&63B).

Plate 104. a&b. *Fissidens walkeri* Broth., on land cuttings; c-e- *Fissidens zollingeri* Mont., c. on muddy wall, d. on crevices of rocks, e. on small stones

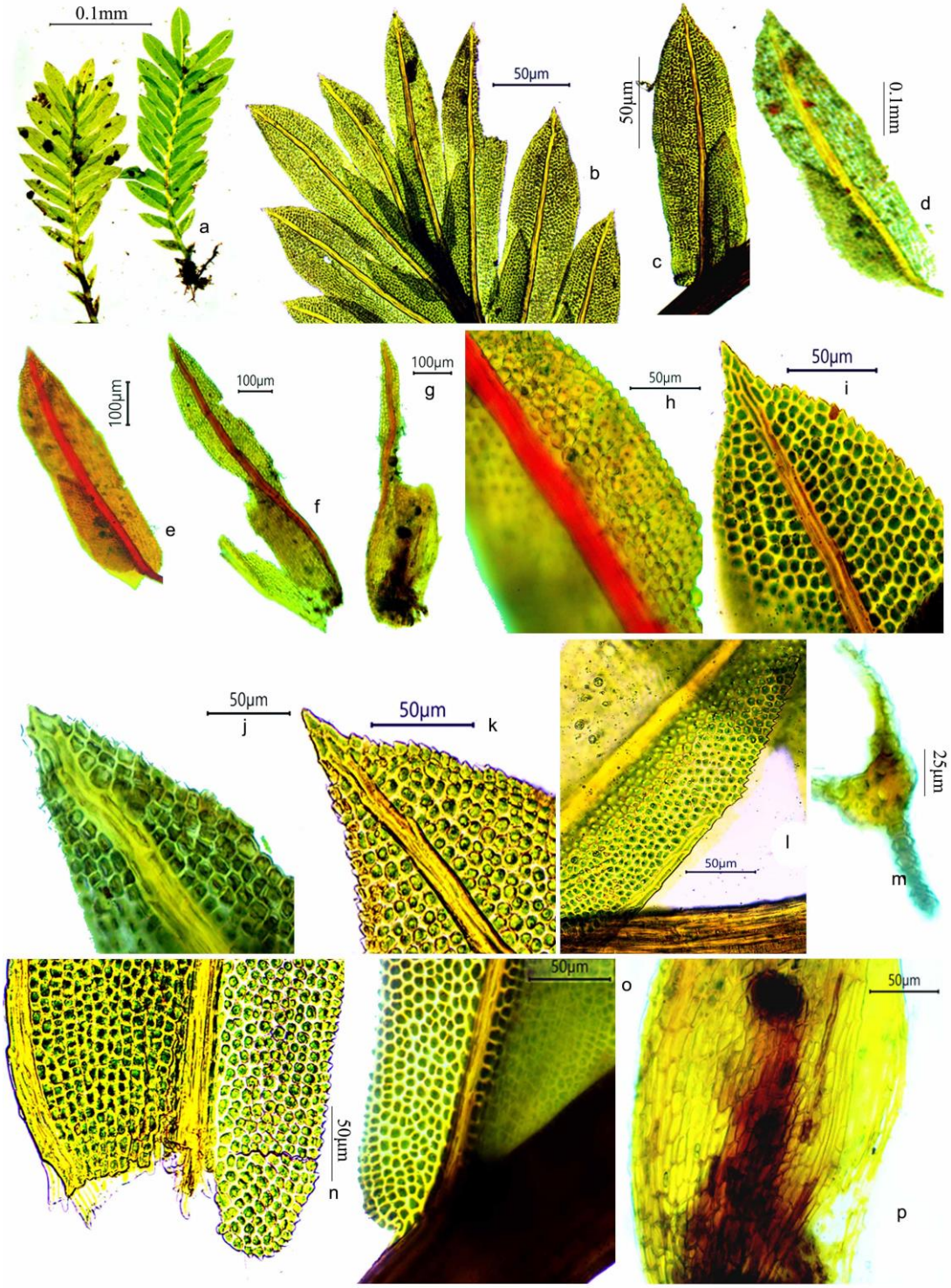


Plate 105. *Fissidens walkeri* Broth., *a*. habit, b. vegetative plant apex, c-e. vegetative leaves, f&g. perigonial leaves, h. leaf margin, i-k. leaf apices, l. vaginant laminae, m. leaf T.S., n. leaf base, o. dorsal lamina near insertion, p. limbidium on perigonial leaf base. (a-c,i,k,l,n,o from ZGC10139; d-h,j,m,p from ZGC732B).

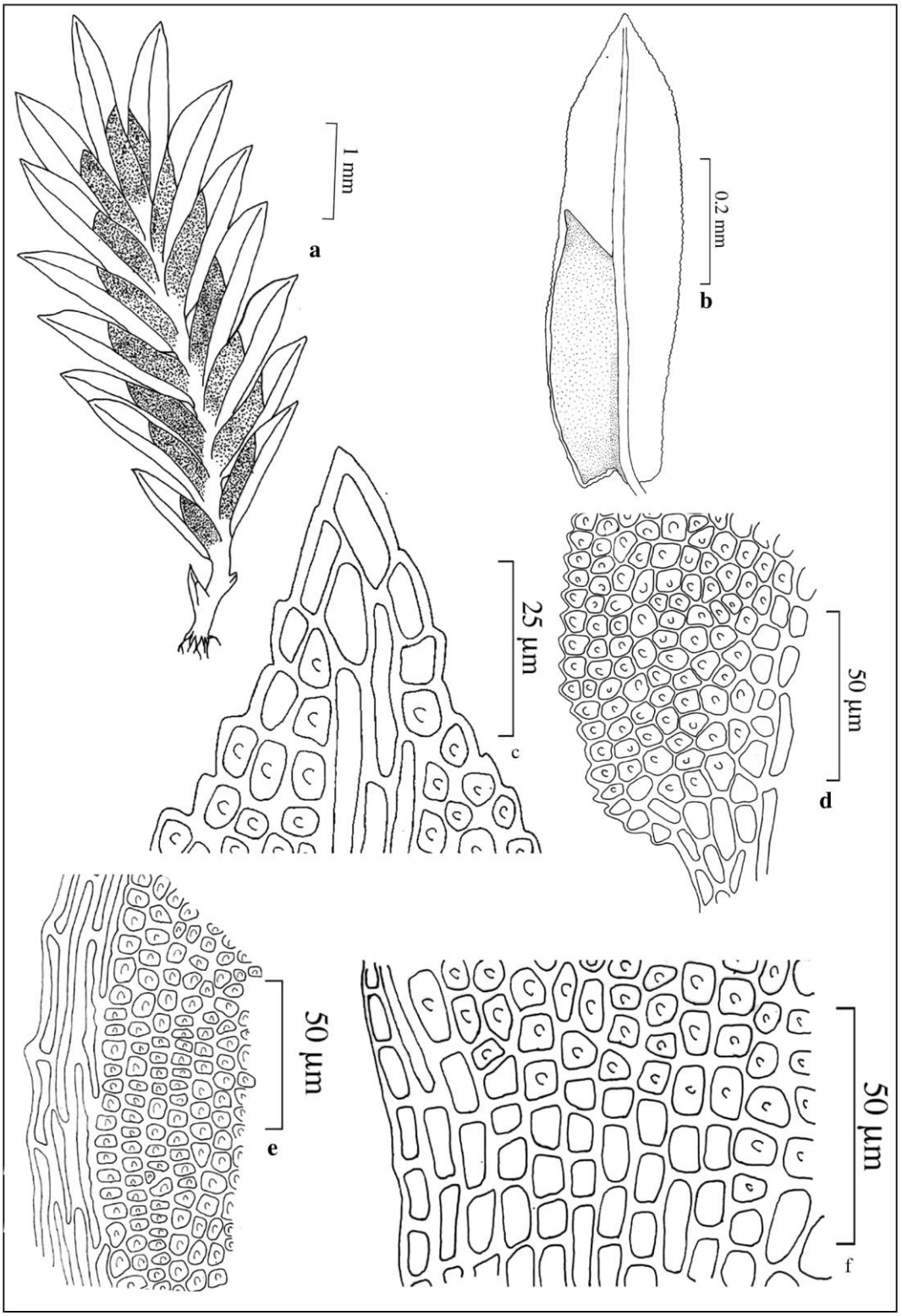
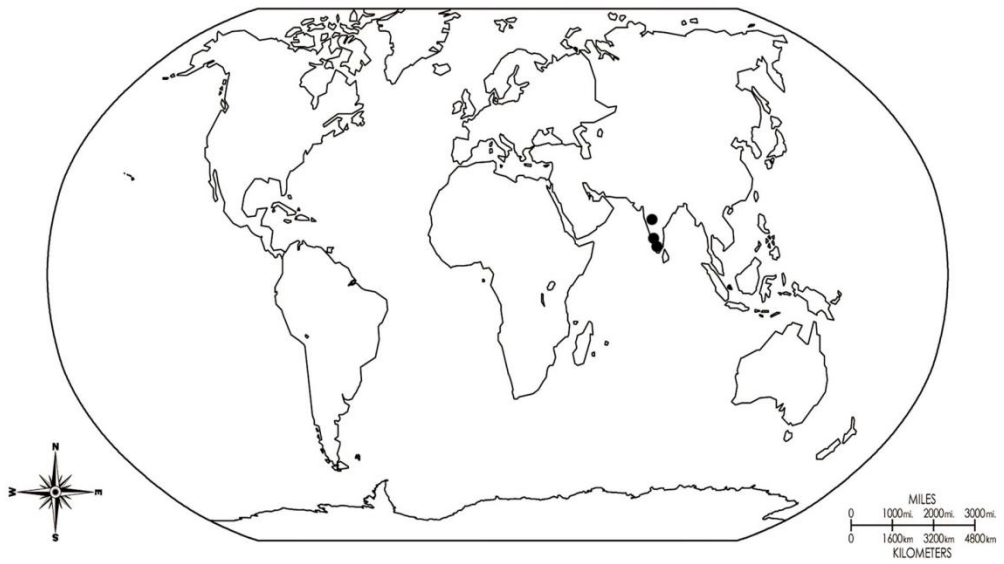
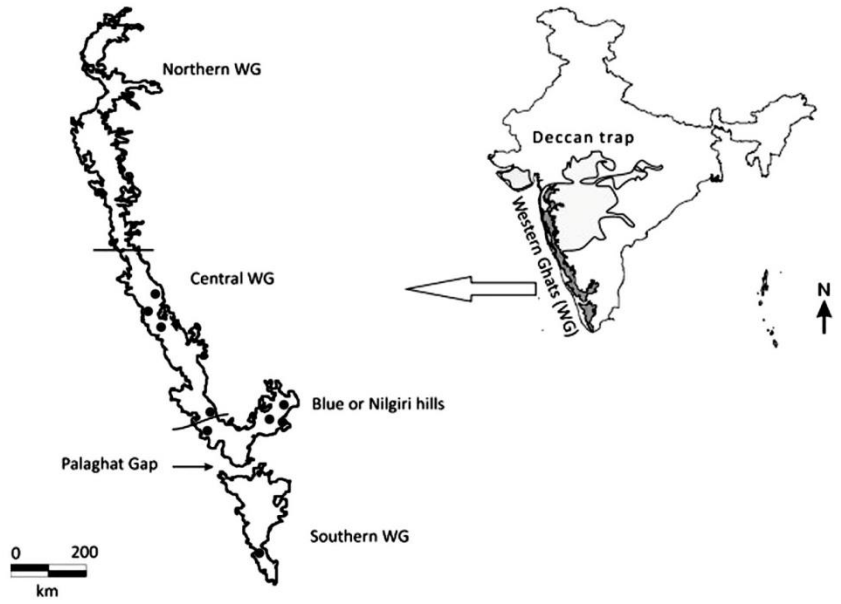


Fig. 57. *Fissidens walkeri* Broth., a. vegetative plant, b. vegetative leaf, c. leaf apex with costa, d. dorsal lamina base near insertion, e. vaginant laminae with limbidium, f. vaginant laminae base.



Map 63A. World distribution of ***Fissidens walkeri*** *Broth.*



Map 63B. Distribution of ***Fissidens walkeri*** *Broth. in Western Ghats*

Specimens examined: India; Kerala, Thiruvananthapuram district (Agasthyamalai Biosphere Reserve (1300m), 12.12.2013, Rajilesh (ZGC 732B), Kozhikode district (Malabar WLS, Kakkayam, Thattittapara, 760m), 14.11.2014, Manjula (ZGC 3906), Wayanad district, (Vellamunda, 1140m), 20.05.14, Manju (ZGC 1031A), (Vythiri), 09.05.2017, Rajesh & Mufeed (ZGC 10139); Goa, Cancona, (Cotigao Wildlife Sanctuary, 88 m), 15.08.2015 Manjula & Deepa (ZGC 15125a); Karnataka (Coorg, Near Bhagmandala), Walker (Walker 334) (CAL!); Maharashtra (Mahabaleshwar), 07.03.1962, A.H. Norkett (Norkett10056) (BM!).

Etymology: The specific epithet *walkeri* honours the botanist 'Walker'.

Fissidens zollingeri Mont., Ann. Sci. Nat., Bot., sér.34: 114. 1845; Dixon, J. Indian Bot. 2: 177. 1921; Blatt., J. Bombay Nat. Hist. Soc. 33: 872. 1929; Bruehl, Rec. Bot. Surv. India 13(1): 17. 1931; Wadhwa, M.V.M. Patrika 4: 91. 1969; Gangulee, Moss. E. India & Adj. 1(2): 478. 1971; Iwatsuki & Suzuki, J. Hattori Lab. 51: 367. 1982; Mohamed *et al.,* J. Bombay Nat. Hist. Soc. 83: 689. 1986; Iwatsuki & Mohamed, J. Hattori Bot. Lab. 62: 342. 1987; Bruggeman-Nannenga & Berendsen, J. Hattori Bot. Lab. 68: 205. 1990; Dabhade, Moss. Khandala: 138. 1998; Lal, Checklist Indian Moss. 64. 2005; Li & Iwatzuki, Moss Fl. China 2: 66. 2001; Nair *et al.,* Bryophyt. Wayanad W. Ghats: 108. 2005; Chaudhary *et al.,* Bryoph. Fl. Gujarat: 72. 2006 (as *F. xophoides* and *F. zollingeri*) & Bryoph. Fl. N. Konkan: 246. 2008; Daniels & Kariyappa, Curr. Sci. 93(7): 981. 2007; Pursell, Fl. Neotrop. Monogr. 101: 225. 2007; Manju *et al.,* Tropical Bryol. Res. Rep. 7: 12. 2008b; Bruggeman-Nannenga & Arts, J. Bryol. 32: 204. 2010; Daniels, Archive Bryol. 65: 57. 2010; Daniels & Daniel, Bryo. South. W. Ghat. 53. 2013; Rani *et al.,* Bryo. Andhra Pradesh. 132. 2014; Bruggeman-Nannenga. Lindbergia 39: 33–34. 2016.

Type: Java, in terra turfosa, coll. Zollinger (1604).

Fissidens kegelianus Muell. Hal., Syn. Musc. Frond. 1: 49. 1848; *F. pseudo-bryoides* Schlieph., Bot. Zeitung (Berlin) 13: 424. 1855; *F. vogelianus* Mitt., Tras. Linn. Soc. London 23: 54. 5 f. 10. 1860; *F. clavipes* Sull., Proc. Am. Acad. Arts 5: 275. 1861 [1862]; *F. monandrus* Mitt., J. Linn. Soc. Bot. 12: 598. 1869; *F.*

macrophyllus Welw. & Duby, Mém. Soc. Phys. Genéve 21: 223. 1872; *Conomitrium caripens* Hampe & Muell. Hal. in Muell. Hal. Linnaea 38: 574. 1874; *Fissidens trinitensis* Hampe *ex* A.Jaeger, Ber. Thätigk. St. gallischen Naturewiss. Ges. 1874-75: 123. 1876; *F. balansaeanus* Besch., Mém. Soc. Sci. Nat. Cherbourg 21: 260. 1877; *F. balansaeanus* var. *limosus* Besch., Mem. Soc. Sci. Nat. Cherbourg 21: 261. 1877; *Conomitrium subpalmatum* Hampe, Vidensk. Meddel. Dansk Naturhist. Foren. Kjøbenhavn. Ser. 3. 9: 273. 1877 [1878]; *Fissidens obsoletidens* Muell. Hal. *ex* Besch., Ann. Sci. Nat. Bot. sér. 6, 9: 332. 1880; *F. platybryoides* Muell. Hal., Fl. 69: 505. 1886; *F. stenocarpus* Muell. Hal., Rev. Bryol. 14:57. 1887; *F. crassicollis* Besch., Rev. Bryol. 18: 50. 1891; *F. flexifrons* Besch., Rev. Bryol. 18: 50. 1891; *Conomitrium bengalense* Hampe in Muell. Hal., Linnaea 39: 364. 1896; *Fissidens bengalensis* Par., Index Bryol.: 461. 1896; *F. coorgensis* Broth., Rec. Bot. Surv. India 1(12): 316. 1899; Schwarz, Frahmia 158: 6. 2014; *F. xiphoides* M. Fleisch., Hedwigia 38 (Beibl.): 125. 1899; *F. gracilis* Schimp. *ex* E.S. Almon, Ann. Bot. 13: 126. 1899; *F. tijucae* Broth., Hedwigia 38 (Beibl.): 59. 1899; *F. acutissimus* Muell. Hal., Gen. Musc. Frond. 57. 1900; *F. mararyensis* Broth. Hedwigia 45: 265. 1906; *F. brachycaulon* Broth. in Mildbr., Wiss. Ergebn. Deut. Zentr.-Afr. Exped., Bot. 2: 143. 11 f. 143. 1910; *F. tenuisetus* Cardot, Rev. Bryol. 35: 64. 1908; *F. jujuiensis* Broth., Ark Bot. 15: 2. 1917.

Plants small, simple, light green; central strand weak to lacking, vegetative stem 6-8 x 3.00-4.50 mm wide including leaves, vegetative plant with 2-7 pairs of leaves; rhizoids reddish, smooth; axillary hyaline nodules differentiated; leaves lax, oblong-lanceolate, rarely linear lanceolate, upper leaves larger, 1.50–3 x 0.30–0.50 mm, tip acute to slightly acuminate, margin entire; limbidium present on all laminae, 5–7 rows at vaginant laminae base, 3-5 rows at apical lamina base, one or two rows towards the apex of leaves; vaginant laminae reaching 1/2 – 3/4 of leaf length, slightly open or closed, 0.10-0.15 mm wide at base, a small curve on the apical lamina where vaginant laminae ends, unistratose; dorsal lamina narrows towards base, joins to the leaf insertion, not decurrent, 2–4 cells wide, dorsal and apical lamina unistratose; costa prominent, yellow–slightly orange, slightly excurrent apex,

cuspidate, bryoides type; mid dorsal laminal cells plane, 7.21-9.27 x 4.12-8.24 µm, mid vaginant laminal cells plane or slightly convex, 8.24-12.36 x 5.15-6.18 µm, juxta costal cells elongated, 27.17-28.95 x 10.88-15.31 µm.

Fertile parts; perigonia not found; perichaetia terminal, perichaetial plants 6.50-11.00 x 1.20-2.00 mm, perichaetial leaves lanceolate with prominent limbidium at base, 1.42-1.73 x 0.24-0.28 mm; sporophyte inclined, setae 3.90-6.00 mm, capsule symmetrical, 0.75-1.05 x 0.25-0.35 mm, 21-24 files of exothecial cells with thickened corners, peristome bryoides type, tooth base 28.84-32.96 µm, 0.17-0.25 mm long; operculum rostrate; spores 8.24-11.33 µm (Plate 104c-e,106(a&b)& Fig.58).

Diagnostic characters: *F. zollingeri* Mont. is characterised by the presence of axillary nodules, short to long and densely to distantly foliated stems, shortly excurrent costa, large cells at vaginant laminae base. It is similar to *F. bryoides* Hedw. and *F. crispus* Mont. in leaf shape and presence of complete limbidium, but in *F. bryoides* Hedw. axillary hyaline nodules absent, central strand is differentiated and some leaves weakly serrulate near apex; in *F. crispus* Mont. costa not excurrent and limbidial cells 3 - 5 layers at vaginant laminae base.

Note: *F. zollingeri* Mont. shows wide variations in morphological characters, and shows resemblance and variations with several species. Hence some authors considered some species as separate from *F. zollingeri* and some considered some species under synonym of *F. zollingeri*. *F. xiphoides* Fleisch. was described by Fleischer (1899) as a distinct species based on the difference in reproductive structures and leaf structure with *F. zollingeri* Mont. He described *F. xiphoides* Fleisch. as autoicous and *F. zollingeri* Mont. as dioicous. But (Iwatsuki & Suzuki, 1982) reported that the sexual condition of both species is autoicous. Gangulee (1971) treated *F. xiphoides* Fleisch. and *F. zollingeri* Mont. as separate with a slight variation in the large and wide leaves with two rowed limbidium at apex. present study considered *F. xiphoides* as a synonym of *F. zollingeri*.

Daniels and Daniel (2013) considered *F. biformis* Mitt. as a synonym of *F. zollingeri* Mont. But these two species have variations like linearly lanceolate leaves with papillose laminal cells and narrowly acute leaf apex of *F. biformis* Mitt. Hence in the present study I considered *F.biformis* as a separate species from *F. zollingeri.* Dabhade (1998) and Chaudhary *et al.* (2008) listed this species as *F. xiphoides* Fleisch. from Maharashtra.

Habitat and General Ecology: Common species in all altitudinal ranges with a variety of habitat such as on open land in soil, on land cuttings, small stones, on brick wall, on concrete wall, laterite stone walls, and on bark of trees in homestead to evergreen forests except in shola forest. Associated species includes bryophytes such as *Hyophila involuta* (Hook.) A. Jaeger, *Fossombronia sp.*, etc. and ferns such as *Adiantum philippense* Linn., *Pityrogramma calomelanos* (Linn.) Link., angiosperm like *Pilea microphylla* (Linn.) Liebm. and ranges from sea level to 1760 m altitude.

