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Contribution to the Bryophyte Flora of India: *Agasthyamalai* Biosphere Reserve in Western Ghats

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ABSTRACT: The bryophyte flora of the *Agasthyamalai* Biosphere Reserve is catalogued. There is no previous report of bryophytes from this area. The checklist consists of 90 taxa (58 mosses, 32 liverworts), of which 16 species are newly reported for the Peninsular India (*Asterella reticulata, Bazzania sumbavensis, Cephalozia pandei, Clastobryopsis muelleri, Cyathophorella adiantum, Dicranoloma subreflexifolium, Herbertus dicranus, Himantocladium cyclophyllum, Hypnum plumaeforme, H. sikkimense, Leucobryum cucullifolium, Radula grandifolia, Symblepharis vaginata, Symphyodon echinatus, Trichocolea udarii* and *Trichostelium boschii*) and another 6 are new for the Kerala State (*Campylopus involutus, Cephaloziella willisiana, Frullania ericoides, Macromitrium moorcroftii, Metzgeria decipiens* and *Leucobryum mittenii*).

KEY WORDS: Bryophytes flora, *Agasthyamalai* Biosphere Reserve, Western Ghats, India.

INTRODUCTION

The *Agasthyamalai* hills, situated at the Southern most tip of the Western Ghats is notable for its very rich and diverse vegetation, dotted with high concentration of endemics. It is considered as a divine grove, which remains as the cultural meeting point of two southern Indian states, Kerala and Tamil Nadu; rich in myths, folk knowledge, biodiversity and associated cultural practices. These hills form the major peaks, towards the tail end of the Western Ghats, before it abruptly falls into low hills at the Kanyakumari (Cape Camorin) district, the southern most tip of the Indian Peninsula. This is a compact range of hills with a main range descending equally steeply to both the western and eastern sides and this is the only part of the Western Ghats where some stretch of the western slopes are also in Tamil Nadu (Nair, 1991).

The dense forests of these hills provide home for many narrow endemics of phytogeographical significance, such as *Paphiopedilum drurii,* the sole representative of slipper orchids in Peninsular India, and *Agasthiyamalaia* an endemic tree genus, etc. Considering its immense conservation potentials, the area has been protected as a Biosphere Reserve since 2001. The angiosperm flora of the area has largely been explored and recorded more than 1100 species (Mohanan and Sivadasan, 2002). Of these more than 30% are endemics and 27 species belong to various threat categories. However, no effort was done earlier to explore the bryophyte diversity in this area.

MATERIALS AND METHODS

Area

The *Agasthyamalai* proper, with its western slopes, form a compact block of hilly range towards the southern most end of the Western Ghats and belongs to the Thiruvananthapuram district of Kerala State. The area is believed to be the abode of the legendary sage of the *Hindu* mythology, *Agasthiar,* he who considered as the founder of the *Sidha* tradition, a traditional medical practice still popular in Southern India. The folk belief depict the lord *Agasthiar* as a short statured and short tempered ever living *Guru*, who still continues his divine meditation somewhere deep in the forests of these hills. Any disturbance to his meditation by entering these forests of the *Agasthiamala*, literally means the '*hills of Agasthiar',* may invite his curse in the form of incurable diseases. The area thus is considered as sacred, and which remain as a symbol of conservation with deep cultural imprints.

Topographically, the area is steeply descending westwardly from the highest peak the *Agasthyakudam,* with an altitude of 1868 m above MSL. Major portion of the area belongs to the two Wild Life Sanctuaries *viz*., Neyyar and Peppara and the rest is in the reserved forests of Thiruvananthapuram forest division. The area is bound on the east by Thirunelveli and south by Kanyakumari district of Tamil Nadu.

IUCN has identified *Agasthyamalai* and its environ as one among the three centers of plant diversity within India, which needs immediate conservation (IUCN, 1987). The bryophyte flora of the eastern and southern

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parts of the *Agasthyamalai* ranges belongs to the Thirunelveli and Kanyakumari districts of Tamil Nadu State were explored by Daniels (2003) and reported about 24 species. However, the *Agasthyamalai* proper and its western slopes, belonging to the Kerala region have not been studied thoroughly, which is attempted here.