Distribution: India (Andaman Islands, Gujarat, Karnataka, Kerala, Goa, Madhya Pradesh, Maharashtra, Tamil Nadu, Uttar Pradesh and West Bengal (Chaudhary *et al.*, 2006, 2008; Dabhade, 1998; Daniels, 2003, 2010; Daniels & Daniel, 2013; Foreau, 1930, 1961; Gangulee, 1971; Mohamed *et al.*, 1986; Lal, 2005; Manju *et al.*, 2008b; Magdum *et al.*, 2017; Nair *et al.*, 2005; Schwarz, 2014b; Rani *et al.*, 2014; Wadhwa, 1969); Central Vietnam, Fiji, India, Java, Malay, Myanmar, North Vietnam, New Guinea, Philippines, Sri Lanka, Sumatra, Samoa, Tahiti; west-central tropical Africa (Benin, Cameroon, Democratic Republic of the Congo, Central African Republic, Gabon, Guinea, Nigeria); east tropical Africa (Kenya, Tanzania, Uganda); south tropical Africa (Angola); and western Indian Ocean (Comoro islands, La Re´union, Madagascar, Rodriguez, Seychelles) (Bruggeman-Nannenga & Arts, 2010; Bruggeman-Nannenga & Berendsen, 1990; Iwatsuki & Suzuki, 1982; Iwatsuki & Mohamed, 1987; Li & Iwatsuki, 2001; Pursell, 2007). The present collection is a new record to Goa. (Map 64A&64B).

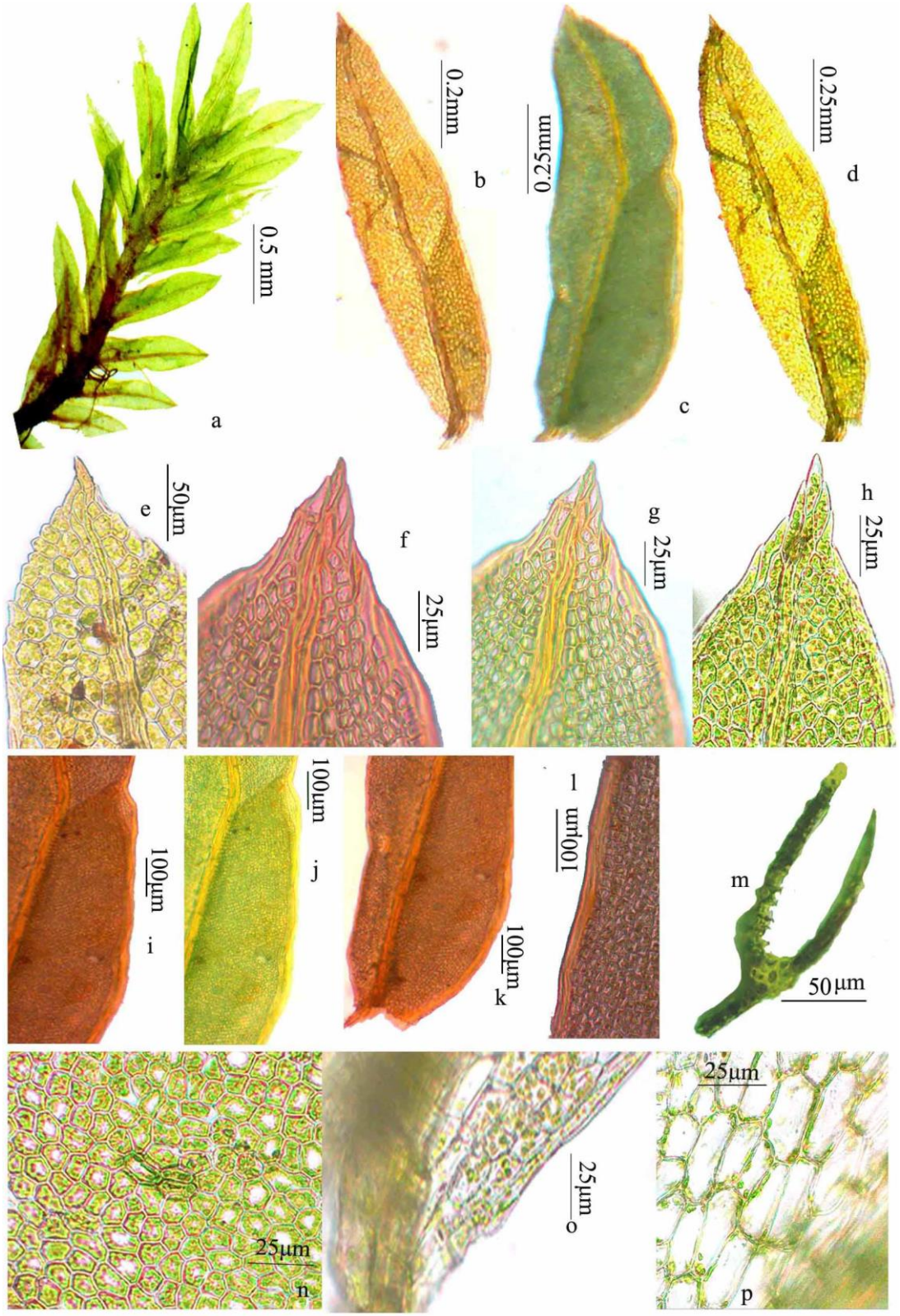


Plate 106a. *Fissidens zollingeri* Mont., a. vegetative plant, b-d. vegetative leaf, e-h. leaf apex, i-k. vaginant laminae, l. laminal cells with limbidium, m. leaf T.S., n. laminal cells, o. dorsal laminal base near insertion, p. vaginant laminae base.

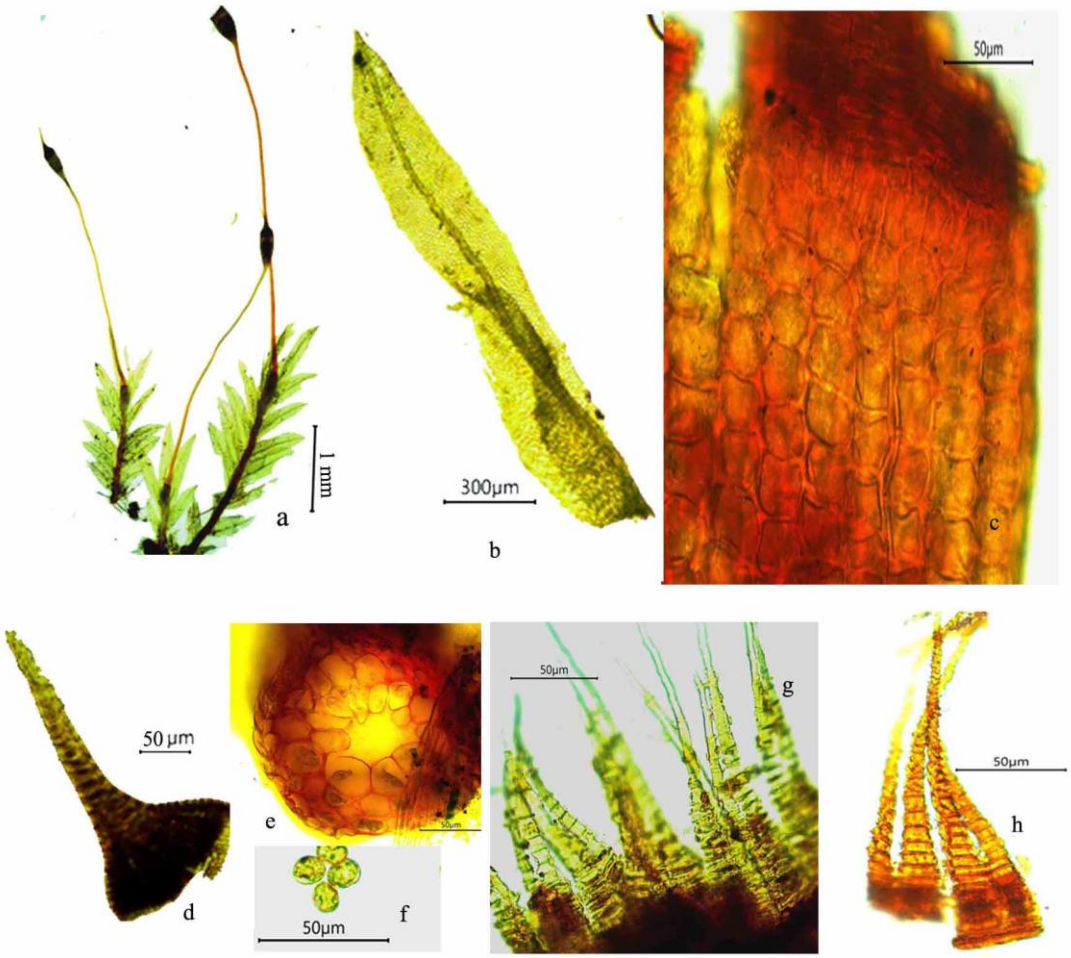


Plate 106b. *Fissidens zollingeri* Mont., a. sporophytic plant, b. perichaetial leaf, c. exothecial cells, d. operculum, e. stem T.S., f. spores, g&h. peristome

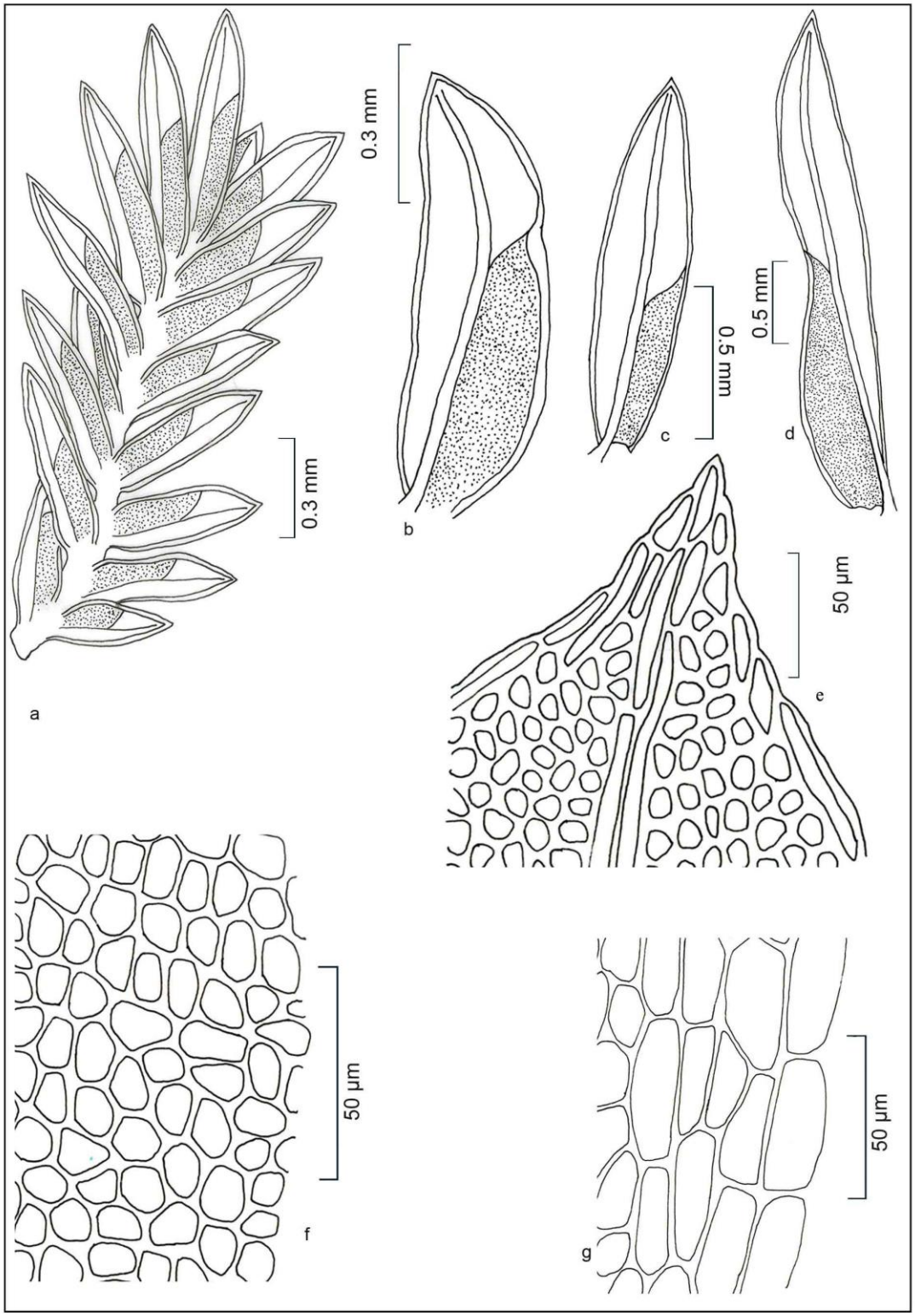
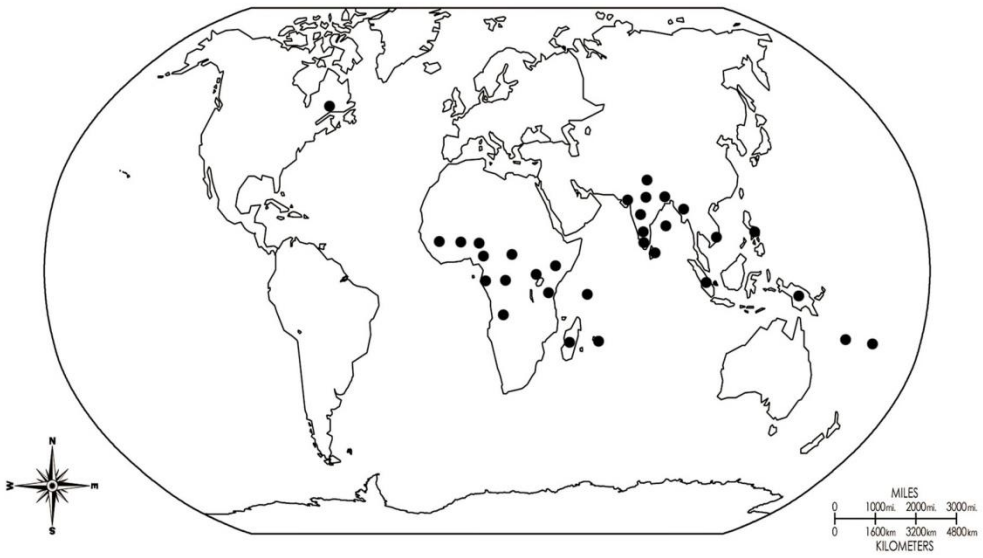
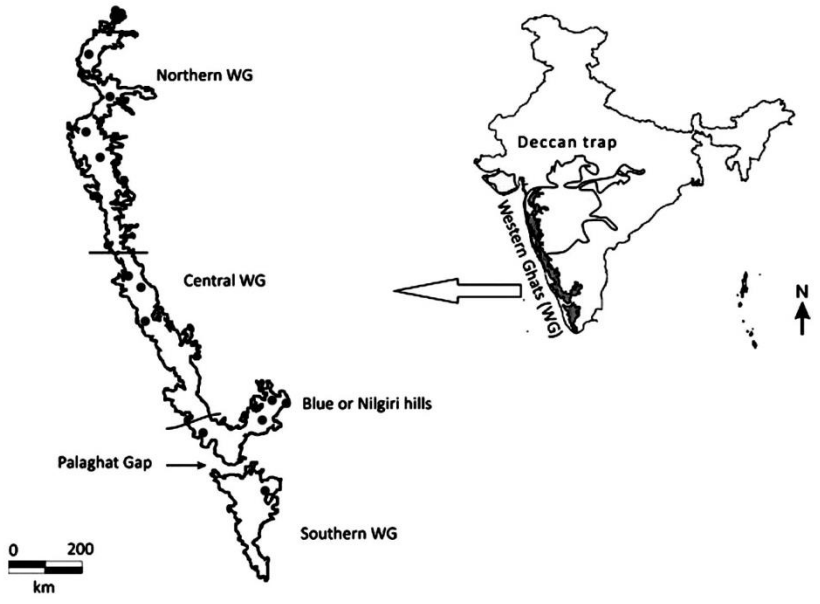


Fig. 58. *Fissidens zolllingeri* Mont., a. vegetative plant, b&c. vegetative leaves, d. perichaetal leaf, e. leaf apex, f. laminal cells, g. vaginant laminae base



Map 64A. World distribution of ***Fissidens zollingeri*** *Mont.*



Map 64B. Distribution of ***Fissidens zollingeri*** *Mont. in Western Ghat*

Specimens examined: India, Kerala; Kerala, Kannur district, Aralam WLS, Kannadivecha kunnu (), 22.008.2017, Vijisha (ZGC 10160), Wayanad district, Lakkidi (750m), 14.09.2001, Manju CN (80098) (CALI!); Kurichiad , Dhottakulachi (920m), 20.04.2002, Manju CN (84557) (CALI!), Periya (764m), 26.09.2016, Shinoj (ZGC 16168), Kozhikode district (Wayanad churam, 600m), 13.07.14, Mithun (ZGC 1241B), Pokkunnu (ZGC campus, 80m), 25.08.2015, Manjula (ZGC 1200), (Ramanattukara, 13m), 17.07.2013, Manju (ZGC 609), Malappuram district, Aroor, Ayikarapadi (), 04.07.2017, Mufeed (ZGC 16388), Mukurti NP (579m), Manju CN (111862B) (CALI!); Karnataka (Jog falls, 497m), 26.09.13, Rajilesh (ZGC 850A), Sirsi (1750ft), 19.09.2014, Manjula & Deepa (ZGC 3638); Kemmanagundi (742m),19.09.2014, Manjula & Deepa (ZGC 3650), Coorg (Sidapur), Feb. 1898, T.L. Walker (Walker 267) (BM!) (as *F. coorgensis*), Chikkamagaluru (Kemmannagundi, 1434m), 09.10.2013, Aruna, K. B. (BCDAK 125!); Tamil Nadu, Nilgiri District (Mukurthi National Park, 2100m), Rajesh (ZGC 111862B); Goa, Cancona, (Cotigao Wildlife Sanctuary, 88 m), 15.08.2015 Manjula & Deepa (ZGC 15126); Tamil Nadu, Palni Hills Foreau (no details) (CAL!) (as *F. coorgensis*); Uttar Pradesh; Shahijahah pur (Near Khutar forest, 146m), 12.09.2014, Vinay Sahu (258217 B!); Kashmir (Gulmarg, 2700m), 09.09.1961, anon.(629) (CAL!) (as *F. xiphioides*);

Etymology: The specific epithet *zollingeri* refers to the botanist 'H. Zollinger' who collected the type specimen of this species from Java.

***Fissidens sp.* 1**

Plants in tufts, light green, older parts yellowish, leaves not overlapping, axillary hyaline nodules absent; rhizoides smooth, brownish; stem yellowish green towards apex, reddish brown towards base, 5.0-7.0 x 1.2-1.7 mm, 11-17 pairs of leaves, central strand differentiated; leaves oblong lingulate, margin crenate, 1.43-1.48 x 0.3-0.37 mm, 4 times long as wide, apex apiculate or mucronate, leaf slightly asymmetric at apex; limbidium restricted to vaginant laminae, three or four rows at vaginant laminae base, single rowed at vaginant laminae apex, uniseriate; vaginant laminae reaching more than 1/2 of apical lamina, closed or slightly open, 0.90-0.98 x 0.20-0.24 mm; dorsal lamina narrowing towards base, not round, 4-6 cells wide,

dorsal lamina and apical lamina uniseriate; costa strong, bryoides type, slightly excurrent, small bent towards apex; laminal cells irregularly quadrangular or polygonal, mammillose, obscure, mid vaginant laminal cells with single conical papillae projection, 13.02-14.91 x 8.68-9.14 µm; mid dorsal laminal cells convex, 12.14-14.47 x 6.04-7.13 µm; gemmae not found.

Fertile parts; perigonia not found; perichaetia terminal, plant 9-10 mm long including sporophyte, similar to vegetative plant, perichaetial leaves slightly elongated with prominent limbidium on vaginant laminae, archegonium not found; sporophyte one or two per perichaetium, 4.0-6.0 mm long; calyptra conical, peristome base 42.59-47.37 µm, 0.15-0.25 mm long; spores globose, 13.73-16.66 µm (Plate 107 & Fig.59).

Diagnostic characters: This species is characterised by oblong lingulate leaves, serrate margin, single mamilla in each cell, limbidium on vaginant laminae. This species is similar to *F. crenulatus* Mitt. and *F. walkeri* Broth. in mamillose laminal cells and limbidium on vaginant laminae margin but differs from *F. crenulatus* in the oblong lingulate leaves and slightly excurrent costa of this species. This species differs from *F. walkeri* in the leaf shape and nature of limbidium. Since this species shows characters that are different from *F. crenulatus* Mitt. and *F. walkeri* Broth. further studies are needed to reveal its identity.

Habitat and General Ecology: On laterite soil in the sacred grooves of low altitude areas.

Distribution: India, Kerala

Specimens examined: India, Kerala, Kozhikode district (Thurayil Kotta, Kunnamangalam, 20m), 11.07.2015, Manjula, K.M. & Deepa, K.M. (ZGC 4290B) (Map 65A&65B).

Note: This specimen does not match with any of the species reported from India. Further investigation is needed to fix its identity and it may turn new species or new record for India.