The temperature of the area varies from 18-35℃, typical of the southern Western Ghats, with February-March being the hottest and December-January being the coolest periods. Both Southwest and Northeast monsoon brings rain to the area ranging from 2400 to 3500 mm/year. The soil is mainly lateritic and red loamy and the area is drained by several perennial streams, which collect to form the two major river systems *viz*., *Neyyar* and *Karamanayar*.

The great diversity in ecological features and high range of altitudinal variation have been responsible for the very rich and diverse vegetation of the area. It belongs to the Indo-Malayan eco-region (Olson et al., 2001) with major vegetation types such as North Western Ghats montane rain forests (IM0135) (= Tropical wet evergreen forests (800-1400 m), North Western Ghats moist deciduous forests (IM0134) (= Tropical Moist deciduous forests (300-800 m), South Western Ghats montane rain forests (IM0151) (= Subtropical montane forest or *Shola* forests (1400-1868) and grasslands. These grasslands of the higher altitudes are seen over the crest of the *Agasthyamalai* peak and at the *Ponkalappara* area. The soil is very shallow and vegetation becomes active mainly after the monsoon and may dry up during the dry season. There is a clear demarcation of vegetation types based on the altitudinal range.

The *Agasthyamalai* Biosphere Reserve (ABR), lies Between 8° 8' to 9° 10' North Latitude and 76° 52' to 77° 34' East Longitude, was established in 2001 with an area of about 3,500 km², of which 1828 km² is in Kerala State and 1672 km² is in Tamil Nadu State (Fig. 1). The ABR straddles the border of Kollam (Quilon) and Thiruvananthapuram (Trivandrum) districts in Kerala and Tirunelveli and Kanyakumari districts in Tamil Nadu at the southern end of the Western Ghats. It is composed of Neyyar, Peppara and Shendurney Wildlife Sanctuaries and their adjoining areas of Achencoil, Thenmala, Konni, Punalur, Thiruvananthapuram forest divisions and Agasthyavanam Special Division in Kerala state.

It is the habitat for 2,000 varieties of medicinal plants, of which at least 50 belongs to rare and endangered categories (Mohanan and Sivadasan, 2002). The area is equally rich in faunal elements also with a large number of bird, butterflies, amphibians and reptiles. The major rare animals of the area include

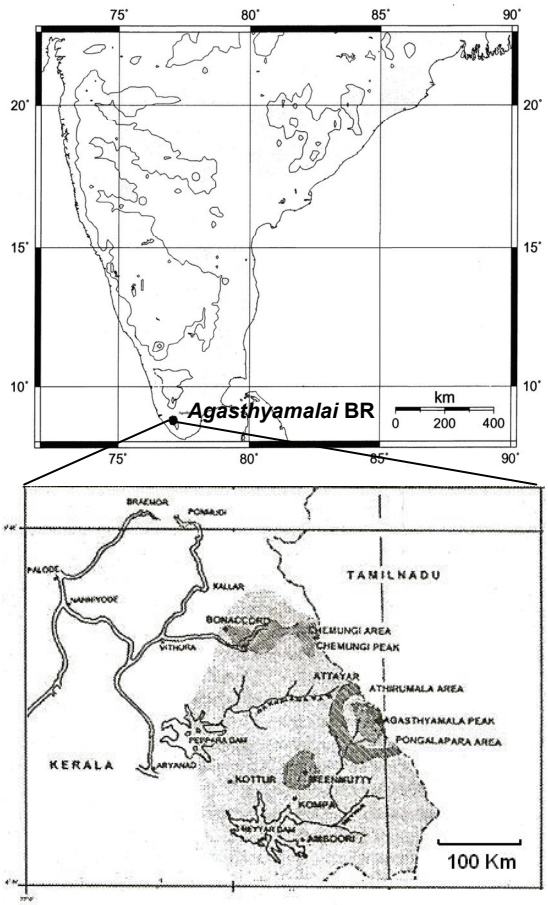


Fig. 1. The *Agasthyamalai* Biosphere Reserve Area.

the Nilgiri Tahr (endemic mammal genus of the southern Western Ghats), *Malabar Spiny Dormouse* (another endemic mammal genus), Tiger, Asian Elephant, etc. The *Agastyamalai* is also notable being the home of the *Kanikaran*, one of the oldest surviving ancient tribes, having thorough knowledge of the local biodiversity, its utilization potentials and with many cultural practices unique to them.