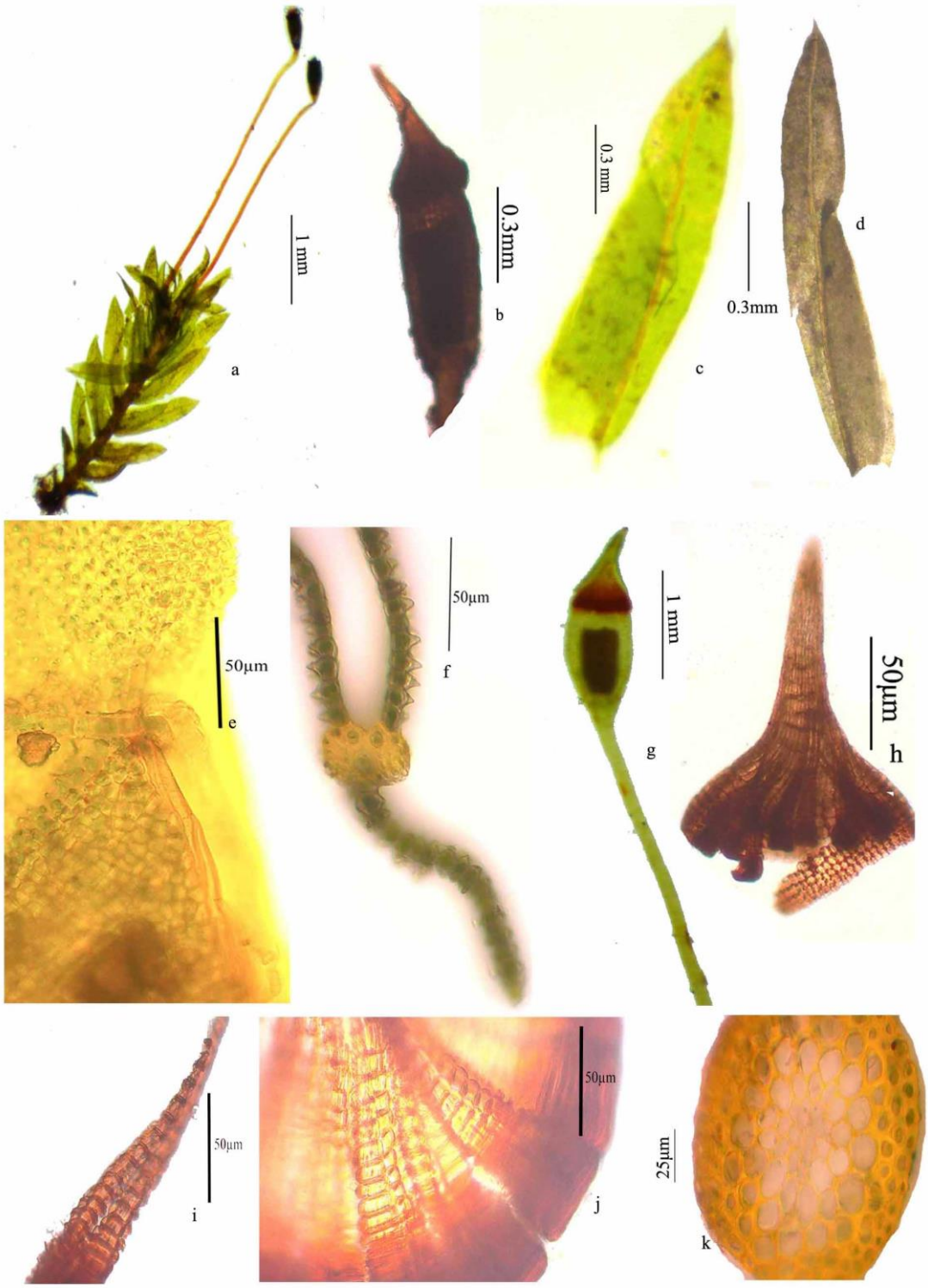


Plate 107. *Fissidens* sp. 1, a. single plant with sporophyte, b. capsule, c. vegetative leaf, d. perichaetial leaf, e. vaginant laminae apex, f. leaf T.S., g. sporophyte, h. operculum, i&j peristome, k. stem T.S.

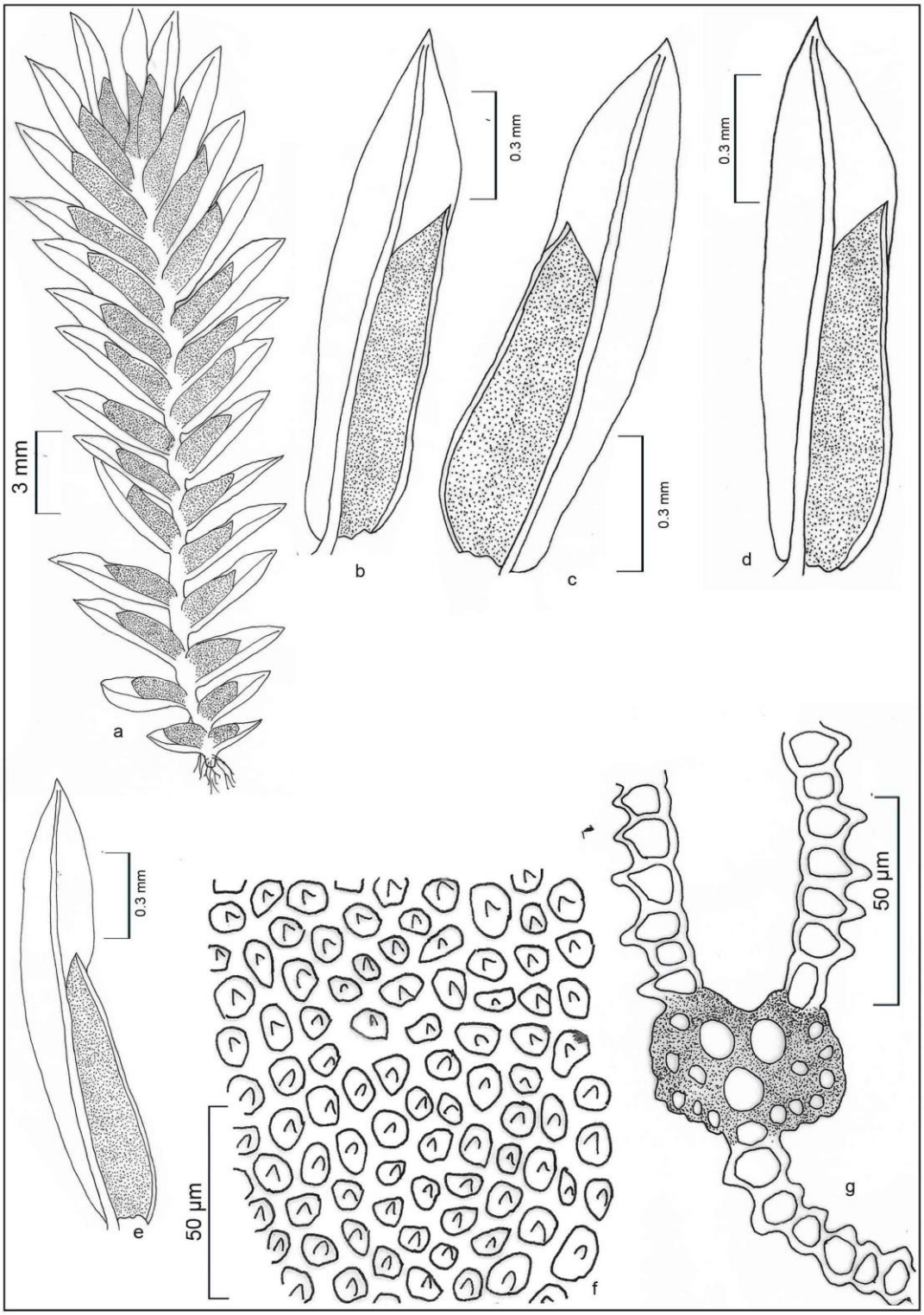
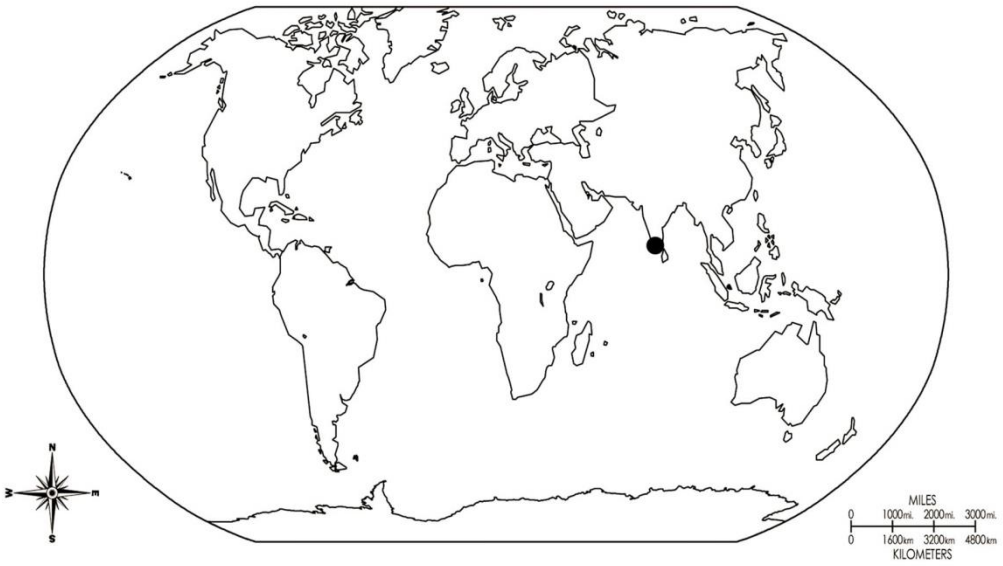
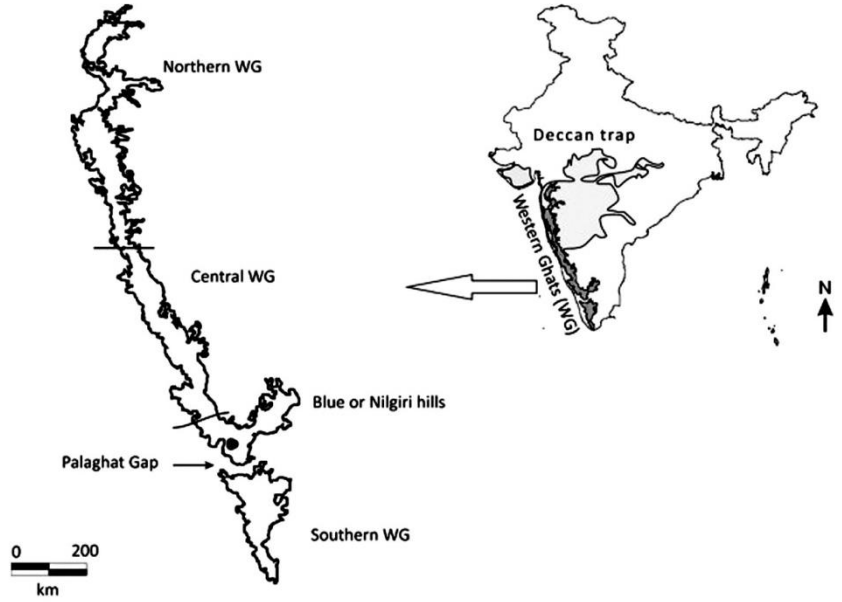


Fig. 59. *Fissidens sp.*1. a. vegetative plant, b-d. vegetative leaves, e. perichaetial leaf, f. dorsal lamina base near insertion, g. leaf T.S.



Map 65A. World distribution of *Fissidens* *sp.1*



Map 65B. Distribution of *Fissidens* *sp.1 in Western Ghat*

***Fissidens sp*. 2**

Plants growing as broken clusters, small, light green, 2.0-2.5 x 0.0.5-0.7 mm, 10-12 pairs of leaves; axillary nodules absent; rhizoids basal, smooth; leaves oblong lanceolate with broad base, leaves narrows towards apex, margin crenulated due to papillae projection, 0.3-0.4 mm long; limbidium absent on all laminae costa strong, yellowish green coloured, excurrent in apiculus, costal cells clear at leaf apex; vaginant laminae more than half of leaf length, unequal, minor lamina open, it ends in the midway of margin and costa, vaginant laina unistratose, base more or less entire; dorsal lamina gradually narrows towards base, base rounded, not decurrent, dorsal lamina and apical lamina unistratose, margin crenulate; laminal cells irregularly hexagonal, small, obscure due to cell mamilla, each cell contains single mamilla but some marginal cells shows two small projections (Plate 108 & Fig.60).

Fertile parts not found.

Diagnostic Characters: This species is characterised by elimbate leaves with excurrent costa ending in short apiculus, leaves oblong, margin crenulate except vaginant laminae base, cells obscure with mamillae. Single mamilla clear in inner laminal cells while two mamillose projections in some marginal cells. This species is similar to *F. pallidinervis* in crenualate margin, elimbate leaves and oblong leaves while differs in costa ending far below leaf apex and pluripapillose laminal cells of *F. pallidinervis.* This species also shows similarity with *F. kurzii* in leaf shape and leaf margin but discrete in the distinct multipapillose laminal cells and percurrent costa of *F. kurzii.*

Habitat and General Ecology: On rocky patch in the moist deciduous forest.

Distribution: India (Tamil Nadu) (Map 66A&66B).

Specimen examined: India, Tamil Nadu (Valparai, 950m), 24.12.2014, Manju C.N (ZGC 3983a).

Note: The specimen is collected without fertile part, it is necessary to completely separate this species from rest of the taxa. The vegetative characters shows some similarity with *F. pallidinervis* and *F. kurzii* but it is not matching completely with any of the available species and hence considered as *Fissidens sp.* 2. Need some more time to fix its identity and may turn as new species or new distributional record.

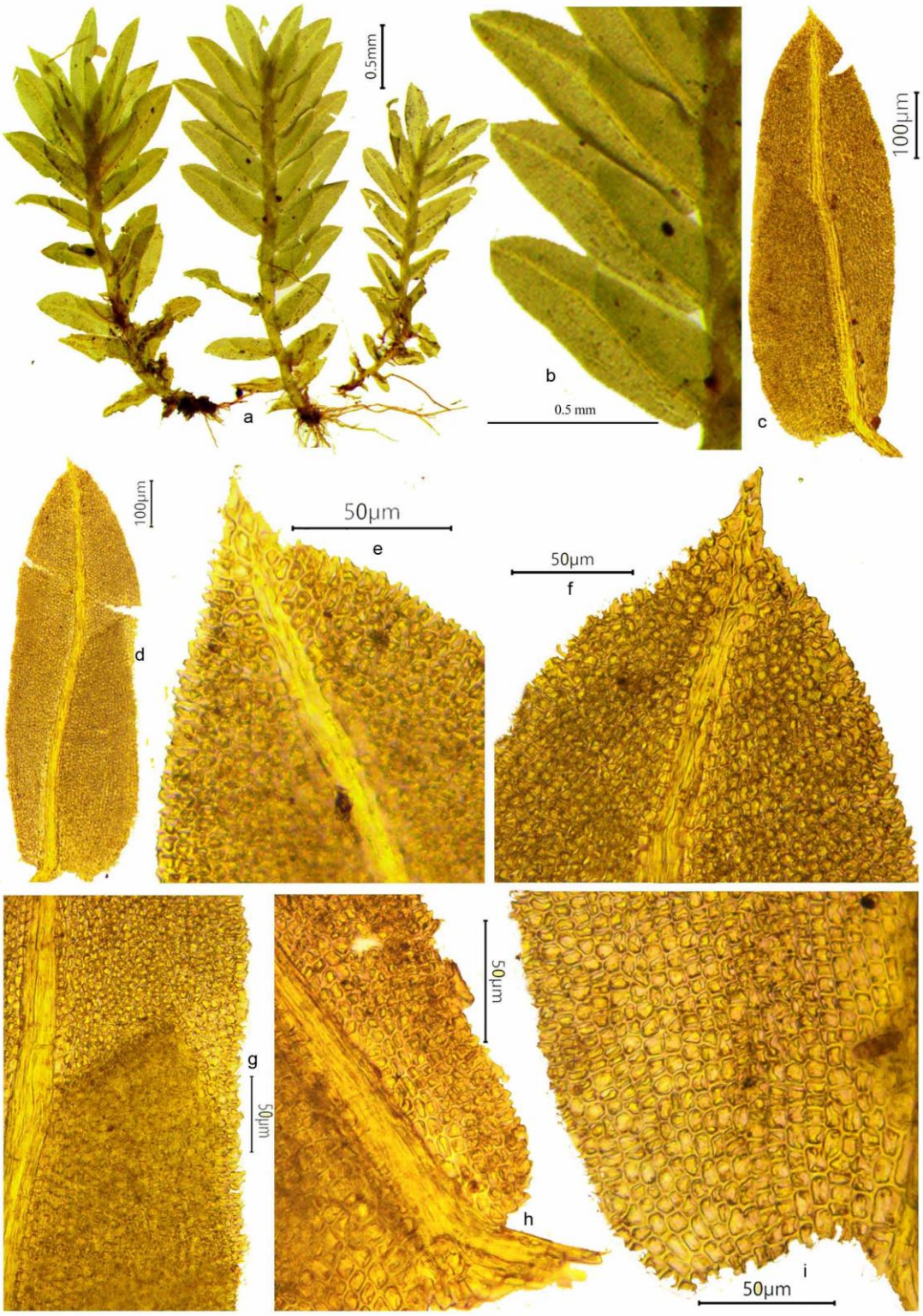


Plate 108. *Fissidens sp*. 2, a. vegetative plants, b-d. vegetative leaves, e&f. leaf apex, g. vaginant laminae apex, h. dorsal lamina base near insertion, i. vaginant laminae base.

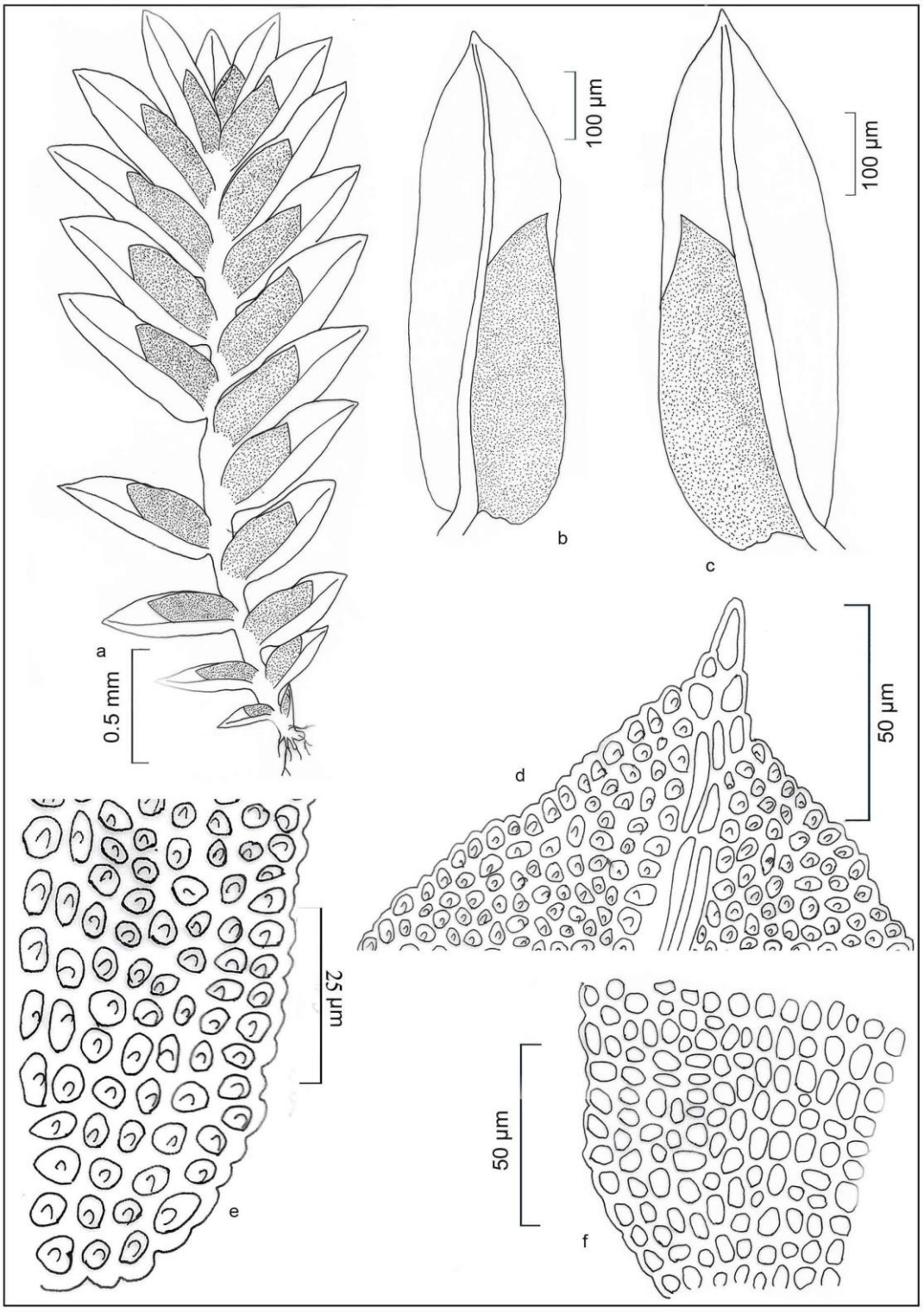
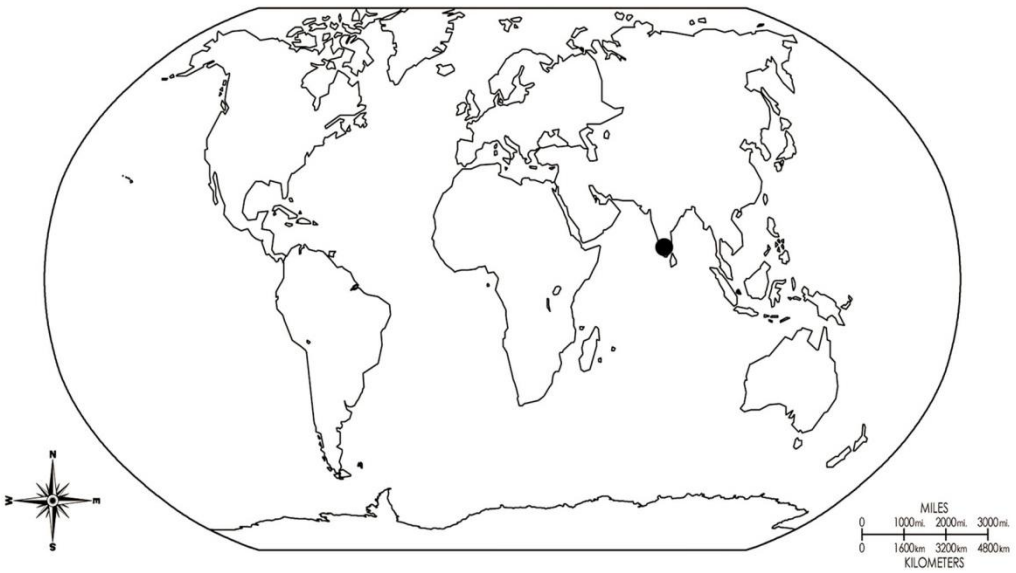
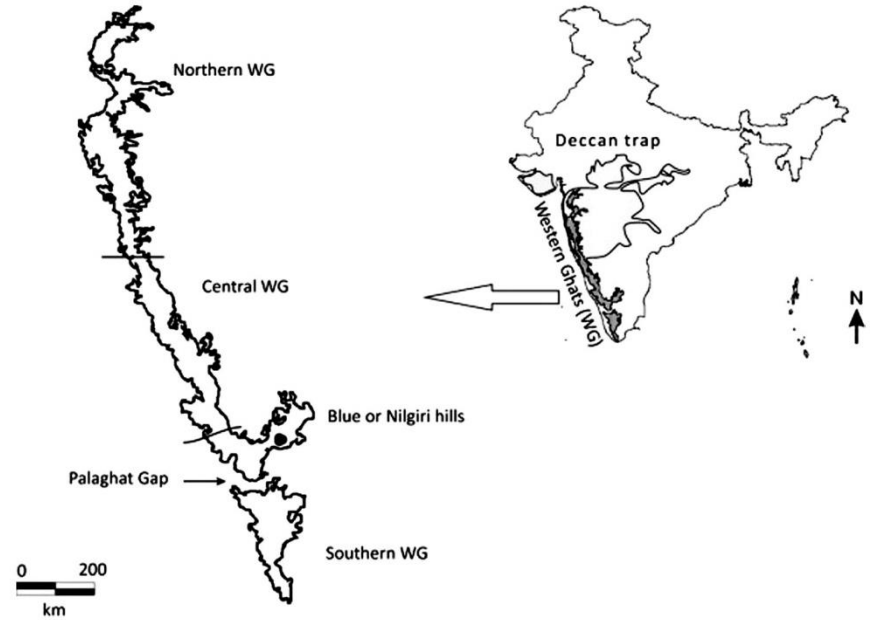


Fig. 60. Fissidens *sp.* 2. a. vegetative plant, b&c. vegetative leaves, d. leaf apex, e. dorsal lamina base near insertion, f. vaginant laminae base.