Enumeration of species

The bryophyte specimens were collected between 2001-2008 and deposited in the Calicut University Herbarium (CALI). Each species is listed with author citation followed by the observations on the substrate/s on which it was found growing in the study area, the locality, altitude, the collector's name (acronyms: *Sequiera* = Stephen Sequiera, *MCN* = Manju, C. N., *KPR* = K. P. Rajesh, *SVK* = Sreenivas, V. K.), collection number, and with comments on the distribution of species. Those species reported by Daniels (2003) from the eastern and southern slopes of the area, i.e., from the Tamil Nadu state are denoted with an asterisk (*). The available photographs are also provided in Figs. 2 & 3.

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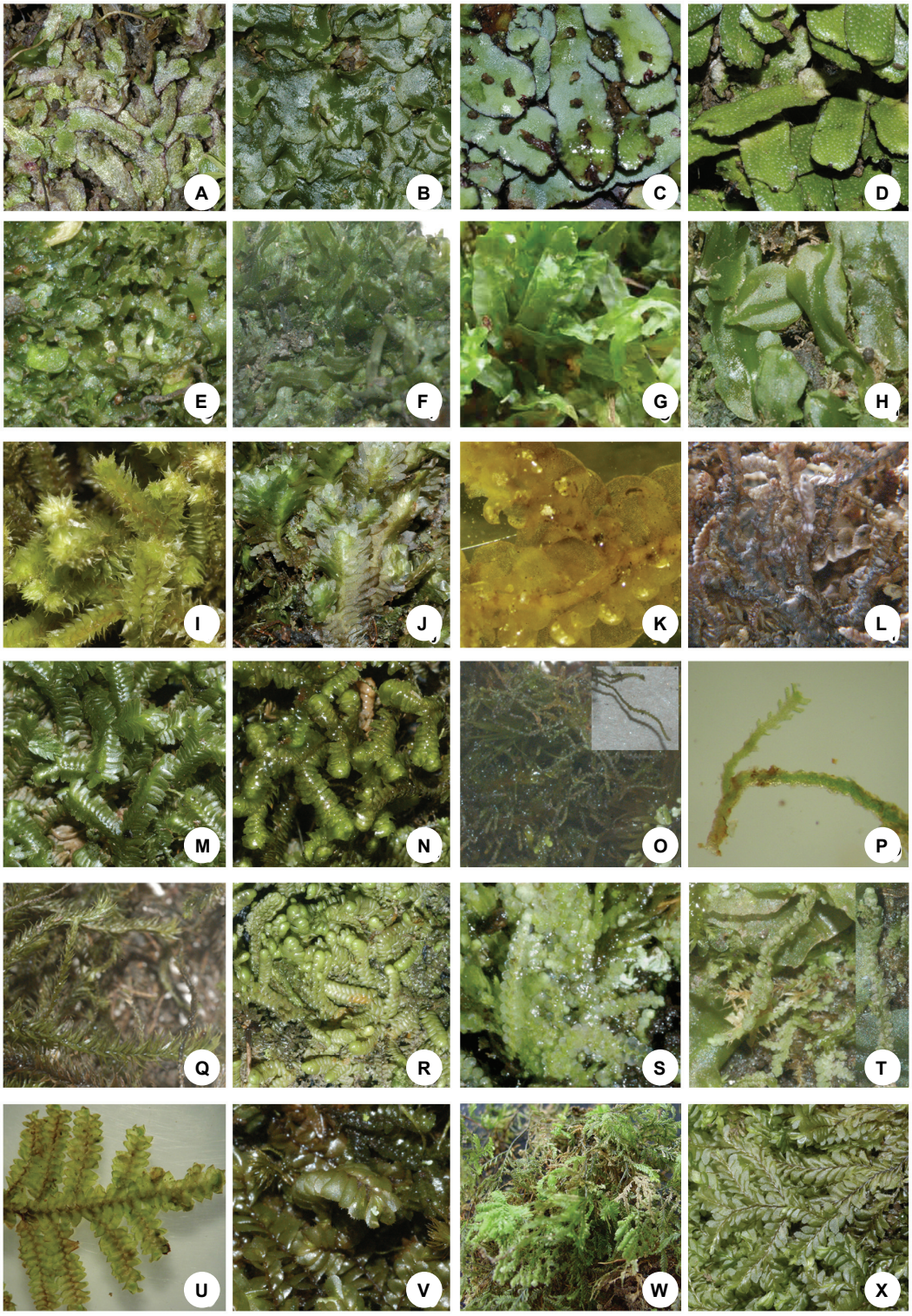


Fig. 2. A: ***Asterella reticulata.*** **B:** ***Dumortiera hirsuta.*** **C:** ***Plagiochasma appendiculatum.*** **D:** ***Targionia hypophylla.*** **E:** ***Riccardia tenuicostata.*** **F:** ***Metzgeria decipiens.*** **G:** ***Pallavicinia lyellii.*** **H:** ***P. ambigua.*** **I:** ***Chandonanthus birmensis.*** **J:** ***Schistochila aligera.*** **K:** ***Frullania ericoides.*** **L:** ***F. tamarisci.*** **M:** ***Bazzania tridens.*** **N:** ***B. sumbavensis.*** **O:** ***Cephaloziella willisiana.*** **P:** ***Cylindrocolea tagawae.*** **Q:** ***Herbertus dicranus.*** **R:** ***Radula grandifolia.*** **S:** ***Lejeunea obfusca.*** **T:** ***Cheilolejeunea serpentina.*** **U:** ***Spruceanthus semirepandus.*** **V:** ***Plagiochila beddomei.*** **W:** ***P. devexa.*** **X:** ***P. fruticosa.***

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Fig. 3. A: ***Pogonatum microstomum.*** **B:** ***Diphyscium*** **sp.** ***C*****:** ***Entosthodon wichurae.*** **D:** ***Calymperes lonchophyllum.*** **E:** ***C. afzelii*****.F:** ***Fissidens anomalus.*** **G:** ***Dicranum*** **sp.H:** ***Dicranoloma subreflexifolium.*** **I:** ***Campylopus ericoides.*** **J:** ***C. flexuosus.*** **K:** ***C. involutus s*** **.L:** ***C. pilifer.*** **M:** ***Symphyodon echinatus.*** **N:** ***Leucobryum cucullifolium.*** **O:** ***L. juniperoideum.*** **P:** ***Macromitrium moorcroftii.*** **Q:** ***Cyathophorum adiantum.*** **R:** ***Himantocladium cyclophyllum.*** **S:** ***Thuidium cymbifolium.*** **T:** ***Hypopterygium aristatum.*** **U:** ***Trichostelium boschii.*** **V:** ***Wijkia surcularis.*** **W:** ***Ctenidium lychnites.*** **X:** ***Hypnum plumaeforme.***

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TAXONOMIC TREATMENTS

MARCHANTIOPHYTA

Aytoniaceae

Asterella reticulata (Kashyap) Kachroo. On land cuttings. *Ponkalappara* (1450 m) *MCN & KPR 106671* (CALI). It is an Indian endemic species earlier known only from the Meghalaya of Eastern Hiamalayas. The present collection is a new record for its extended distribution to the Western Ghats of Peninsular India (Fig. 2A).