Map 66A. World distribution of ***Fissidens*** *sp. 2*



Map 66B. Distribution of ***Fissidens*** *sp. 2 in Western Ghats*

Species with data insufficiently known

In the present study seven species and two varieties reported from Western Ghats is excluded from the key due to the unavailability of type, authentic specimens, detailed description, etc. After the type collection and some listing in checklist there is no further details regarding these species. The available detailes from the literatures area provided here.

Fissidens amplifolius Dixon & P.de la Varde, Ann. Cryptog. Exot. 3(4): 170, 1 f. 1. 1930.

Type: Agasthyamalai, *Foreau 978* (PC; RHT). Endemic to Tamil Nadu.

Daniels (2010) listed this species based on earlier collection. It is an endemic species of Tamil Nadu and Foreau first collected this species from Tamil Nadu part of Agasthyamalai. Dixon & Potier de la Varde (1930) and Foreau (1964) collected this species from Thirunelveli in Tamil Nadu and Bruhl (1931) listed this species from Palni hills.

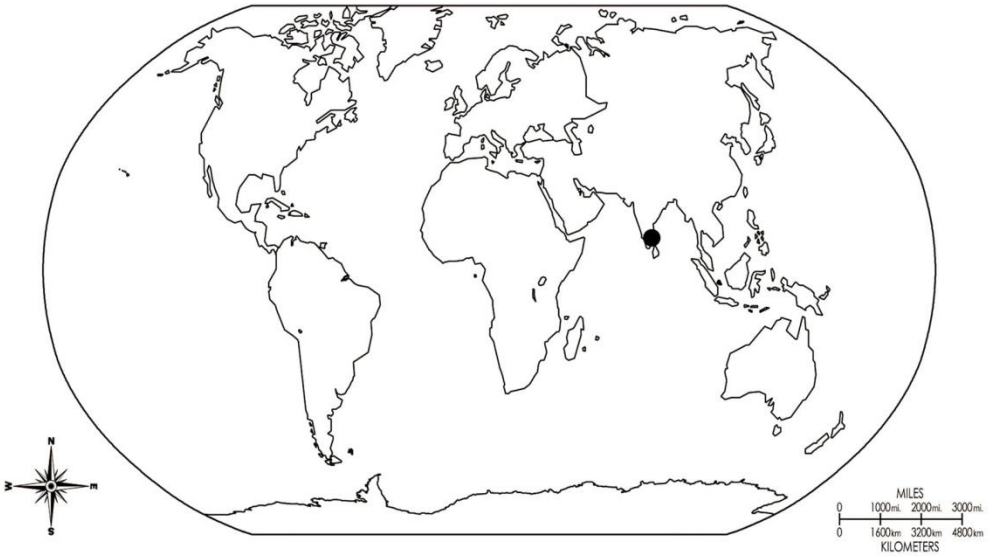
Collection details: – Mundanthurai, Tirunelveli, 1928, *Foreau 978* [Dixon & Potier de la Varde 1930: 170]. – Palni Hills [Bruhl 1931: 19]. – Mundanthurai, Tirunelveli [Foreau 1964]. PC; RHT [Matthew 1973: 522]; Caribbean Islands (Wiljk *et al*. (1959-1969) (Map 67A&67B).

Fissidens carnosus Broth., Rec. Bot. Surv. India 1(12): 314. 1899; Crosby *et al*. Missouri Bot. Garden. 1999; Frahm *et al*., Arch. Bryol. 158: 13. 2013.

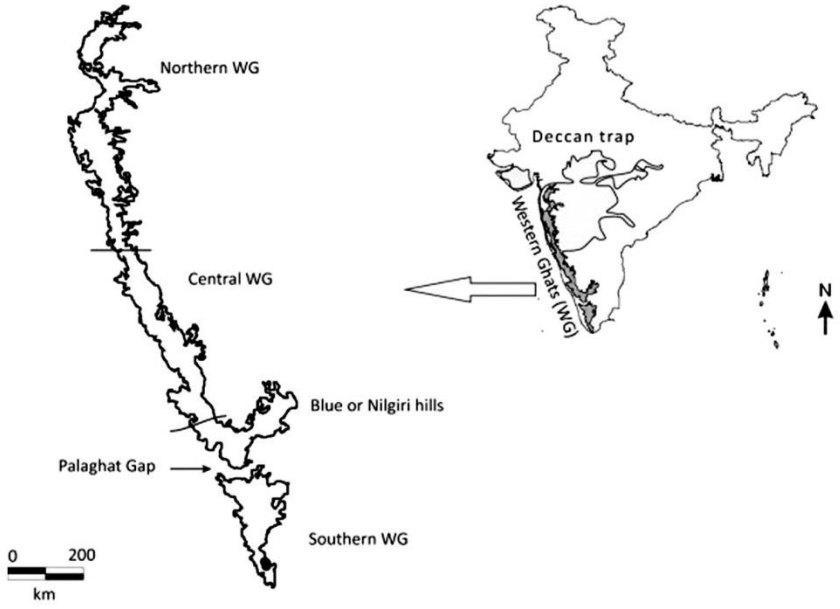
Type: Hatur - [Coll./herb. no. Walker, T.L. 1094201 (BM)] - Brotherus 1899 [Coll./herb. no. Walker, T.L. 178]

Fissidens carnosus Muell. Hal., Gen. Musc. Frond. 67. 1900. (homonym, invalid)

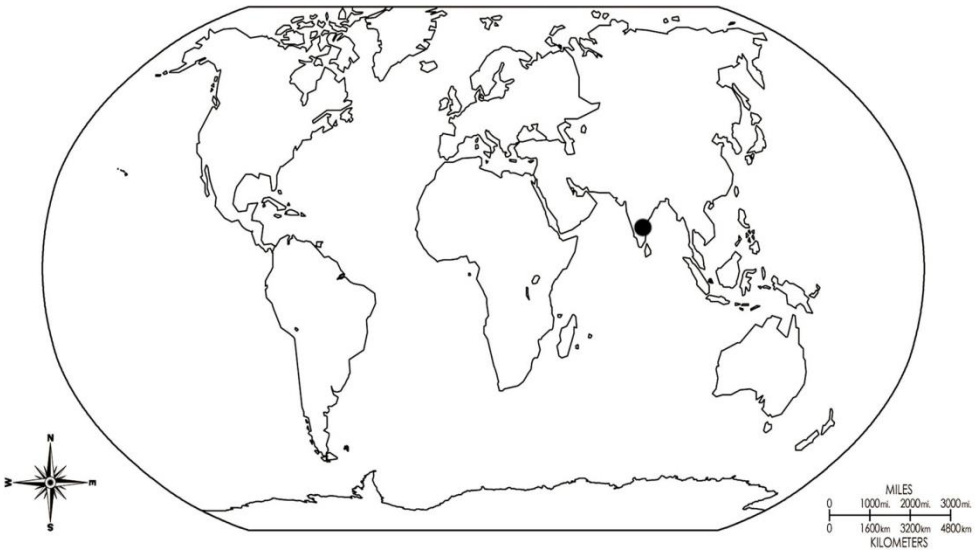
Collection details: Karnataka, Coorg: near Hatur (Brotherus, 1899, type) Frahm *et al*., 2013 & Schwarz (2014b) listed this species from Karnataka based on the type specimen (Map 68A&68B).



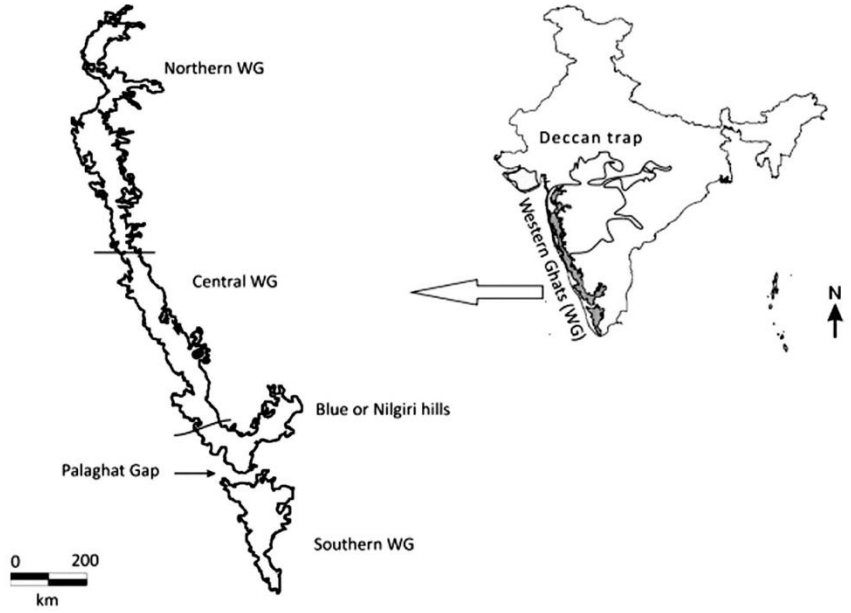
Map. 67A. World distribution of ***Fissidens amplifolius*** *Dixon & P.de la Varde*



Map. 67B. Distribution of ***Fissidens amplifolius*** *Dixon & P.de la Varde in Western Ghats*



Map 68A. World distribution of ***Fissidens carnosus*** Broth.



Map 68B. Distribution of ***Fissidens carnosus*** Broth. *in Western Ghats*

Fissidens ceylonensis Dozy & Molk. var. ***acutifolius*** Dixon & P. de la Varde, Rev. Bryol. 52: 38. 1925.

Daniels (2010) listed this variety based on earlier collection. But I could not collect this variety during my present study and could not locate the type. Dixon & Potier de la Varde (1930) and Foreau (1930 & 1961) reported this species from upper palnis in Tamil Nadu. Manju *et al.* (2008b) also listed this species based on Ellis (1992b) from Kerala.

Collection details: Tamil Nadu– Palni Hills, Tiger Shola (*Foreau 110*); Shembaganur, *Eucalyptus* forest, *Foreau 1312*) [Dixon & Potier de la Varde 1930: 185, as *F. pennatulus*].– Upper Palnis: Kodaikanal no. *235*, 1912; Tiger Shola No. *368*, 1923 [Foreau 1930: 7].– Palni Hills [Foreau 1961: 15]. – PC; RHT [Matthew 1973: 522] (Map 69A&69B).

Fissidens fuscoviridis Thwaites & Mitt., J. Linn. Soc., Bot. 13: 323. 1873; Crosby *et al*. Missouri Bot. Garden. 1999; Frahm *et al*., Arch. Bryol. 158: 13. 2013; Tixier, Ceylon. J. Sci. Biol. Sci. 16 (1&2): 26. 1983.

Type: Karnataka; Virajpet - Brotherus 1899 [Coll./herb. no. Walker, T.L.137]; Watekoli – Brotherus, 1899 [Coll./herb. no. WALKER, T.L. 149]

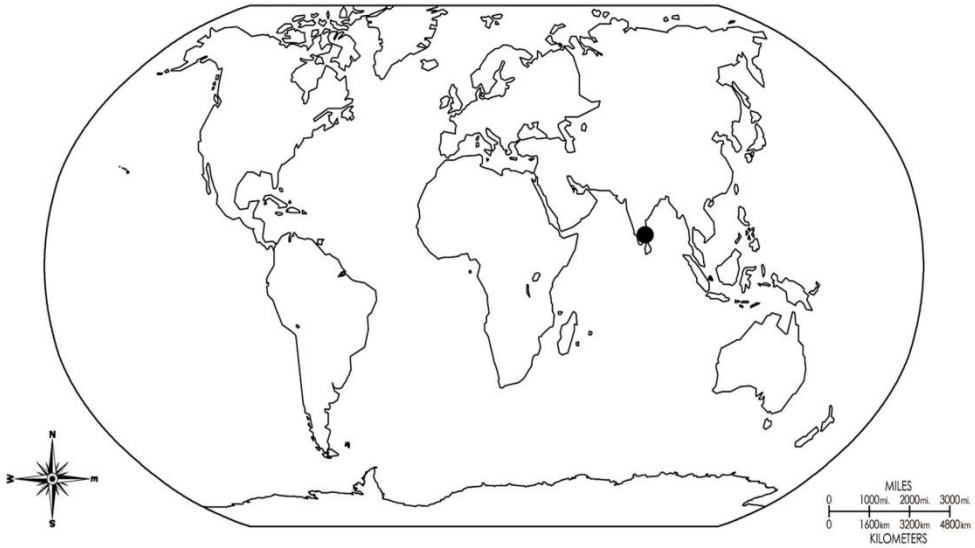
Noguchi (1973) and Tixier (1983) listed this species from Sri Lanka without any description and illustration. They reported this species as endemic to Sri Lanka (Map 70A&70B).

Fissidens hyalinus Hook. & Wilson, J. Bot. (Hooker) 3: 89, tab. 2. 1841.

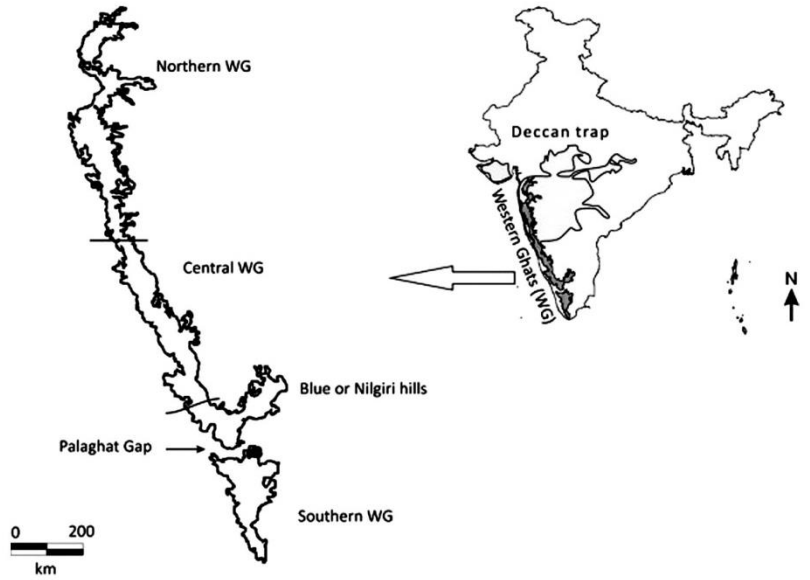
Fissidensnymanii M. Fleisch., Musci Buitenzorg 1: 19. 1. 1904. *Fissidens satsumensis* Sakurai, Bot. Mag. (Tokyo) 47: 735. 1933.

Collection details: Perumalmalai at 1562 m., 1956 [Foreau 1961: 15, as *Fissidens nymanii* M.Fleisch.]. – Nilgiri-Ooty; Palni [Gangulee 1971: 462] (Map 71A&71B).

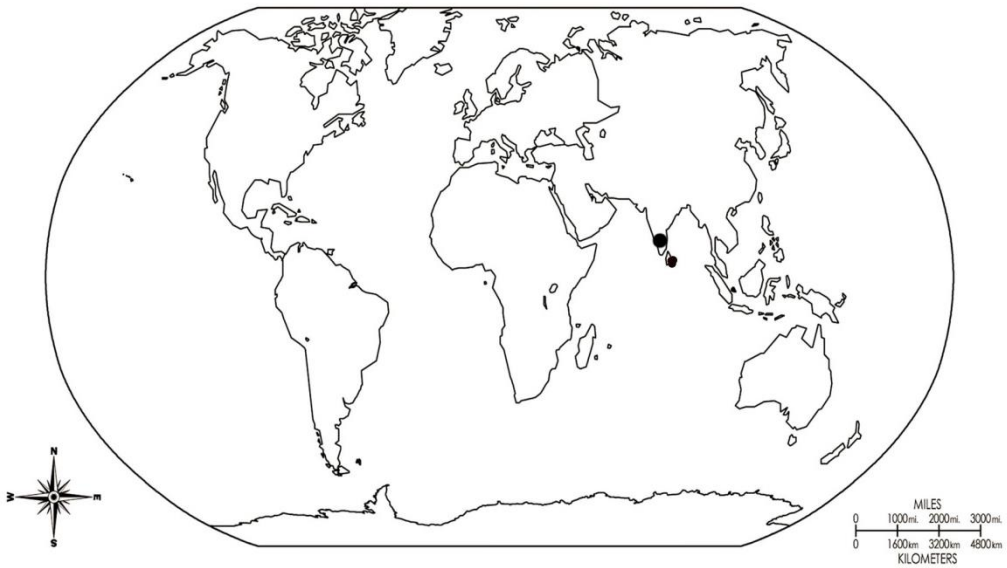
Note: *F. enervis* is compared with *F. hyalinus* based on the details given by (pers. comm.) Bruggeman-Nannenga of Netherlands.



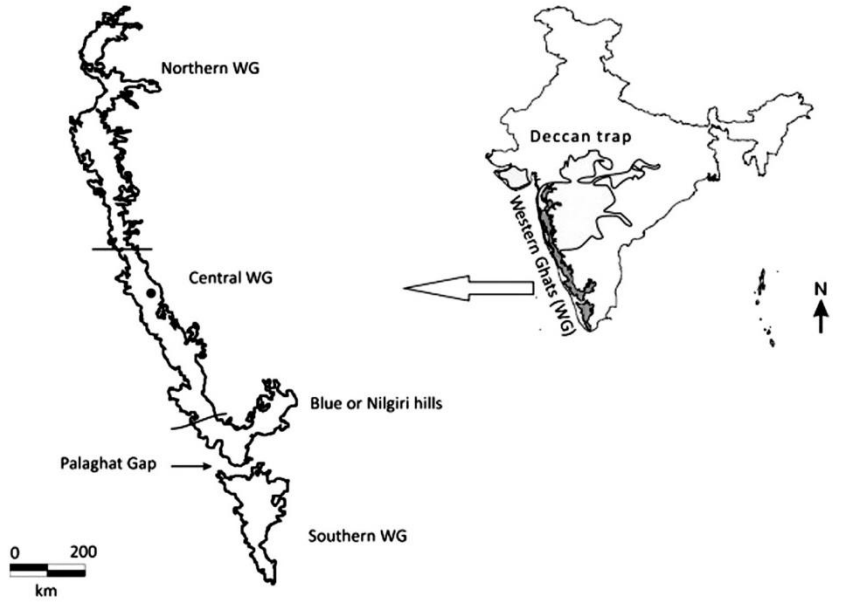
Map 69A. World distribution of ***Fissidens ceylonensis*** *Dozy & Molk. var.* ***acutifolius*** *Dixon & P.de la Varde*



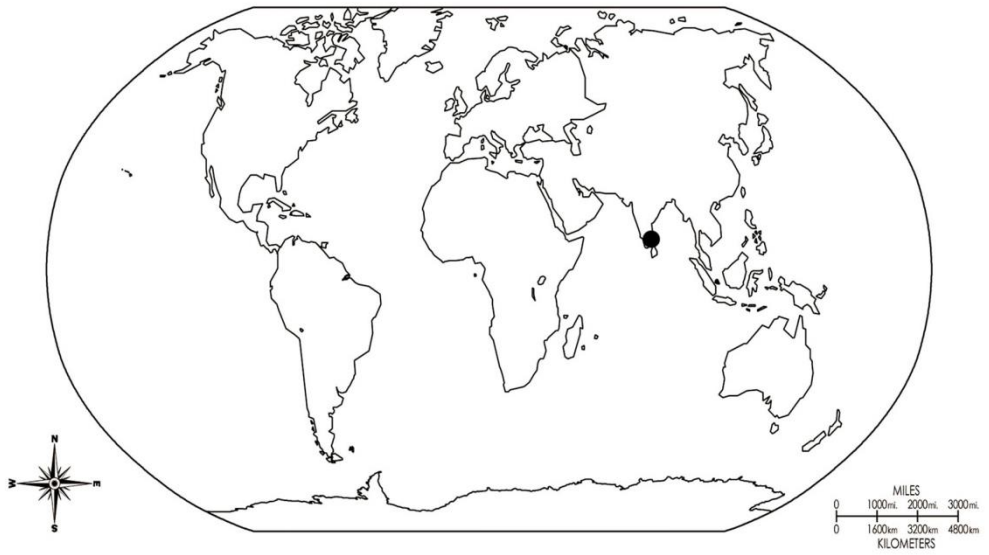
Map 69B. Distribution of ***Fissidens ceylonensis*** *Dozy & Molk. var.* ***acutifolius*** *Dixon & P.de la Varde in Western Ghats*



Map 70A. World distribution of ***Fissidens fuscoviridis*** *Thwaites & Mitt.*



Map 70B. Distribution of ***Fissidens fuscoviridis*** *Thwaites & Mitt. in Western Ghat*



Map 71A. World distribution of ***Fissidens hyalinus*** *Hook. & Wilson*

Map 71B. Distribution of ***Fissidens hyalinus*** *Hook. & Wilson in Western Ghats*

Fissidens karwarensis Dixon, J. Indian Bot., 2: 179. 1921.