Marchantiaceae

Dumortiera hirsuta (Sw.) Nees. On rocky patches where water drips regularly. *Chemunji* (1300 m) *Sequiera 106331, Agasthyamalai* (1350 m) *MCN & KPR 106589* (CALI). This is widely distributed in the high altitude areas of the Western Ghats. It has wide distribution in Southern India (Tamil Nadu, Kerala), Northern India (Simla, Mussoorie, Kumaon, Pachmahri), Nepal, Japan, Brazil, Mexico, Jamaica, North & South America, Europe, New Zealand, Hawaii and Africa (Fig. 2B).

Plagiochasma appendiculatum Lehm. & Lindenb. On rocks near streams. *Ponkalappara* (1450 m), *MCN & KPR 106661* (CALI). It is a common species of high altitude regions of the Western Ghats and is distributed in the North-east India (Hiamalayas, Khasi, Meghalaya, Nainital), Southern India (Tamil Nadu, Kerala), China, Saudi Arabia, Yemen, Oman, United Arab Emirates, Kuwait, Socotra, Qatar and Bahrain (Fig. 2C).

Targioniaceae

Targionia hypophylla L. On land cuttings in shola forests. *Agasthyamalai peak* (1500 m) *MCN & KPR 106672* (CALI). It is a widely distributed species in the medium and high altitudes of the Western Ghats. This species is distributed in Southern India (Kerala, Tamil Nadu, Karnataka), Central India (Mt. Abu), North-east India (Western Himalayas, Mussoorie, Pachmahri, Simla, Sikkim, Chirapunji, Khasi hills), Japan, Chile, Korea, Taiwan, China, Hawaii, Peru, Europe, N. & S. America and Australia (Fig. 2D).

Aneuraceae

Riccardia tenuicostata Schiffn. On moist rocks and on exposed roots of higher plants. *Agasthyamalai* (1250 m), *SVK 106613/a* (CALI). It is widely distributed in Kerala State. Also distributed in Tamil Nadu, Darjeeling, Eastern Himalayas and Western Himalayas in India and Singapore and Java (Fig. 2E).

Metzgeriaceae

Metzgeria decipiens (C.Massal.) Schiffn. Epiphytic. *Ponkalappara* (1300 m), *SVK 106617/b* (CALI). Srivastava and Udar (1975) reported this species from Nilgiri mountains in Southern India. It is distributed in India (Tamil Nadu: Nilgiri Mountains; Easten Himalayas, Western Himalayas, Kerala: present collection), Nepal, Japan, Borneo, Java, Hawai, New Caledonia, Australia, New Zealand, Tasmania and Chile. The present collection is a new record for Kerala State (Fig. 2F). Treated by some authors as a synonym of *M. furcata* (L.) Corda

Pallaviciniaceae

* *Pallavicinia lyellii* (Hook.) S.Gray. On base of tree trunks. Attayar (1100 m), *Sequiera 106330,* Way to *Pandavamala* (1300 m), *SVK 106638/b* (CALI). It is distributed in Southern India (Kerala, Karnataka), North-east India (Assam, Gauhati, Shillong, Pachmahri), Sri Lanka, Europe, Jamaica, Cuba, Brazil, Java, Singapore, Philippines, Japan (Ryukyu), Moluccas, New Zealand, Africa and America (Fig. 2G).

Pallavicinia ambigua (Mitt.) Steph. On rocks. *Ponkalappara* (1500 m), *MCN & KPR 106654* (CALI). It is distributed in North-east India (Western Himalayas), Southern India (Kerala, Tamil Nadu), China and Japan (Fig. 2H).

Trichocoliaceae

Trichocolea udarii D.K.Singh. On rocky patches. *Ponkalappara* (1400 m) *MCN & KPR 106643* (CALI). This Indian endemic species was first described from Jaintia Hills of Meghalaya by Singh (1983). Singh and Nath (2007) also reported this species from Cherrapunji in East Khasi hills and Mawsiangdur forest in the West Khasi hills. The present collection is a new record for its extended distribution to the Western Ghats of Peninsular India.