Type: Karnataka, Karwar - [Coll./herb. no. Sedgwick, L.J. 1094341 (BM), 10/1919] - Dixon 1921 [Coll./herb. no. Sedgwick, L.J. 6368]; Shiggaon - [Coll./herb. no. Sedgwick, L.J. 1094342).

Schwarz (2014b) listed this species based on earlier collection from Karnataka. The type from Kanara and collected by Sedgwick, Dixon 1921 reported this species from Karnataka. Daniels (2010) listed this species based on earlier collection. It is an endemic species of South India and Dixon & Potier de la Varde (1930) and Foreau (1961) reported this species from Shembaganur Forest and Old Ghat road in Tamil Nadu.

Collection details: – Karnataka, Karwar - [Coll./herb. no. Sedgwick, L.J. 1094341 (BM), 10/1919] - Dixon 1921 [Coll./herb. no. Sedgwick, L.J. 6368]; Shiggaon - [Coll./herb. no. Sedgwick, L.J. 1094342; Shembaganur Forest (about 9th mile), *Foreau 1133* [Dixon & Potier de la Varde 1930: 185].– Old Ghat Road at 1676 m., 1929 [Foreau 1961: 15] (Map 72A&72B).

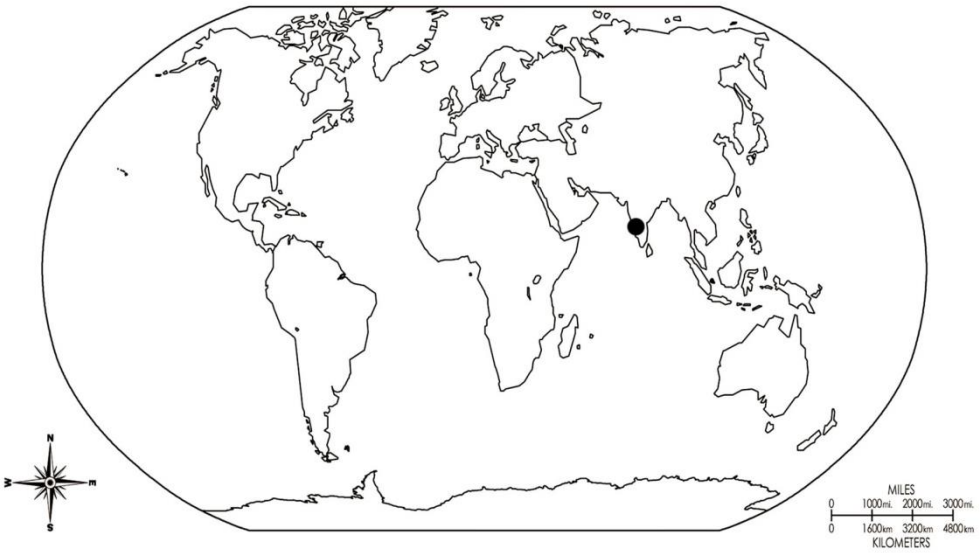
Fissidens perumalensis Dixon & P. de la Varde, Rev. Bryol. 52: 38. 1925.

Type: Palni hills, *Foreau 740* (PC). Endemic to Palni hills.

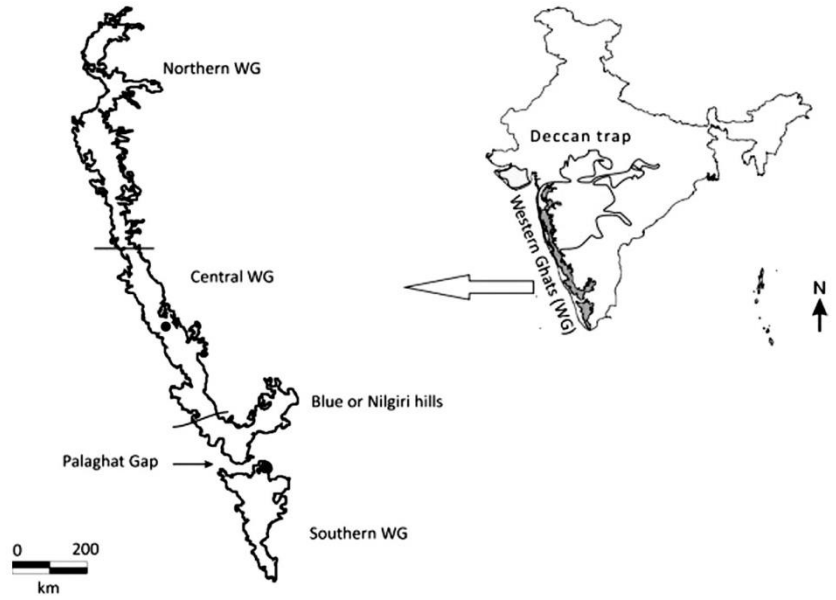
Itti Pallam, Palni Hills, 4 Feb 1927, no. *740* [Dixon & Potier de la Varde 1927].– Lower Palnis: near Perumalmalai, no. *740*, 1927; Itti Pallam, Palni Hills, 4 Feb 1927 (No. *740*) [Foreau 1930. 7].– Palni Hills [Bruhl 1931: 19].– Itti Pallam, near Perumalmalai, at 1699 m., 1927 [Foreau 1961: 15].– PC [Matthew 1973: 522] (Map 73A&73B).

Fissidens teniolatus Dixon & P. de la Varde, Ann. Cryptog. Exot. 3(4): 169, 1 f. 2. 1930.

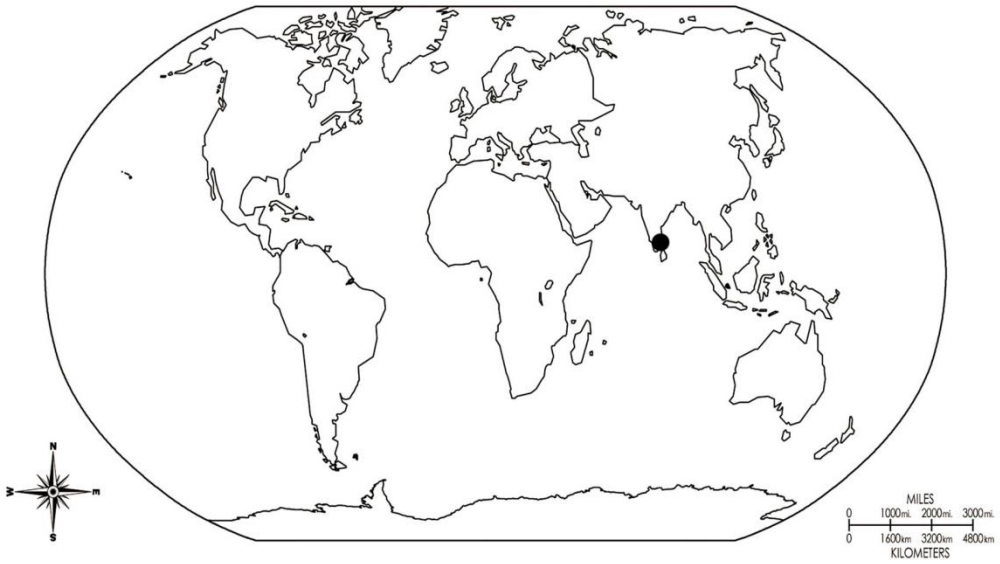
Dabhade (1998) reported this species from Mahabaleswar in Maharashtra. It is an accepted name in Tropicos, but no other citations other than type. Crosby, *et al*. (1999) commented that the species is insufficiently known because no more information about the species than Index Muscorum and merely relisted without additional specimens in a checklist since 1963 (Map 74A&74B).



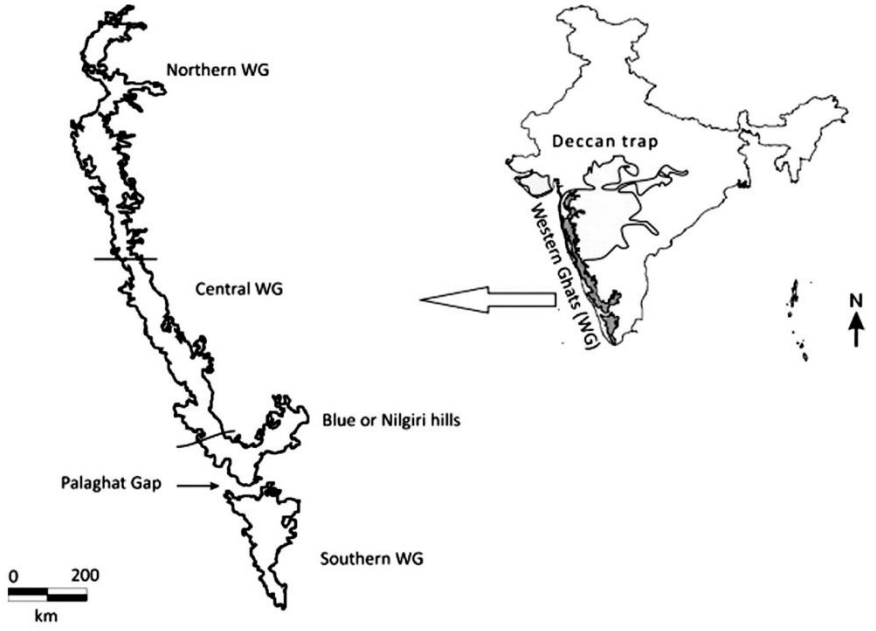
Map 72A. World distribution of ***Fissidens karwarensis*** *Dixon*



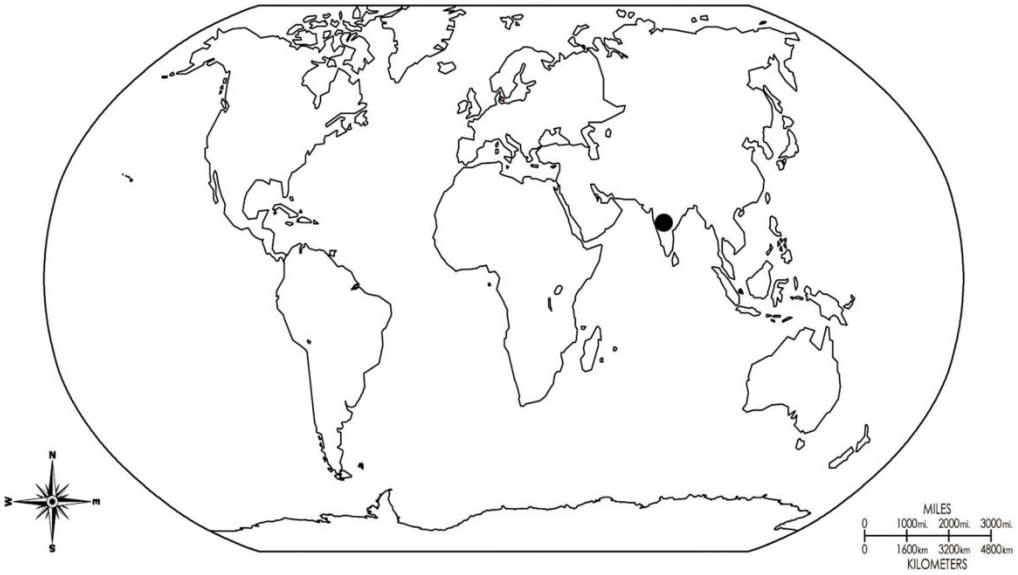
Map 72B. Distribution of ***Fissidens karwarensis*** *Dixon in Western Ghats*



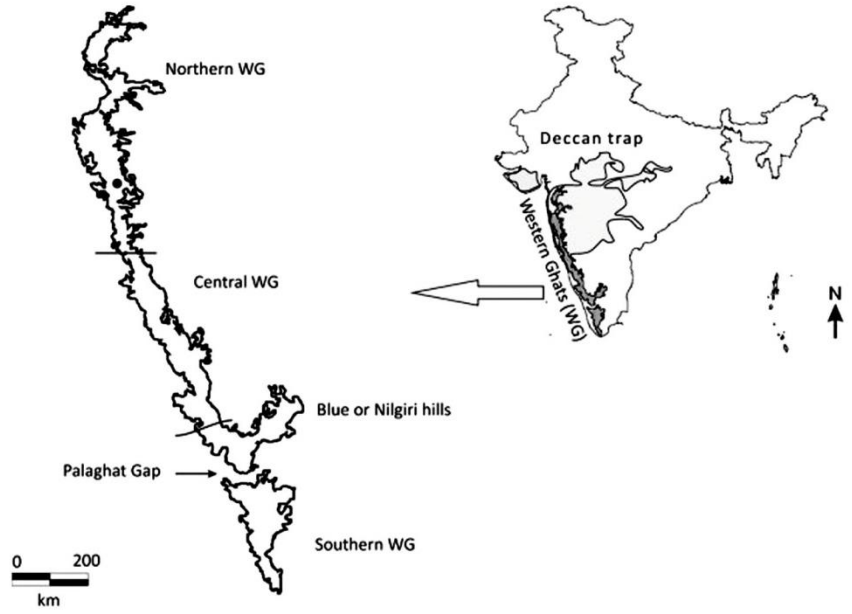
Map 73A. World distribution of ***Fissidens perumalensis*** *Dixon & P.de la Varde*



Map 73B. Distribution of ***Fissidens perumalensis*** *Dixon & P.de la Varde in Western Ghats*



Map 74A. World distribution of ***Fissidens teniolatus*** *Dixon & P. de la Varde*



Map 74B. Distribution of ***Fissidens teniolatus*** *Dixon & P. de la Varde in Western Ghats*

Fissidens walkeri Broth. var. ***elimbatus*** (Broth.) Dixon, J. Indian Bot. 2: 177. 1921.

Type: var. elimbatus (Broth.) Dixon Coorg: Mt. Tandiandamol (Brotherus, 1899).

Fissidens elimbatus Broth., Rec. Bot. Surv. India 1(12): 316. 1899.

Dixon (1921) described this species from Kanara in Karnataka. Daniels (2010) listed this species based on earlier collection. But during the p[resent study I could not locate this variety and Tropicos accept this species.

Collection details: Karnataka, Coorg: Mt. Tandiandamol (Brotherus, 1899); – Tamil Nadu, Bottom Station at 900 m., 1929, *Foreau 1216* [Dixon & Potier de la Varde 1930: 185; Foreau 1961: 16] (Map 75A&75B).

Vohra *et al.* (1982) reported 83 species of mosses from Silent valley National Park in Palakkad district of Kerala. Among these, two collections were *Fissidens*, but not yet reported this species. The collected specimens were deposited at Central National Herbarium, Kolkata (CAL) and we could not locate the specimen during the present study. The specimens were misplaced or lost.

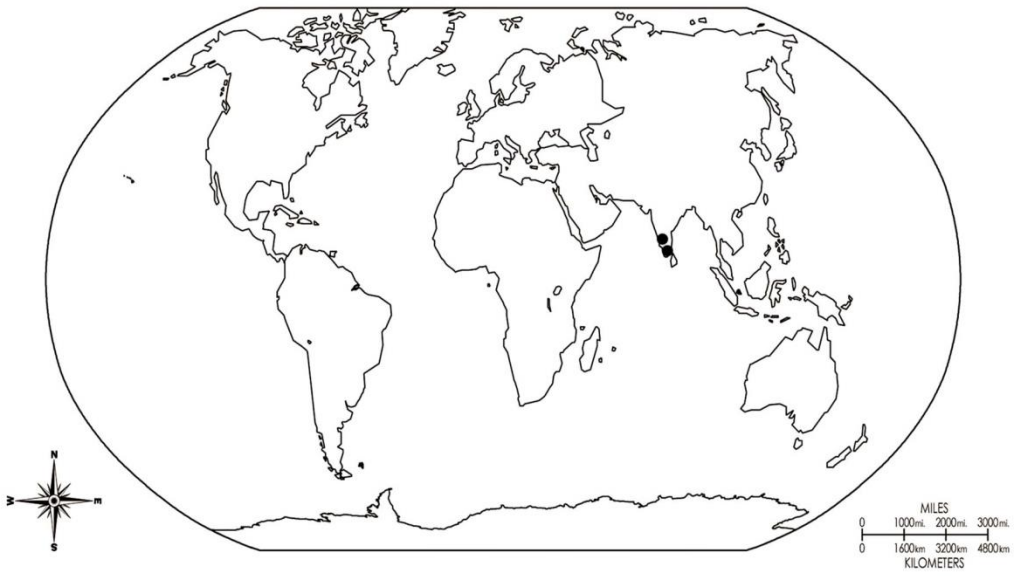
Illegitimate names

Fissidens grandifolia D.S.

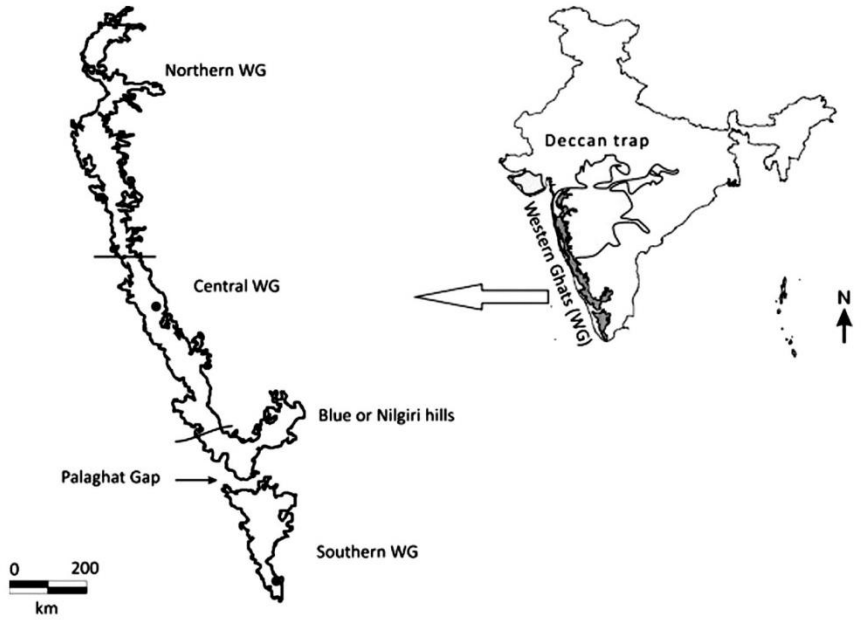
Fissidens barbuloides D.S.

Fissidens undulaefolia D.S.

Subramanian (2016) published *F. grandifolia* D.S.from Coonoor in Tamil Nadu and commented that he has earlier reported two other *Fissidens* from South India. Among these, he described *Fissidens undulaefolia* D.S. from Naduvattom in 2010 and *F. barbuloides* D.S. as a new species from Guruvayur in Kerala during 2011 (Subramanian, 2016). The illustration given in the protologue of *F. grandifolia* D.S.is very poor without any characters to support his findings. He did not designated the type in his paper and described that the isotypes were kept in his custody at home and holotype is deposited in BSI (CBE, TN). But the herbarium of BSI, Coimbatore is abbreviated as MH and during our present survey we could not locate the species from BSI, Coimbatore.



Map 75A. World distribution of ***Fissidens walkeri*** Broth. var. ***elimbatus*** (Broth.) Dixon



Map 75B. Distribution of ***Fissidens walkeri*** Broth. var. ***elimbatus*** (Broth.) Dixon *in Western Ghats*

Ecology of Fissidentaceae in Western Ghats

The family Fissidentaceae are the monotypic family having cosmopolitan members with majority of the species distributed in the warm, humid tropics and with the number decreasing as latitude increases. Generally, most of the species shows a diversified habitat preference in the Western Ghats except for some species such as *F. kammadensis, F. manilalia, F. pallidinervis* and *F. sedgwickii.* They are known from very few localities, with narrow habitat preferences. The macro and micro climatic conditions such as water availability, pH of the substratum, light availability and the degree of disturbance are the various characters which influence the growth pattern of the Bryophytes in general. Most of the species growing in low altitude areas grow along with other species. However, this condition is different in high altitude evergreen and semi evergreen areas, where some species are found solely as pure stands, without any associations. This may be due to the availability of light and temperature in the low altitude areas and due to closed canopy the availability of light and temperature is very less compared to low altitude areas.

Some species are found only in single vegetation type such as *Fissidens asplenioides* Hedw. in evergreen forests and *F. anomalus* in Shola forests. It was in corroboration with the earlier reports. The distribution of *F. anomalus* Mont. in the Western Ghats is restricted to Shola forests of above 1500 m above sea level. It grows as epiphyte and also as saxicolous. All the earlier records are also from high altitude areas ranging from 1500 to 2200 m. It shows that this species prefers to grow in temperate or montane climate. Li and Iwatzuki (2001) reported up to 53 pairs of leaves in the vegetative plant collected from Japan, which may be due to its most congenial habitat in the temperate climate. In the Western Ghats it shows upto 20 leaf pairs. *F. anomalous* is found growing along with other bryophytes such as *Trachypus bicolor* Reinw. & Hornsch., *Macromitrium sulcatum, Plagiochila arbuscula* and *P. chinensis.*The species such as *F. crispulus* Brid., *F. bryoides* Hedw., *F. ceylonensis* Dozy & Molk., *F. flaccidus* Mitt. and *F. pellucidus* Hornsch. are very common species in the study area.

F. pellucidus is reported from most of the terrestrial habitat such as on soil, land cuttings, rocks and termite mounts, with altitudinal range of msl to 1300 m. However, the density of occurrence decreases with increase of altitude in the Western Ghats. This species is also reported as mixed patches along with other

bryophytes. *F. crispulus* Brid., is the common species in all altitudinal ranges followed by *F. ceylonensis* Dozy & Molk., *F. flaccidus* Mitt., *F. pellucidus* Mitt. and *F. bryoides* Hedw.

F. crispulus Brid., *F. flaccidus* Mitt. and *F. ceylonensis* Dozy & Molk. are most diversified members showing high degree of habitat variation. *F. crispulus* Brid. and *F. firmus* Mitt. grow near aquatic habitat in the evergreen forest. These species are reported from rocks in streams and rivers. *F. crispulus* is also reported from the basal rocks of waterfalls.

Species such as *F. grandifrons* Brid., *F. sedgwickii* Broth. & Dixon and *F. firmus* Mitt. are aquatic. *F. firmus* grows in terrestrial habitat also. The aquatic habitat of *F. grandifrons* and *F. sedgwickii* is supported by its stiff elimbate leaf characters, pluristratose laminal cells and more or less obscure costa. These characters are absent in *F. firmus* which may be due to the existence of this species as both aquatic and exposed terrestrial habitats. Pursell and Allen (1994) reported that even though *F. grandifrons* have morphological adaptations for aquatic habitat, its sporophyte is similar to that of a terrestrial species. During the present study, *F. crispulus* is also collected from submerged as well as rocks which are flooded seasonally. These type of habitat were not reported earlier for this species.

Ecological analysis of *Fissidens* in Western Ghats

Community ecological studies on Bryophytes is a vibrant area of research in the Europe and some tropical countries. Preparation of large data sets, and their analysis had resulted in providing deep insights on the significance of this group in the nature. Works such as Watson (1981), Van Reenen and Gradstein (1984), Gradstein and Salazar (1992), Wolf (1993), Gonzalez-Mancebo and Hernández-Garcia (1996), Grytnes *et al*. (2006), Bruun *et al*. (2006), Grau *et al.* (2007), Ah-Peng *et al.* (2007), had also resulted in planning better conservation strategies. Both qualitative and quantitative techniques were adopted for the community ecological studies of Bryophytes. Recently, some noteworthy studies such as Costa *et al*. (2018), Jiang *et al*. (2018), etc presented excellent synthesis of Bryophyte community ecology.

Plant community ecological studies in India, are mainly concentrated on trees and shrubs. Ecological studies of Cryptogams were not got much attention in India. It may be due to the difficulties in identifying them in the field. Some such

studies were conducted on the Lichens and Bryophytes in Himalayan area such as Negi and Gadgil, M. (1996, 1997), Negi (2000b), Negi and Upreti (2000), Negi and Gadgil (2001), Pinokiyo *et al*. (2008), Bahuguna *et al*. (2014), Upreti and Tandon (2014), Joshi *et al*. (2016), and very few in Southern India, such as Nayaka *et al*. (2001). Community ecological parameters of particular taxa, on an autecological perspective, such as species turn over, similarity assessments, etc along gradients of habitat, microhabitats, altitude, etc were not attempted by many in Southern India or India at large.

Cluster analysis was performed to check the distribution pattern along the gradients of Macrohabitats, microhabitats, and altitude. Sorensen Similarity Index was worked out using the PAST 3.20 software (http://folk.uio.no/ohammer/past) (Hammer, 2018).

The pattern obtained is quite interesting, and slightly differs from the expected models. It is usually hypothesised that, the species diversity increases with increase of altitude. However, the *Fissidens* in the Western Ghats showed an odd trend. It showed increased diversity in the low altitude to a certain extend, but declined at higher regions. It may be due the nature of the *Fissidens*, in showing more affinity in the well-lighted areas. The diversity of *Fissidens* species was lesser in upper crests of the Western Ghats, as compared to Bryophytes and other groups of plants. Usually the diversity of upper reaches are higher, than the low altitude areas.

The clusters in the dendrogram indicate the sharedness of the items under consideration. Those having more shared species cluster together, and those with unique species tend apart. Thus the turnover of species, or addition of non-shared species, as passing from one grade to another is evident. The patterns studied under three major categories are briefly presented below.

Distribution of *Fissidens* species along the vegetational gradient.

A total of 11 major vegetation types or Macrohabitats were identified after initial analysis. Some of the habitats were clubbed together, as there were no significant difference with respect to the distribution of the *Fissidens* species. The data matrix of *Fissidens* species of the Western Ghats (Table 2) thus prepared was subjected to the Cluster analysis (Graph 1&2).

Table 2. Distribution of *Fissidens* spp. along Macrohabitats in the Western Ghats. (1- present, 0- absent)

Species	EG	SEG	MDF	FPLN	SH	DDF	SG	HPLN	URB	GR	LP/SRB
F. anomalus Mont.	0	0	0	0	1	0	0	0	0	0	0
F. asplenioides Hedw.	1	0	0	0	0	0	0	0	0	0	0
F. beckettii Mitt.	0	0	0	0	0	0	0	0	0	1	0
F.biformis Mitt.	0	1	1	0	0	0	0	0	0	0	0
F. bryoides Hedw.	0	1	1	0	0	0	0	0	0	0	0
F. brevinervis Broth.	0	0	0	0	0	0	0	0	1	0	0
F. ceylonensis Dozy & Molk.	1	1	1	1	0	1	1	1	1	1	1
F.crenulatus Mitt.	1	1	1	0	0	0	0	0	**0**	0	0
F.crispulus var. *robinsonii* (Broth.) B.C.Tan & Choy	0	0	1	1	0	0	0	0	0	0	0
F.crispulus Brid. var *crispulus*	1	1	1	1	0	1	1	1	1	1	1
F.crispus Mont.	1	0	0	0	1	0	0	0	0	0	0
F. curvatus Hornsch.	0	1	0	0	0	0	0	0	0	0	0
F. diversifolius Mitt.	1	0	0	0	0	0	0	0	0	0	0
F. dubius P. Beauv.	1	0	0	0	0	0	0	0	0	0	0
F.enervis Sim	1	0	0	0	0	0	0	0	0	0	0
F. excedens Broth**.**	1	0	0	0	0	0	0	0	0	0	0
F. firmus Mitt**.**	1	1	1	0	0	0	0	0	0	0	0
F.flaccidus Mitt.	1	1	1	1	0	1	1	1	1	1	1
F.ganguleei Nork.	1	0	0	0	0	0	1	0	0	0	0
F. gardneri Mitt**.**	1	0	0	0	0	0	0	0	0	0	0
F. grandifrons Brid.	1	0	0	0	0	0	0	0	0	0	0
F. geminiflorus Dozy & Molk.	1	0	0	0	0	0	0	0	0	0	0
F. griffithii Gangulee	0	0	0	0	0	0	0	1	0	0	0
F.hollianus Dozy & Molk.,	1	1	1	0	0	0	0	0	0	0	0
F. incognitus Gangulee	0	0	0	0	1	0	0	0	0	0	0
*F. involutus*subsp. *involutus* Wilson *ex.* Mitt.	0	0	0	1	0	0	0	0	0	1	0
*F. involutus*subsp.*curvatoinvolutus* (Dixon) Gangulee	0	0	0	0	0	0	0	0	1	0	0
F.javanicus Dozy & Molk.	0	0	0	0	0	0	0	1	0	0	0
F. jungermannioides Griff**.**	1	0	0	1	0	0	0	0	0	0	0
F. kalimpongensis Gangulee	0	0	1	0	0	0	0	0	0	0	0
F.kammadensis Manju, K.P. Rajesh & Madhus.	0	0	0	0	0	0	1	0	0	0	0
F.kurzii Muell. Hal.	1	1	0	0	0	0	0	0	0	0	0
F. laxitextus Broth. *ex* Gangulee	1	0	0	0	0	0	0	0	0	0	

F.longtonianus Z. Iwats. & Tad.Suzuki	1	0	0	0	0	0	0	0	0	0	0
F. lutescens Broth.	0	0	0	0	1	0	0	0	0	0	0
F. macrosporoides Dixon & P.de la Varde	0	0	0	1	0	0	0	0	0	0	0
F.macrosporus Dixon	1	0	0	0	0	0	0	0	0	0	0
F. manilalia Manjula, Manju & K.P. Rajesh	0	0	0	0	0	0	0	0	1	0	0
F. microdictyon Dixon & P. de la Varde	0	0	0	0	1	0	0	0	0	0	0
F. neomagofukui Z. Iwats. & Tad. Suzuki	0	0	0	0	1	0	0	0	0	0	0
F. obscurus Mitt.	1	0	0	0	0	0	0	0	0	0	0
F.orishae Gangulee	1	0	0	0	1	0	0	0	0	0	0
F.pallidinervis Mitt.	1	1	0	0	0	0	0	0	0	0	0
F.pellucidus Hornsch.	1	1	1	1	0	1	1	1	1	1	1
F. pokhrensis Nork. *ex* S.S. Kumar	1	0	0	0	0	0	0	0	0	0	0
F. polysetulus Muell. Hal. *ex* Nork. & Gangulee	1	0	0	1	0	0	0	1	0	0	0
F. pulchellus Mitt**.**	1	0	0	0	1	0	0	0	0	0	0
F. ranchiensis Gangulee	0	0	1	0	0	0	0	0	0	0	0
F. sedgwickii Broth. & Dixon	1	0	0	0	0	0	0	0	0	0	0
F. serratus Muell. Hal.	1	1	0	0	0	0	0	0	0	0	0
F.speluncae Broth.	1	0	0	0	0	0	0	0	0	0	0
F. subangustus Fleisch.	1	0	0	0	0	0	0	0	0	0	0
F.subbryoides Gangulee	1	0	0	0	0	0	0	0	0	0	0
F. subpalmatus Muell. Hal.	1	1	0	0	0	0	0	0	0	0	0
F. taxifolius Hedw.	1	0	0	0	1	0	0	0	0	0	0
F. taxifolius var. *auriculatus* (Muell. Hal.) A.E.D. Daniels & P. Daniels	0	0	0	0	0	1	0	0	0	0	0
F. taxifolius var. *calcuttense* (Gangulee) A.E.D. Daniels & P. Daniels	0	0	0	0	0	1	0	0	0	0	0
F. taxifolius var. *teraicola* (Muell. Hal.) A.E.D. Daniels & P. Daniels	0	0	0	0	0	1	0	0	0	0	0
F. viridulus (Sw.) Wahlenb.	1	0	0	0	0	0	0	0	0	0	0
F.walkeri Broth.	1	1	0	0	0	0	0	0	0	0	0
F. zollingeri Mont.	1	1	1	1	0	1	1	1	1	1	1
Fissidens sp. 1	0	0	0	0	0	0	1	0	0	0	0
F. crispulus var. *nov.*	1	0	0	0	0	0	0	0	0	0	0
Fissidens sp. 2	0	0	1	0	0	0	0	0	0	0	0

Analysis of the Macrohabitats or major vegetation types of the study area shown interesting patterns (Table 3&4, Graph 1). The Shola forests (SH) as expected turned up as quite distinct in its species composition. It showed only 16.67% similarity with Evergreen forests. Other than Evergreen forests, Shola species does not extend to any other vegetation types. Laterite Plateaus and Scrub Jungles (LP/SRB) of the midlands of the study area is the most interesting vegetation type. It shows more than 20% similarity in its species composition with other vegetation types, except Shola forests. It indicates the significance of this habitat in providing suitable microhabitats for the species. It shows similarity of 23.26% with Evergreen forests, to 83.33% with Grasslands in the species composition of *Fissidens*. Same is the trend shown by Urban habitats (URB) with other habitats in holding similar species. It shows 21.28% similarity with Evergreen forests to 62.5% with Homestead plantations (HPLN). Its similarity with other vegetation types are as Semi Evergreen forests (41.67%), Moist Deciduous forests (45.45%), Dry Deciduous forests (62.5%), Sacred groves (62.5%), Forest Plantations (55.56%). Homestead areas also shows similar trend in holding *Fissidens*. Except for Shola, its species composition also shows greater similarity with other major habitats. Sacred groves are forest fragments of evergreen, semi evergreen, moist deciduous or dry deciduous nature. However, considering its conservation potential, it is treated here as a separate habitat. It shows similarity with all other habitats, except Shola forests. Maximum similarity was showed with Laterite Plateaus and Scrub Jungles (LP/SRB) (76.92%). It may be due to the location of the Sacred groves in the midlands, amidst the Scrub jungle or human habitation. Most of the species of Grasslands (similarity 66.67%), Urban habitats (62.50%), Homestead plantations (62.50%) and Forest plantations (55.56%) appear in the Sacred Groves.

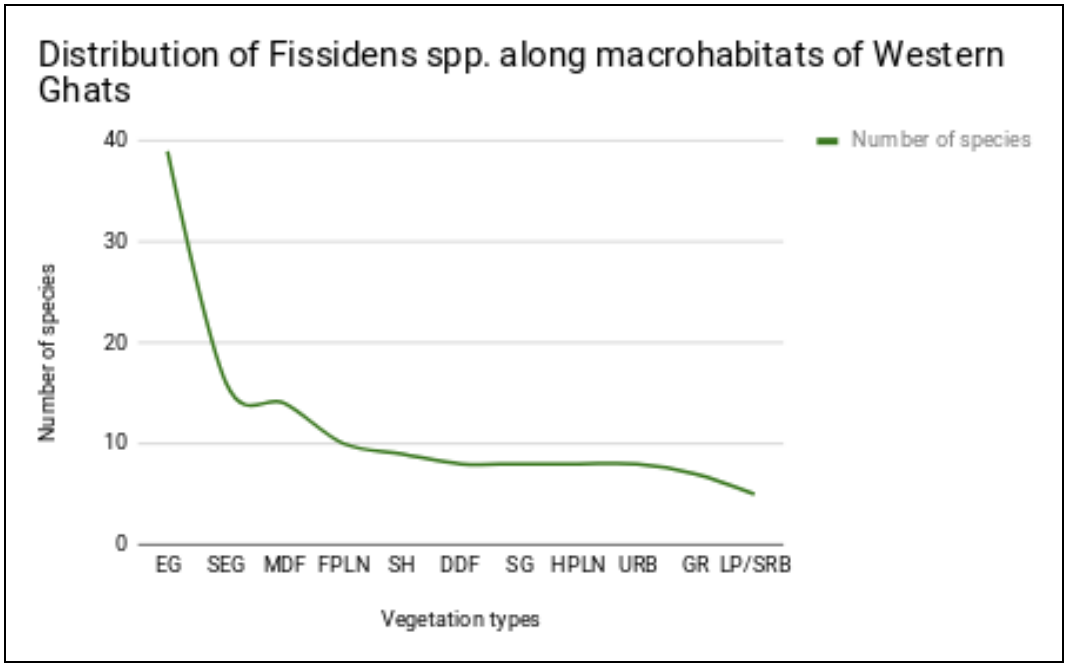


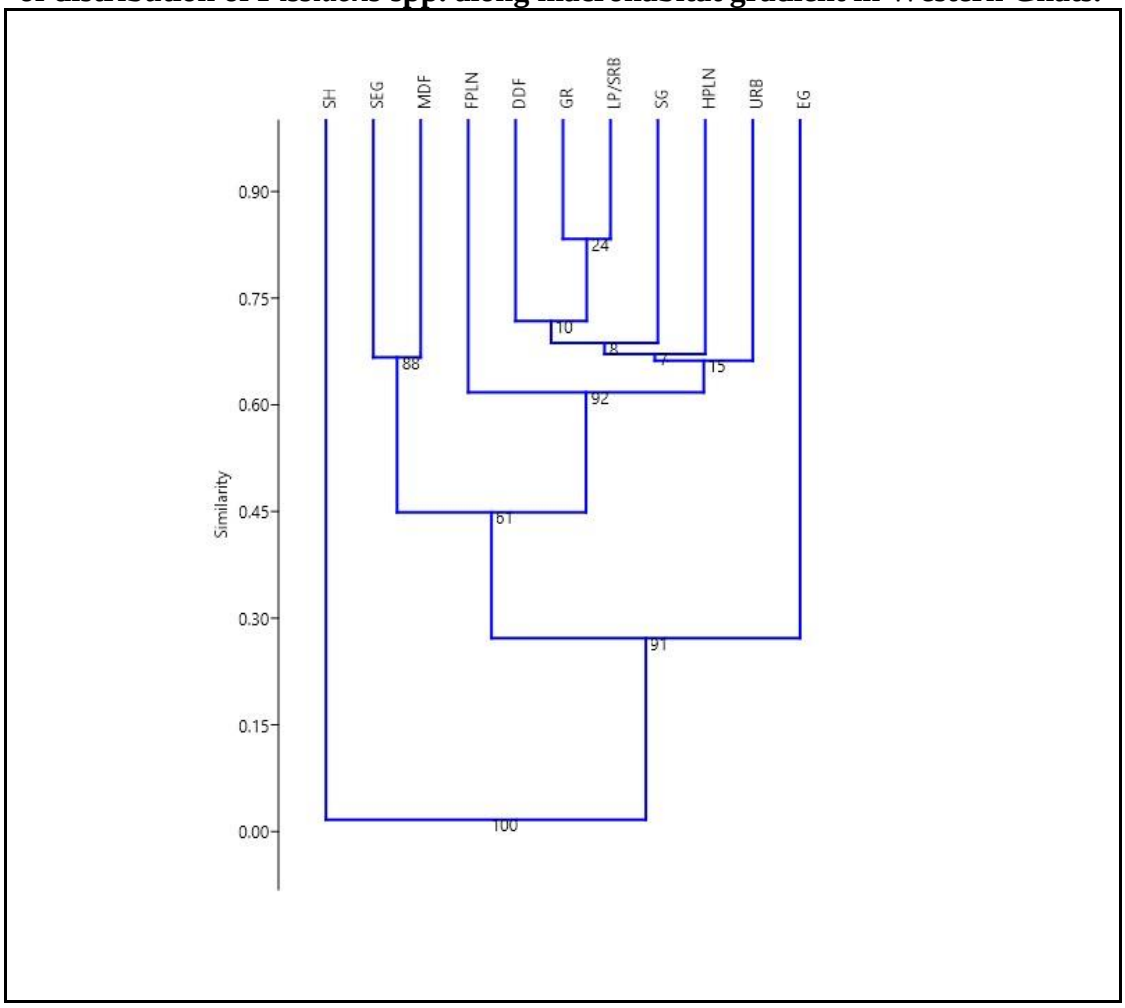
Table 3. Summary of distribution of *Fissidens* spp. along Macrohabitats in the Western Ghats.

Abbreviation	Vegetation types	No. of species
EG	Evergreen Forest	39
SEG	Semi Evergreen forest	16
MDF	Moist Deciduous Forest	14
FPLN	Forest Plantations	10
SH	Shola Forest	9
DDF	Dry Deciduous Forest	8
SG	Sacred Grove	8
HPLN	Homestead Plantations	8
URB	Urban areas	8
GR	Grassland	7
LP/SRB	Laterite Plateau/ Scrub Land	5

Table 4. Sorensen similarity index on distribution of *Fissidens* spp. along macrohabitat gradient in Western Ghats.

	SEG	SH	MDF	DDF	SG	FPLN	HPLN	URB	GR	LP/SRB
EG	0.473	**0.167**	0.302	0.213	0.255	0.286	0.255	0.213	0.217	0.233
SEG		0.000	0.667	0.417	0.417	0.385	0.417	0.417	0.435	0.476
SH			0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MDF				0.455	0.455	0.500	0.455	0.455	0.476	**0.526**
DDF					0.625	0.556	0.625	0.625	0.667	**0.769**
SG						0.556	0.625	0.625	0.667	**0.769**
FPLN							0.667	0.556	0.706	**0.667**
HPLN								0.625	0.667	**0.769**
URB									0.667	**0.769**
GR										**0.833**

Graph 2. Dendrogram of Cluster Analysis based on Sorensen Similarity Index of distribution of *Fissidens* spp. along macrohabitat gradient in Western Ghats.



Distribution of *Fissidens* species along the microhabitats.

A total of 16 microhabitats were identified after initial analysis (Table 5). Some of the microhabitats were clubbed together, as there were no significant difference with respect to the distribution of the *Fissidens* species. The data matrix of *Fissidens* species of the Western Ghats (Table 6) thus prepared was subjected to the Cluster analysis (Table 7; Graph 3).

Table 5. Summary of distribution of *Fissidens* spp. along microhabitats in the Western Ghats

Abbreviation	Micro habitat	No. of Species
BR/CW	Brick wall/ Concrete wall	4
BT	Bark of Trees	16
CR	Crevices of Rocks	6
ER	Exposed roots	7
LC	Land Cuttings	31
LG	Logs	5
LR	Large Rocks	26
LSW	Laterite stone walls	5
RM	Rhizome of ferns	2
SMR	Submerged rocks	5
SR	Small Rocks	14
SS	Sandy soil	1
TG	Twigs	4
TM	Termite Mount	4
TR	Terrestrial on Soil	25
WR	Wet rocks	8

Table 6. Distribution of *Fissidens* spp. along microhabitats in Western Ghats.