Jungermanniaceae

Chandonanthus birmensis Steph. On rocky patches. *Chemunji* (1250 m), *Sequiera 106319* (CALI). It is distributed in Southern India (Kerala), North-east India (Sikkim, Darjeeling), China, Nepal, Myanmar, Java, Japan (Ryukyu), Taiwan, Madagascar, Canada, Pacific Islands and Africa (Fig. 2I).

Schistochilaceae

* *Schistochila aligera* (Nees & Blume) Jack & Steph. On rocky patches. Way to *Pandavamala* (1300 m), *SVK 106631* (CALI). It is a wide spread Indomalesian species known in India from Kerala (Silent Valley National Park: Sispara), Tamil Nadu (Walaghat, Nilgiri hills) and Nicobar Islands (Fig. 2J).

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Jubulaceae

Jubula hutchinsiae (Hook.) Dum. Subsp. *Javanica* (Steph.) Verd. On base of trees. *Athirumala* (1200 m), *Sequeira 80320/b* (CALI). Its distribution extends from Turkey and Caucasus Mts., Madagascar and Indomalesia to Vietnam and to the Bismarck archipelago. In India it is known from the Eastern India (Sikkim Himalaya and Khasi hills). Pocs et al. (2007) reported this as new record for Peninsular India.

Frullania ericoides (Nees ex Mart.) Mont. On bark of trees and shrubs. Way to *Ponkalappara* (1500 m), *MCN & KPR 106664* (CALI). It is distributed in Eastern India (Meghalaya, Shillong, Cherapunjii), Southern India (Tamil Nadu, Kerala: present colection) China, Japan, Mexico and America. The present collection is a new record for Kerala (Fig. 2K).

Frullania tamarisci (L.) Dumort.- On bark of trees and shrubs. Way to *Ponkalappara* (1450 m) *MCN & KPR 106668* (CALI). This species is distributed in Southern India (Kerala, Tamil Nadu), Northern India (Himalaya), Sri Lanka, Malaysia, China, Taiwan, Korea, Japan, Europe and Asia minor (Fig. 2L).

Frullania sp. On rock along with Cylindrocolea tagawae. *Chemunji* (1300 m) *Stephen 106311b* (CALI). It is not matching with any of the species of *Frullania* known from India. Further studies are required to fix the identity.

Lepidoziaceae

* *Bazzania tridens* (Reinw. et al.) Trev. Epiphytic along with other mosses. *Ponkalappara* (1300 m), *MCN & KPR 106635; 106588; SVK 106620/b* (CALI). Widely distributed in the tropical and temperate regions of Asia; in India it is distributed in Eastern India (Assam, Sikkim), Southern India (Tamil Nadu, Kerala) (Fig. 2M).

Bazzania sumbavensis (Gottsche ex Steph.) Steph. On bark of trees and shrubs. *Ponkalappara* (1300 m), *SVK 106619, 106621* (CALI). It is distributed in Eastern India (Assam, Meghalaya, Sikkim), Java and Sumatra. The present collection is a new record for its extended distribution to the Western Ghats of Peninsular India (Fig. 2N).

Cephaloziellaceae

Cephalozia pandei Udar & Kumar. On rocky patches and on land cuttings along with other mosses and *Utricularia* sp. *Ponkalappara* (1250 m), *SVK 106613/b* (CALI). It is an Indian endemic species first reported from Darjeeling. Sigh and Nath (2007) reported it from Meghalaya. The present collection is a new record for its extended distribution to the Western Ghats of Peninsular India.

Cephaloziella willisiana (Steph.) Kitag. Epiphytic. *Ponkalappara* (1250 m), *SVK 106642* (CALI). This was first described by Stephani (1908) from Ceylon (Sri Lanka) and Southern India under the name *Cephalozia willisiana* Steph. Stephani (1924) described *Cephalozia andreana* Steph. from Madura in Southern India which is now synonymised under *Cephaloziella willisiana* (Steph.) Kitag. It is also distributed in Meghalaya in India and in China, Thailand, Malaya, Sri Lanka, Java and New Caledonia. The present collection is a new record for the Kerala state (Fig. 2O).