	LC	LR	TR	BT	SR	WR	ER	CR	LSW	SMR	LG	TM	BR/ CW	TG	RM	SS
F. anomalus Mont.	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0
F. asplenioides Hedw.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F. beckettii Mitt.	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
F. biformis Mitt.	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
F. bryoides Hedw.	1	1	1	0	1	0	0	1	0	0	0	0	0	0	0	0
F. brevinervis Broth.	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
F. ceylonensis Dozy & Molk.	1	1	1	1	1	1	1	1	1	0	1	1	1	0	1	0
F. crenulatus Mitt.	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0
F. crispulus var. *robinsonii* (Broth.) B.C.Tan & Choy	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F. crispulus Brid. var *crispulus*	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0
F. crispus Mont.	1	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0
F. curvatus Hornsch.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F. diversifolius Mitt.	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
F. dubius P.Beauv.	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
F. enervis Sim	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
F. excedens Broth**.**	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
F. firmus Mitt**.**	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
F. flaccidus Mitt.	1	1	1	1	1	1	1	1	1	0	1	0	1	0	0	0
F. ganguleei Nork.	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
F. gardneri Mitt**.**	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
F. grandifrons Brid.	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
F. geminiflorus Dozy & Molk.	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F. griffithii Gangulee	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
F. hollianus Dozy & Molk.	1	0	1	0	0	0	1	0	0	1	0	0	0	0	0	0
F. incognitus Gangulee	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
F. involutus subsp. *involutus* Wilson *ex.* Mitt.	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
F. involutus subsp. *curvatoinvolutus* (Dixon) Gangulee	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
F. javanicus Dozy & Molk.	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F. jungermannioides Griff**.**	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
F. kalimpongensis Gangulee	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0

F. kammadensis Manju, K.P. Rajesh & Madhus.	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
F. kurzii Muell.Hal.	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
F. laxitextus Broth. *ex* Gangulee	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F. longtonianus Z. Iwats. & Tad.Suzuki	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
F. lutescens Broth.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F. macrosporoides Dixon & P. de la Varde	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F. macrosporus Dixon	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
F. manilalia Manjula, Manju & K.P. Rajesh	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
F. microdictyon Dixon & P.de la Varde	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F. neomagofukui Z. Iwats. & Tad. Suzuki	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
F. obscurus Mitt.	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
F. orishae Gangulee	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
F. pallidinervis Mitt.	0	0	0	1	0	0	0	0	0	0	1	1	0	1	0	0
F. pellucidus Hornsch.	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0
F. pokhrensis Nork. *ex* S.S. Kumar	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
F. polysetulus Muell. Hal. *ex* Nork. & Gangulee	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
F. pulchellus Mitt.	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
F. ranchiensis Gangulee	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
F. sedgwickii Broth & Dixon	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
F. serratus Muell. Hal.	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F. speluncae Broth.	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
F. subangustus Fleisch.	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0
F. subbryoides Gangulee	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
F. subpalmatus Muell.Hal.	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
F. taxifolius Hedw.	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F. taxifolius var. *auriculatus* (Muell. Hal.) A.E.D. Daniels & P. Daniels	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
F. taxifolius var. *culcuttense* (Gangulee) A.E.D. Daniels & P. Daniels	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
F. taxifolius var. *teraicola* (Muell. Hal.) A.E.D. Daniels & P. Daniels	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
F. viridulus (Sw.) Wahlenb.	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F. walkeri Broth.	0	1	0	0	1	0	0	0	0	0	0	0	0	1	0	0
F. zollingeri Mont.	1	1	1	0	1	0	0	1	1	0	0	1	1	0	0	0
Fissidens sp. 1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0
Fissidens sp. 2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fissidens crispulus var. *nov.*	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Sandy Soil (SS) was found as the most dissimilar habitat, which showed highest dissimilarity. It showed only 7.407% with the microhabitat Large rock (LR). A single species, *Fissidens obscurus*, is present in this microhabitat. Land cuttings were found as the most species rich microhabitat for *Fissidens*, with 31 species. It is followed by Large Rocks (LR) (26 species), Terrestrial on Soil (TR) (25 species), Bark of Trees (BT) (16 species), and Small Rocks (SR) (14 species). Species composition of other microhabitats ranges from 8 (as in Wet Rocks) to 1 in Sandy Soil (Table 5; Graph 3&4). Twigs (TG) is the other unique microhabitat which showed large amount of dissimilarity. It had showed only 25% similarity to Termite mount (TM). Similarity to other microhabitats are less than that, *viz*., with Large rocks (LR) 6.667%, with Bark of trees (BT) 10%, with Small Rocks (SR) 11.111%.

Microhabitats which shows great similarity are Laterite Stone walls (LSW) and Brick wall/Concrete wall (BR/CW) with 88.889%; Crevices of Rocks and Brick wall/Concrete wall (BR/CW) with 80%; Termite mount (TM) and Brick wall/Concrete wall (BR/CW) with 75%. All these shows the microhabitat preferences of *Fissidens* species in the Western Ghats area.

Gaph 3. Distribution of *Fissidens* spp. along Microhabitats in Western Ghats

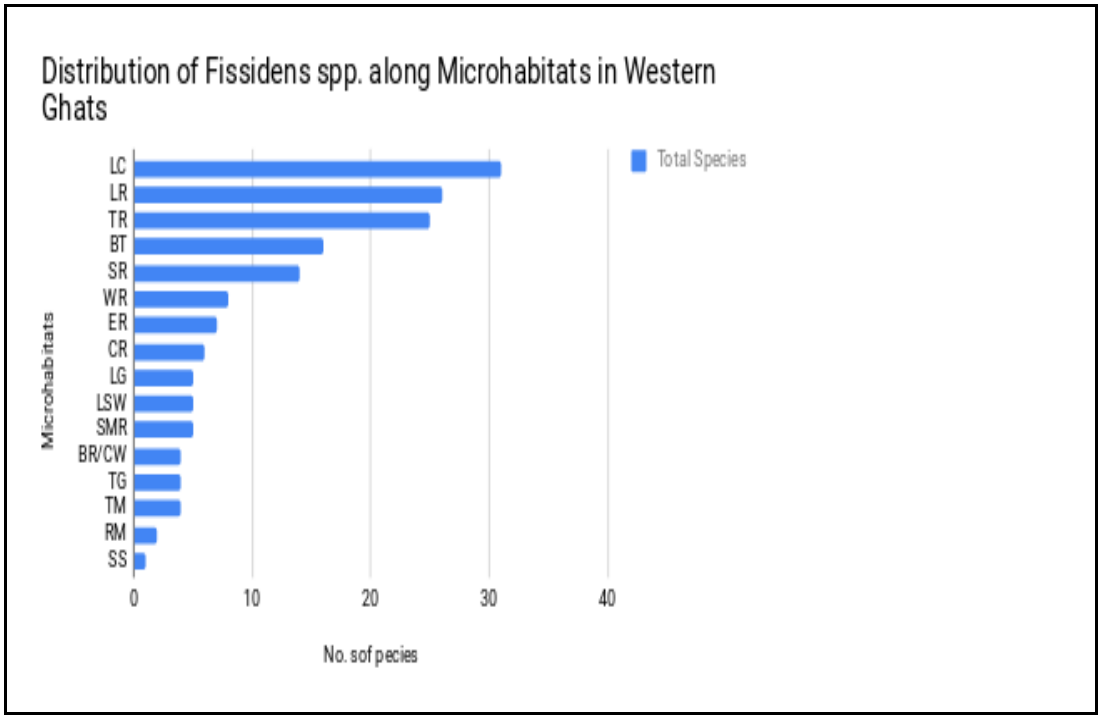
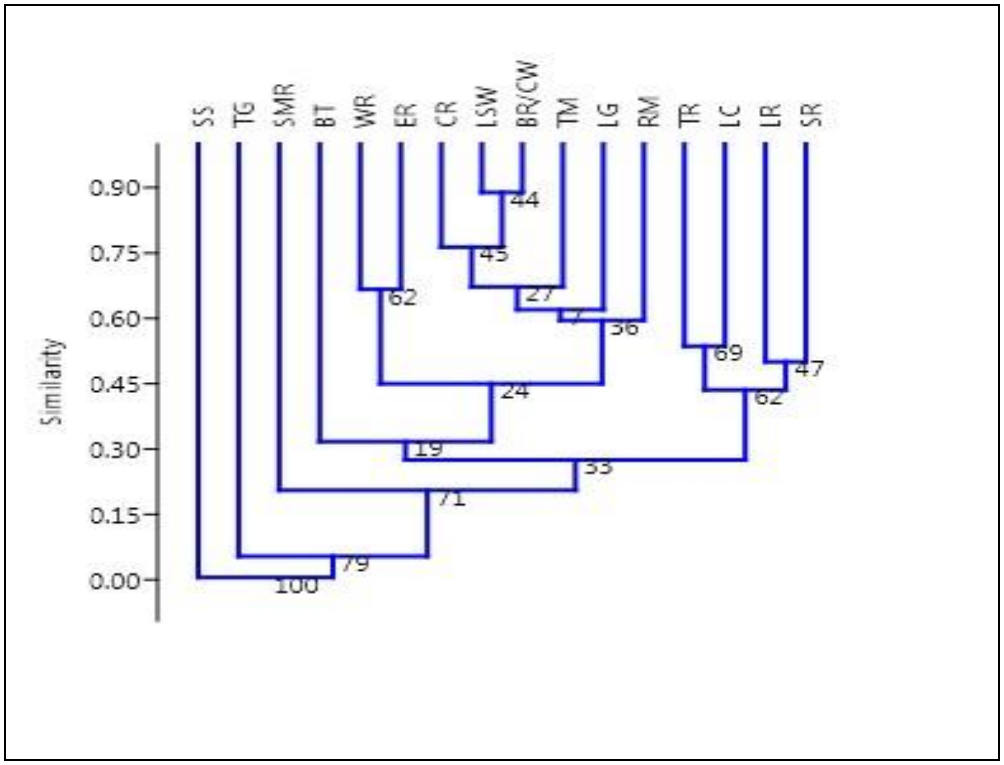


Table 7. Sorensen similarity index for distribution of *Fissidens* spp. along microhabitat gradient in Western Ghats.

	LC	LR	SR	CR	TM	BR/CW	LSW	SMR	WR	ER	BT	TG	RM	LG	SS
TR	0.536	0.431	0.410	0.387	0.207	0.276	0.333	0.133	0.242	0.313	0.244	0.000	0.148	0.267	0.000
LC		0.456	0.444	0.324	0.171	0.229	0.222	0.167	0.256	0.316	0.255	0.000	0.121	0.222	0.000
LR			0.500	0.375	0.200	0.267	0.258	0.065	0.235	0.242	0.333	0.067	0.143	0.194	0.074
SR				0.500	0.333	0.444	0.421	0.105	0.364	0.286	0.200	0.111	0.250	0.316	0.000
CR					0.600	0.800	0.727	0.182	0.429	0.462	0.273	0.000	0.500	0.545	0.000
TM						0.750	0.667	0.222	0.333	0.364	0.300	0.250	0.667	0.667	0.000
BR/CW							0.889	0.222	0.500	0.545	0.300	0.000	0.667	0.667	0.000
LSW								0.200	0.462	0.500	0.286	0.000	0.571	0.600	0.000
SMR									0.462	0.333	0.095	0.000	0.286	0.200	0.000
WR										0.667	0.333	0.000	0.400	0.462	0.000
ER											0.348	0.000	0.444	0.500	0.000
BT												0.100	0.222	0.476	0.000
TG													0.000	0.222	0.000
RM														0.571	0.000
LG															0.000

Graph 4. Dendrogram of Cluster Analysis based on Sorensen Similarity Index of distribution of *Fissidens* spp. along microhabitat gradient in Western Ghats.

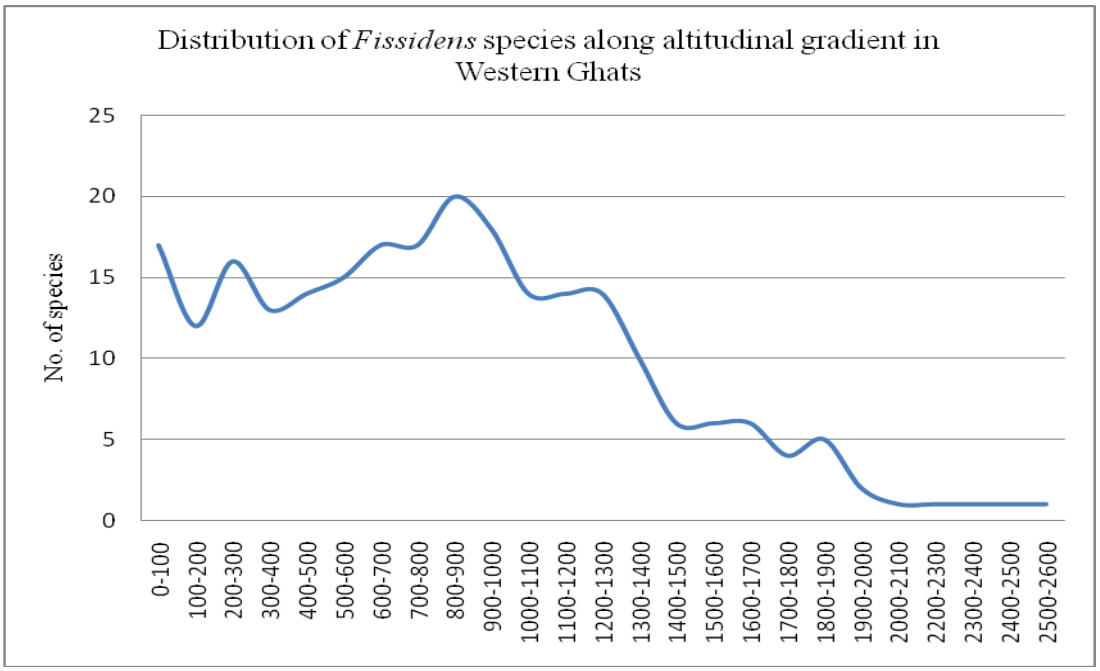


Distribution of *Fissidens* species along the altitudinal gradient.

Data matrix on the distribution of *Fissidens* species of the Western Ghats along altitudinal zones of 100 m was prepared. It ranged from 0-2600 m. The data matrix thus prepared was subjected to the Cluster analysis (Table 8&9; Graph 5&6). The zone from 600-1000 m showed maximum species (17-20 spp.), among which the zone 800-900 m showed the highest peak with 20 species. Minimum species diversity (1 sp.) was seen along the zone of above 2000 m.

It showed a decreasing trend with increase of altitude at higher ranges, such as above 2000 m. Only one species was found in the high altitude region. It is due to the general nature of the *Fissidens*. It prefers habitats with good quality of light. Most of the species are light tolerant or light adapted. In the upper reaches of the Western Ghats, the habitats are with more closed canopy. The Shola forests, holds high degree of species richness for all other groups including Bryophytes. However, the diversity of *Fissidens* is comparatively lesser in the upper reaches. More species of *Fissidens* are present in the low altitude and medium altitude areas.

Graph. 5. Distribution of *Fissidens* spp. along altitudinal gradient in Western Ghats.



Graph 6. Dendrogram of Cluster Analysis based on Sorensen Similarity Index of distribution of *Fissidens* spp. along altitudinal gradient in Western Ghats.

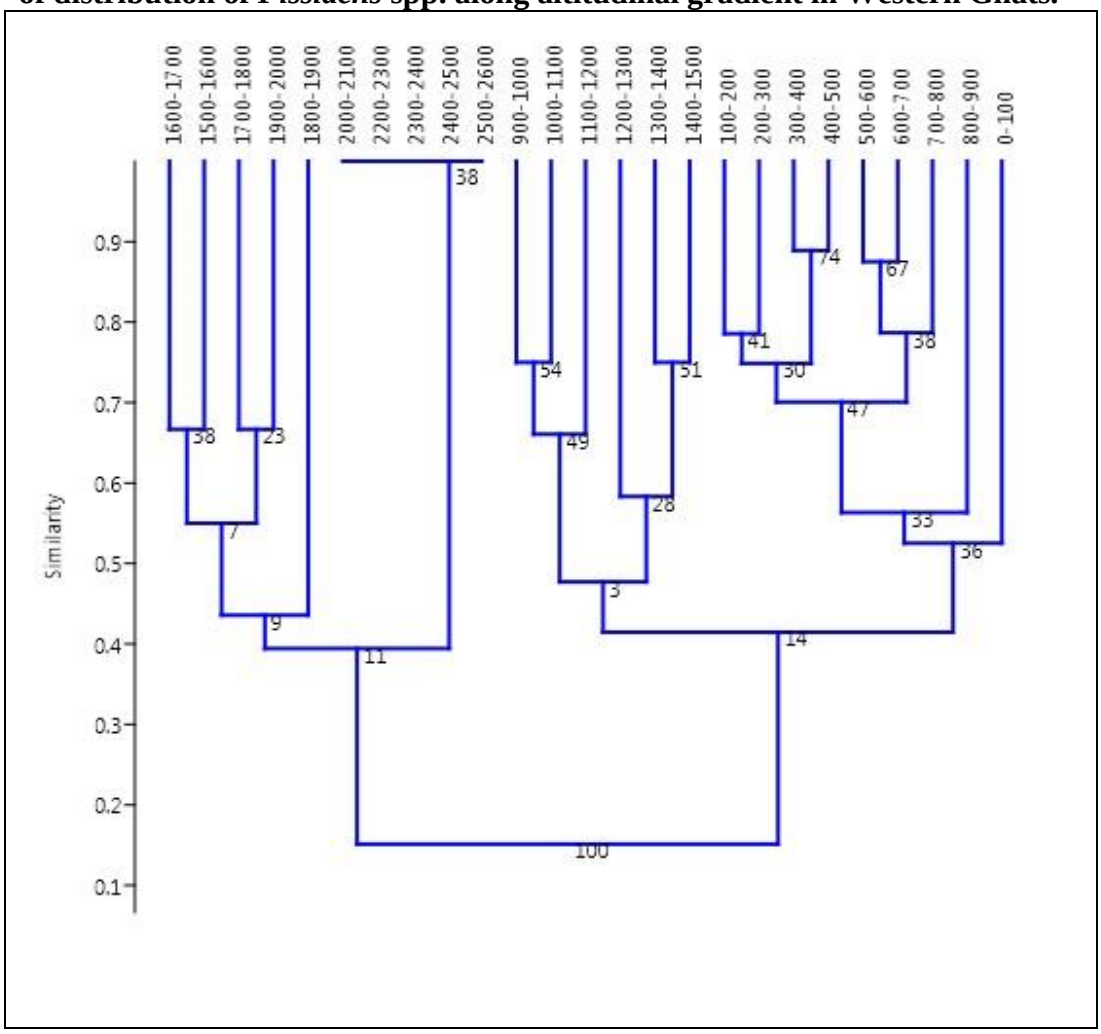


Table 8. Distribution of *Fissidens* spp. along altitudinal gradient in Western Ghats. (1- present, 0- absent)

Alt-range	0-100	100-200	200-300	300-400	400-500	500-600	600-700	700-800	800-900	900-1000	1000-1100	1100-1200	1200-1300	1300-1400	1400-1500	1500-1600	1600-1700	1700-1800	1800-1900	1900-2000	2000-2100	2200-2300	2300-2400	2400-2500	2500-2600
F. anomalus Mont.	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
F. asplenioides Hedw	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
F. beckettii Mitt.	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
F. biformis Mitt.	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F. bryoides Hedw.	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F. brevinervis Broth.	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F. ceylonensis Dozy & Molk.	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0
F. crenulatus Mitt.	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F. crispulus var. *robinsonii* (Broth.) B.C.Tan & Choy	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F. crispulus Brid. var *crispulus*	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F. crispus Mont.	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F. curvatus Hornsch.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
F. diversifolius Mitt.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
F. dubius P. Beauv.	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
F. enervis Sim	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
F. excedens Broth.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
F. firmus Mitt.	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
F. flaccidus Mitt.	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F. ganguleei Nork.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F. gardneri Mitt.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
F. grandifrons Brid.	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F. geminiflorus Dozy & Molk.	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F. griffithii Gangulee	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F. hollianus Dozy & Molk.	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0
F. incognitus Gangulee	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F. involutus subsp. *involutus* Wilson *ex.* Mitt.	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F. involutus subsp. *curvatoinvolutus* (Dixon) Gangulee	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
F. javanicus Dozy & Molk.	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F. jungermannioides Griff.	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F. kalimpongensis Gangulee	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F. kammadensis Manju, K.P. Rajesh & Madhus.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F. kurzii Muell.Hal.	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F. laxitextus Broth. *ex* Gangulee	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0		0	0	0	0	0	0	0	0	0
F. longtonianus Z. Iwats. & Tad.Suzuki	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

F. lutescens Broth.	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F. macrosporoides Dixon & P. de la Varde	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F. macrosporus Dixon	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F. manilalia Manjula, Manju & K.P. Rajesh	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F. microdictyon Dixon & P.de la Varde	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
F. neomagofukui Z. Iwats. & Tad. Suzuki	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F. obscurus Mitt.	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0
F. orishae Gangulee	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
F. pallidinervis Mitt.	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
F. pellucidus Hornsch.	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
F. pokhrensis Nork. *ex* S.S. Kumar	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F. polysetulus Muell. Hal. *ex* Nork. & Gangulee	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F. pulchellus Mitt**.**	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F. ranchiensis Gangulee	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F. sedgwickii Broth. & Dixon	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F. serratus Muell. Hal.	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
F. speluncae Broth.	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
F. subangustus Fleisch.	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F. subbryoides Gangulee	1	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F. subpalmatus Muell. Hal.	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F. taxifolius Hedw.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
F. taxifolius var. *auriculatus* (Muell. Hal.) A.E.D. Daniels & P. Daniels	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F. taxifolius var. *culcuttense* (Gangulee) A.E.D. Daniels & P. Daniels	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F. taxifolius var. *teraicola* (Muell. Hal.) A.E.D. Daniels & P. Daniels	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F. viridulus (Sw.) Wahlenb.	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
F. walkeri Broth.	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
F. zollingeri Mont.	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
Fissidens sp. 1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fissidens sp. 2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fissidens crispulus var. *nov.*	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 9. Sorensen similarity index for distribution of *Fissidens* spp. along altitudinal gradient in the Western Ghats.

	100-200	200-300	300-400	400-500	500-600	600-700	700-800	800-900	900-1000	1000-1100	1100-1200	1200-1300	1300-1400	1400-1500	1500-1600	1600-1700	1700-1800	1800-1900	1900-2000	2000-2100	2200-2300	2300-2400	2400-2500	2500-2600
0-100	0.621	0.545	0.533	0.516	0.500	0.471	0.529	0.486	0.457	0.387	0.400	0.452	0.370	0.261	0.261	0.174	0.190	0.091	0.105	0.000	0.000	0.000	0.000	0.000
100-200		0.786	0.800	0.769	0.741	0.690	0.690	0.500	0.467	0.462	0.480	0.385	0.455	0.333	0.333	0.333	0.250	0.118	0.143	0.000	0.000	0.000	0.000	0.000
200-300			0.759	0.667	0.645	0.606	0.606	0.444	0.412	0.400	0.414	0.333	0.385	0.273	0.273	0.182	0.200	0.095	0.111	0.000	0.000	0.000	0.000	0.000
300-400				0.889	0.786	0.733	0.733	0.545	0.452	0.444	0.462	0.370	0.435	0.316	0.316	0.211	0.235	0.111	0.133	0.000	0.000	0.000	0.000	0.000
400-500					0.759	0.710	0.710	0.588	0.438	0.429	0.444	0.429	0.417	0.300	0.300	0.200	0.222	0.105	0.125	0.000	0.000	0.000	0.000	0.000
500-600						0.875	0.750	0.514	0.424	0.414	0.429	0.345	0.400	0.286	0.286	0.190	0.211	0.100	0.118	0.000	0.000	0.000	0.000	0.000
600-700							0.824	0.595	0.514	0.452	0.467	0.387	0.370	0.261	0.261	0.174	0.190	0.091	0.105	0.000	0.000	0.000	0.000	0.000
700-800								0.757	0.629	0.516	0.533	0.452	0.444	0.261	0.261	0.174	0.190	0.091	0.105	0.000	0.000	0.000	0.000	0.000
800-900									0.632	0.529	0.485	0.471	0.400	0.231	0.231	0.154	0.167	0.160	0.091	0.000	0.000	0.000	0.000	0.000
900-1000										0.750	0.581	0.438	0.429	0.250	0.250	0.167	0.182	0.174	0.100	0.000	0.000	0.000	0.000	0.000
1000-1100											0.741	0.571	0.583	0.400	0.400	0.300	0.333	0.316	0.250	0.133	0.133	0.133	0.133	0.133
1100-1200												0.593	0.609	0.421	0.421	0.316	0.353	0.222	0.267	0.143	0.143	0.143	0.143	0.143
1200-1300													0.667	0.500	0.400	0.300	0.333	0.211	0.250	0.133	0.133	0.133	0.133	0.133
1300-1400														0.750	0.533	0.375	0.429	0.267	0.333	0.182	0.182	0.182	0.182	0.182
1400-1500															0.667	0.500	0.600	0.364	0.500	0.286	0.286	0.286	0.286	0.286
1500-1600																0.667	0.600	0.364	0.500	0.286	0.286	0.286	0.286	0.286
1600-1700																	0.600	0.364	0.500	0.286	0.286	0.286	0.286	0.286
1700-1800																		0.444	0.667	0.400	0.400	0.400	0.400	0.400
1800-1900																			0.571	0.333	0.333	0.333	0.333	0.333
1900-2000																				0.667	0.667	0.667	0.667	0.667
2000-2100																					1.000	1.000	1.000	1.000
2200-2300																						1.000	1.000	1.000
2300-2400																							1.000	1.000
2400-2500																								1.000

Economic Importance of this group in Western Ghats

There is no direct economic Importance for this group. More clinical studies are started only recently. Since these species are very small and sometimes microscope is essential to view this plant, less importance is given by the horticulturists. But some species are attracted by the garden enthusiasts. Now a days they are using bryophytes including *Fissidens* imported from some foreign countries. Srivastava *et al.* (2011) done plant mediated synthesis of silver nanoparticles using *F. minutus* Thwaites & Mitt. and studied its anti-microbial properties which yielded that aqueous extract of *F. minutus* treated with 0.5mM silver nitrate solution produced silver nanoparticles at room temperature rapidly and the nanosilver produced has a potent antibacterial activity against both gram positive and gram negative bacteria. Deora and Rathore (2013) studied the antimicrobial properties of some bryophytes from Mt. Abu against certain bacterial strains. They found that the crude extract of *F. bryoides* Hedw. has the capacity to work against *Xanthomonas citri* and no bacterial growth was observed in more than 50% concentration. The growth of *Agrobacterium tumifaciens* and *Streptomyces scabies* are also negatively affected by the concentration gradient of *F. bryoides* Hedw.

Eventhough they studied the properties *in vitro* the large scale attempts are not reported from the area. Apart from these studies, the economic aspects of this group has not been explored in detail. Some species such as *F. kammadensis, F. sedgwickii*, etc. grow well in aquarium. Except for that, the members of the family are of less economic potential.

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Chapter: VI

SUMMARY & CONCLUSION

SUMMARY AND CONCLUSION

The studies on the taxonomy and other aspects of bryophytes has got due importance in the recent years in tropics and temperate regions. Earlier, this group was gravely neglected in India, mainly due to the lack of good manuals or monographs and literatures on the bryophytes. Another main reason for this is, probably the limited number of researchers in bryology compared to the enormous diversity of the group. It is nearly impossible to bring out the bryophyte flora of India single handedly, considering the vast extent of our country and geographical diversity.

The situation was not different in the Western Ghats. They were also mostly of random collections or floristic documentations of some areas and reporting list of species or new records of occurrence. However, in the recent past it progressed consistently and resulted in a lot of documentations such as Nair *et al*., 2005, Manju *et al.*, 2008a & 2008b; Daniels *et al*., 2013; Manjula *et al*., 2015a & 2017; Daniels *et al*., 2018 etc. Such publications turned as resource guides for easy identification of this group in this region.

The revisionary studies with deeper intensity is probably the best method in developing a national database. Such works are common in bryologically well explored parts of the world. In India, however, such works are rare. The present work is significant in this aspect. This study is one of the first detailed work on a single family in the Western Ghats. It resulted in comprehending the details on 59 species, one subspecies and five varieties of the genus *Fissidens* of Fissidentaceae. Among these two species and one variety are proposed as new as a result of this study. One new species *viz*., *Fissidens manilalia* Manjula, Manju & K.P. Rajesh could be published during this period. Seven species, one subspecies and two varieties are excluded due to taxonomic ambiguity. The present study resulted in recording new distributional records such as one for Asian region, one for India, one for Western Ghats, nine for Kerala, one for Karnataka and nine for Goa (Table 10). The study also recorded populations of four endemic species to India four endemic

species to Southern India, one endemic species to Western Ghats and three endemic species to Kerala. Earlier, most of the species were known from Western Ghats with scanty data. Many of them were known only as part of some checklists. *F. involutus* var. *involutus*, *F. jungermannioides*, *F. kalimpongenesis* were known only by single collection or with scanty data. The present study provides detailed information on all such species. About 79 valid taxa are reported from India and among these 59 species, one subspecies and five varieties were described from the Western Ghats. The species *F. viridulus* is earlier considered as a synonym of *F. bryoides*. It was re-examined, and re-instated as part of this study.

The first major work on this family from India is that of Gangulee (1971). He has given due importance to the family and described 51 species. Among these, 18 taxa are synonimised under different species.

He classified the family into sections and subsections. A lot of variations are available for the intrageneric treatment of this family. Among which the most popularly accepted one is those of Pursell and Bruggeman- Nannenga (2004). It is followed in this study, being easily followed as based on characters including vegetative and reproductive features.

The ecological features of the *Fissidens* species of the Western Ghats were also analysed. Cluster analysis based on Sorensen Similarity Index was performed to reveal the pattern of distribution along macrohabitats, microhabitats and altitudinal gradients.

Analysis of the Macrohabitats or major vegetation types of the study area shown interesting patterns. A total of 11 Macrohabitats were identified. The Shola forests (SH) as expected turned up as quite distinct in its species composition. It showed only 16.67% similarity with Evergreen forests. Other than Evergreen forests, Shola species does not extend to any other vegetation types. Most interesting vegetation types for *Fissidens* species in the Western Ghats is Laterite Plateaus and Scrub Jungles (LP/SRB) of the midlands and Urban habitats. This habitat showed maximum similarity with other macrohabitats, except for Shola forest. Sacred groves also showed similarity with all other habitats, except Shola forests, with

varying degrees of similarity. Maximum similarity was showed with Laterite Plateaus and Scrub Jungles (LP/SRB) (76.92%).

Analysis of Microhabitats also showed similar interesting patterns. A total of 16 microhabitats were identified. Sandy Soil (SS) was found as the most dissimilar habitat, without any shared species. It holds a single species, *F. obscurus*, and showed only 7.407% similarity with the nearby microhabitat Large rock (LR). Land cuttings were found as the most species rich microhabitat for *Fissidens*, with 31 species. It is followed by Large Rocks (LR) (26 species), Terrestrial on Soil (TR) (25 species), Bark of Trees (BT) (16 species), and Small Rocks (SR) (14 species). The microhabitat Twigs (TG) is another unique microhabitat which showed large amount of dissimilarity. It had showed only 25% similarity to Termite mount (TM). Most of the microhabitat shows greater similarity with other microhabitats such as Laterite Stone walls (LSW) and Brick wall/Concrete wall (BR/CW) with 88.889%; Crevices of Rocks and Brick wall/Concrete wall (BR/CW) with 80%; Termite mount (TM) and Brick wall/Concrete wall (BR/CW) with 75%. All these shows the microhabitat preferences of *Fissidens* species in the Western Ghats area.

Examination of the distribution pattern along altitudinal gradient also yielded interesting pattern. The altitude in Western Ghats ranges from 0-2600 m. Contrary to the normal distribution pattern of most of other plants, the occurrence of *Fissidens* decreased with increase of altitude. Shola forests occupying at the higher altitude zones, strongly influenced this pattern. Minimum species diversity (1 species) was seen along the zone of above 2000 m. Maximum species diversity (20 species) could be observed along the altitudinal zone of 800-900 m. The zone from 600-1000 m showed maximum species (17-20 spp.). The human modified and disturbed habitats of the lowlands, but holds good number of species.

Table 10. Important findings of the present study

New taxa published during the study	*Fissidens manilalia* Manjula, Manju & K.P. Rajesh (2017)
Two new species and one variety as *inedit*	*Fissidens* sp. 1 *Fissidens* sp. 2 *Fissidens crispulus* var. *nov.*
New record to Asia	*Fissidens enervis* Sim (Bruggeman-Nannenga *et al*., 2016)
New records to India	*Fissidens speluncae* Broth.
New record to Western Ghats	*Fissidens viridulus* (Sw.) Wahlenb.
New records to Kerala	*Fissidens asplenioides* Hedw. *Fissidens biformis* Mitt. *Fissidens macrosporus* Dixon *Fissidens pallidinervis* Mitt. *Fissidens sedgwickii* Broth. & Dixon *Fissidens subangustus* Fleisch. *Fissidens subpalmatus* Muell. Hal. *Fissidens taxifolius* Hedw. *Fissidens walkeri* Broth.
New records to Karnataka	*Fissidens involutus* subsp. *curvatoinvolutus* Dixon.
New records to Goa	*Fissidens bryoides* Hedw. *Fissidens ceylonensis* Dozy & Molk. *Fissidens crenulatus* Mitt. *Fissidens crispulus* Brid. var. crispulus *Fissidens flaccidus* Mitt. *Fissidens pallidinervis* Mitt. *Fissidens pellucidus* Hornsch. *Fissidens walkeri* Broth. *Fissidens zollingeri* Mont.
Recording of populations of endemic species to India	*Fissidens macrosporoides* Dixon *Fissidens orishae* Gangulee *Fissidens pokhrensis* Nork. *ex* S.S. Kumar *Fissidens polysetulus* Muell. Hal. Nork. *ex* Gangulee
Recording of populations of endemic species to Kerala	*Fissidens manilalia* Manjula, Manju & K.P. Rajesh *Fissidens longtonianus* Iwatsuki & Suzuki *Fissidens kammadensis* Manju, K.P. Rajesh & Madhus.
Recording of populations of endemic species to Southern India	*Fissidens lutescens* Broth. *Fissidens macrosporus* Dixon *Fissidens microdictyon* Dixon & P. de la Varde *Fissidens walkeri* Broth.
Recording of populations of endemic species to Western Ghats	*Fissidens arunii* J.P. Srivast. & Nork.

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Appendix 1

Glossary of technical terms

Abscission	Layer detaching from the stems that bear them at a predetermined place, the abscission zone.
Acrocarpy	Producing sporophytes at the tips of main stems.
Acostate	In mosses, lacking a nerves.
Acute	Tapering with nearly straight margins to a point with an angle less than 90
Adaxial	Facing towards a stem or an axis, hence leaf's "upperside" or "inner"surface.
Annulus	Ring, of sporophyte mouth with thick walled cells involved in opening of the sporangium.
Anomalous	Out of the ordinar, unlike others in its group.
Anterior	Positioned in front of another organ.
Antheridium (Plural antheridia)	A bryophyte's male reproductive organ.
Antherozoid (Spermatozoid)	A biflagellate sperm (male gamete) of a bryophyte.
Apical lamina	The upper portion of leaf above the vaginant laminae on the same side in the specialised leaf of *Fissidens.*
Apiculate	In mosses, leaf ending in a short point that's part of the leaf lamina rather than the tip of the costa.
Apiculus	A short abrupt point at a tip or apex.
Archegonium (Plural archegonia)	A bryophyte's female reproductive organ.
Auriculate	Equipped with ear-like structures,usually near the base.
Autoicous	Monoicous, producing both male and female sex organs on the same plant but in separate inflorescences.
Axillary	Said of anything that's located in an axil.
Axillary hyaline nodule	Cluster of enlarged hyaline cortical cells located in the axils of leaves, morphologically it is a branch primodia.
Bifurcating	Forking, dividing into two sharp branches or prongs.
Bistratose	Two cell layer thick.
Caducous	Falling off soon after formation, not persistent.
Calyptra	Enlarged remains of archegonia.
Capsule	A dry dehiscent fruit composed of two or more united carpels, opening by valves, slits or pores.

Cauline	Part of or belonging to the stem.
Central strand	A group of elongated cells with narrow lumina located in the center of the stem.
Chlorophyllose	Having chlorophyll and therefore green ,as in the ordinary leaf cells of most bryophytes.
Cladautoicous	Perigonia and perichaetia are terminal on elongate branches of the same plant.
Cladistics	A philosophy of classification that arranges organisms by their common ancestry, based on the branching of the evolutionary family tree, as perceived by shared character state.
Clavate	Club shaped; thickened towards the end.
Complanate	Flattened
Contorted	Irregularly bent, twisted and curved.
Convex	Curving or bulging out.
Corticolous	Living on bark.
Corrugate	Regularly or evenly wavy, folded or wrinkled in one direction.
Costa (Plural Costae)	Thickened mid rib or nerve of a leaf.
Crispate	Curled or ruffled.
Crenulate	Margin of leaf with small, crenate teeth.
Crumbled	Break or fall apart into small fragments, especially as part of a process of deterioration
Cucullate	Resembling or shaped like a hood.
Decumbent	Prostrate towards the base but erect or ascending towards the tip.
Decurrent	Said of leaf margins that extent below the leaf's insertion as ridges or wings on the stem.
Dentate	Prominently toothed with acute symmetrical projections pointing outwards.
Dichotomous	Forking,dividing into two equal branches.
Dimorphic	Having two distinctly different forms,
Dioicous	Perigonia and perichaetia are produced on separate gametophytes of more or less same size or the perigonial plant may be smaller.
Distal	Towards the apex of the structure or towards opposite end of attachment.
Distichous	Arranged in to opposite rows
Dorsal lamina	The wing opposite to the Vaginant laminae of *Fissidens* leaf.
Duplicate	Arranged or growing in pairs.
Ecostate	Leaves without a midrib.
Elimbate	Lacking a differentiated border for leaf.
Embryophyte	Any plant that produces an embryo during its life cycle.

Edangered	An organism seriously at risk of extinction.
Endostomes	In many mosses, the inner peristome, usually arising from a basal membrane and consisting of segments alternating with one or more thin cilia.
Epidermis	Outermost layer of stem.
Epilithic	Growing on rock.
Epiphyllous	A plant that grows on the living leaves of another plant.
Ephemeral	Short-lived, soon disappearing or remaining for a very short time.
Equitant	Clasping or straddling the stem
Etymology	Origin of the particular word.
Excurrent	Extending beyond the apex.
Exothecium	The outermost layer of cells in a sporangium.
Filiform	Filamentous, thread-like long and slender .
Fimbriate	Fringed.
Foot	The base of the sporophyte that is embedded in the gametophyte and extracts water, mineral nutrients and photosynthate.
Frondiform	Resembling a frond, as of a fern; having stem and leaves fused in one.
Fugacious	Lasting for a very short time or falling away early.
Gametophyte	The multicellular gamete producing generation of an embryophyte. It begins as a haploid spore shed by the sporophyte.
Gemma (Plural Gemmae)	Multicellular vegetative propagule, it may be subterranean (underground), rhizoidal, axillary and epiphyllous.
Gemmiform	Bud-like.
Greater lamina	The lower wing of vaginant laminae in *Fissidens* leaf.
Gregarious	Growing in groups and locally dominant.
Gonioautoicous	Gemmiform perigonial branches produced in leaf axils below a terminal perichaetium.
Guttula (Plural Guttulae)	One or more oil-like droplets in cell lumina or nucleus like hyaline spots.
Haplolepideous	Said of a joined peristome tooth in which each segment of its outer face is formed from remnants of the walls of only a single cell.
Holotype	A specimen that's designated as an authentic reference specimen by the auther of a new species, subspecies or variety.
Homostichous	Minor laminae of all leaves in both sides of the stem oriented in a single rank.
Hyaline	Almost transparent.
Imbricate	Overlapping like tiles

Incrassate	Thick, stout.
Intra generic	Within the genus
Intra laminal / Intra marginal	Limbidium/ semilimbidium bordered with one or more rows of chlorophyllose laminal cells.
Invalid	A name or epithet that may be effectively published but is not in accordance with Articles 32-45of th I.C.B.N.
Lamellae	A projection on the back of a peristome tooth.
Lanceolate	Narrowly ovate and tapering to a point at the apex.
Lectotype	In a case where a holotype was never designated for a scientific name, a specimen that's selected to act as the type, the selection is made by a later author from the material studied by the original author of the name.
Lenticular	A 3 –dimensional body that is circular in section and convex on both sides.
Laterally heterostichous	Minor laminae facing up on one rank of leaves in on side of stem and opposite in the other side.
lamina	In mosses, the flat blade of aleaf, not including the midrib if present.
Limbidium (Plural Limbidia)	A band of unistratose to pluristratose, hyalineto yellowish prosenchymatousstereid cells
Lingulate	Tongue shaped
Lithophyte	Plant growing on rock.
Lumen	(of cells) the space within the cell walls; (of spore wall) the space bounded by reticulations.
Major lamina	Larger wing of vaginant laminae (Same as greater lamina)
Mamilla (Plural Mamillae)	Rounded projection of a uniformly thickened cell wall with nipple like tip.
Mammillate	Withnipple-like processes.
Microenvironment	The immediate environment of a taxa, especially as adistinct part of a larger environment.
Minor lamina	Smaller wing of vaginant laminae
Mitrate (or mitriform)	Shaped like a bishop's cap.
Monoicous	Antheridia and archegonia produced on the same plant.
Monomorphic	Having only a single form, not variable. All stems, exclusive of the gemiform(bud like) perigonial stems, are more or less the same length.
Monophyletic group	A single common ancestorplus all of its descendants.
Mucronulate	Ending in a very short stiff point.
Multistratose	More than one layer of cells
Obscure	Dark, indistinct or hard to see, as with leaf cells

	obscured by dence surface papillae or cell walls obscured by vacuoles.
Obtuse	Blunt, with the sides making an angle of more than 90^0.
Operculum	In mosses ,the lid that blocks the capsule mouth;in liverworts, the apical portion of a sporangium that opens during dehiscence.
Outer cortical cells	Cells found beneath the epidermis.
Palmate (frondiform)	Arranged like the fingers of a hand
Papilla (Plural Papillae)	A minute solid protuberance on a cell surface or a local thickening of the wall.
Papillate	Roughened or ornamented with one or more papillae per cell.
Percurrent	Extending to the apex but not beyond
Perichaetium (Plural perichaetia)	Female sex organs plus the surrounding cluster of modified leaves.
Peripheral guide cells	On the edge
Perigonium (Plural Perigonia)	The male sex organs plus the cluster of modified leaves surrounding them
Peristome	A single or double circle of teeth inside the mouth of a moss capsule.
Phaneropore	A stomate that's fully exposed on the surface,with its guard cells on the same level as the adjacent exothecial cells.
Pinnate	Arranged like a barbs on a feather
Pluripapillose	Having several (2-6) papillae per cell.
Pluristratose	Three or more layered
Primordium	The embroyonic stage of a leaf or other organ,made up of undifferentiated cells.
Protologue	The original description of a taxon; more correctly everything. Associated with a name at its valid publication.
Protonema (plural protonemata)	The first growth stage of a bryophyte,produced from a germinating spore ,gemma,or other propagule.
Polymorphic	Having more than one forms, highly variable. Perichaetial stems are much shorter and with fewer pairs of leaves than the infertile stems.
Polyoicous	Having the archegonia and antheridia sometimes on the same plant and sometimes on different plants
Polyphyllous	With many leaves or leaflets.
Polyploidy	The state of having three or more sets of chromosomes.
Prorate	Having a roughened surface caused by the protruding tips of prosenchymatous cells

	overlapping at their ends.
Prosenchymatous	Composed of prosenchyma, a tissue made up of long, tapering, parallel cells over lapping at their tips rather than joined end to end.
Protuberant	Bulging out
Proximal	Towards the base of the structure or towards the point of insertion.
Pseudautoicous	Although physiologically dioicous, the production of dwarf males to some degree mimics the male/female relationship of autoicous taxa.
Rejected name	Illegitimate, incorrect binomial rejected by I.C.B.
Rhizautoicous	Monoicous, with the perigonium can be gemmiform on a short branch attached to the perichaetial stem by rhizoids. It may be clustered around the base of perichaetial stem or scattered throughout the collection.
Robust	Strong, thick, vigorous.
Rostrate	Beaked.
Saxicolous	Growing on rock.
Scabrous	Rough to touch,with small pointed protrusions.
Scarious	Thin and dry, not green; also spelled scariose.
Semilimbidium	Limbidial cells not present throughout the leaf margin, present either on vaginantlaminae alone or on vaginantlaminae and at base of apical lamina.
Serrate	Toothed like a saw, with regular acute and angled teeth pointing towards the apex.
Serrulate	Minutely serrate.
Seta	Stalk of capsule.
Sheathing	Enveloping and enclosing,with a sheath.
Smooth	Lacking any surface irregularities such as papillae, spines, mamillae etc.
Specific epithet	In scientific names, the part that follows the genus name.
Sporophyte	The spore producing generation of an embryophyte. It begins as a diploid zygote formed by the fusion of an antherozoid and an egg.
Squamose	Covered with scales.
Stereid cell	“Stiffener” cells that support the leaves and stems of some mosses.
Strong limbidium	Stereid cells of limbidium elongate with sharply pointed ends and with a wall thicker than the diameter of the lumen.
Stomatose	Having stomata.
Sub percurrent	Not extending up to apex or ending many cells below apex.
Subterranean	Below the soil.

Subulate	Shaped like an awl, tapering to a fine point from a board base.
Synoicous	Both antheridia and archegonia occur in the same perichaetium.
Synonym	The different names used for the same taxonomic group or taxon.
Terrestrial	On or in the ground.
Theca	The outer covering of sporophyte.
Tooth	Small pointed projection, usually triangular.
Trabeculate	Having the appearance of minute girders or crossed beams.
Unistratose	One cell layer thick.
Vaginant lamina (Plural Vaginantlaminae)	The clasping proximal (lower) portion of the *Fissidens* leaf. It is a slotted forward edge that sheaths the stem at leaf insertion.
Ventral	Synonymous with the abaxial or lower surface abaxial is technically more precise, whereas lower surface is easier to understand.
Vulnerable	Threatened in its survival.
Weak limbidium	Stereid cells of limbidium with more or less truncate (having a blunt end) end and the walls are usually thinner than the lumina.