Cylindrocolea tagawae (Kitag.) Schust. On trunks of trees and shrubs along with other mosses. *Chemunji* (1250 m), *Sequiera 106311a, 106316/b* (CALI). It was earlier reported as endemic to Thailand (Schuster, 1980), but was later reported from the Southern Island of Ryukyu Islands (Japan) (Yamaguchi and Seki, 1983), India (Udar and Kumar, 1983) and from Hong Kong (So and Zhu, 1997). In India it is distributed in Southern India (Kerala), Central India (Madhya Pradesh) and Northern India (Pachmahri) (Fig. 2P).

Herbertaceae

Herbertus dicranus (Taylor ex Gottsche et al.) Trevis. Epiphytic. *Ponkalappara* (1300 m), *SVK 106626* (CALI). This Indian endemic species was first reported from Darjeeling, Sikkim and Himalayas by Miller (1965). Singh and Nath (2007) reported it from Meghalaya in the Eastern Hiamalayas. The present collection is a new record for its extended distribution to the Western Ghats of Peninsular India (Fig. 2Q).

Geocalycaceae

Lophocolea sp. On earth cuttings. *Agasthyamalai* (1300 m) *MCN & KPR 106583* (CALI). It is not matching with any of the species of *Lophocolea* known from India. Further studies are required to fix the identity.

Radulaceae

Radula grandifolia Steph.- Epiphytic. *Agasthyamalai* (1400 m) *MCN & KPR 106629, 106644* (CALI). This species is distributed in Western Himalayas and Eastern Hiamalayas. The present collection is a new record for its extended distribution to the Western Ghats of Peninsular India (Fig. 2R).

Lejeuneaeceae

Cololejeunea lanciloba Steph. Epiphyllose on *Mangifera indica*. *Agasthyamalai* (1000 m) *MCN & KPR 106673* (CALI). It is an Indian endemic species distributed in Andaman & Nicobar Islands, Meghalaya, Eastern Himalayas and Mysore. Manju et al. (in press) recorded this species as new record for Kerala state.

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Lejeunea obfusca Mitt. On exposed roots of higher plants along with *Pallavizinia lyellii* and *Bazzania tridens*. Way to *Pandavamala* (1300 m) *SVK 106620/c, 106636* (CALI). It is distributed in North India (Pachmahri), South India (Kerala) and Sri Lanka (Fig. 2S).

Lejeunea eifrigii Mizut. On base of tree trunks. *Athirumala* (1200 m), *Sequiera 80320/4* (CALI). Indomalesian species, previously known from Malaysia to Papua New Guinea and to New Caledonia. Pocs et al. (2007) reported this species as new to the Indian subcontinent.

Cheilolejeunea serpentina (Mitt.) Mizut. On base of tree trunks along with *Pallavicinia lyellii*. Way to *Pandavamala* (1300 m) *SVK 106638/a, MCN & KPR 106657* (CALI). It is distributed in Southern India (Kerala, Tamil Nadu), Northern India (Pachmahri), Andaman & Nicobar Islands, Sri Lanka, Cameroon, Caroline Islands, Java, Madagascar, Malacca, Philippines, Singapore, Sumatra, Seychelles and Thailand (Fig. 2T).

Spruceanthus semirepandus (Nees) Verd. Epiphytic. *Pandavamala* (1450 m) *MCN & KPR 106658* (CALI). It is distributed in South India (Kerala, Karnataka, Tamil Nadu), Northeastern India (Western Himalaya, Sikkim, Khasi hills, Meghalaya, Darjeeling), Sri Lanka, Japan, China, Java, Borneo, Philippines and Taiwan (Fig. 2U).

Plagiochilaceae

Plagiochila beddomei Steph. Epiphytic. Way to *Pandavamala* (1250 m) *SVK 106630* (CALI). It is a widely distributed species in the high altitudes of Western Ghats. It is also distributed in other parts of Southern India (Tamil Nadu, Kerala), China and Thailand (Fig. 2V).

Plagiochila devexa Steph. Epiphytic. *Agasthyamalai* peak (1500 m) *MCN & KPR 106655* (CALI). It is distributed in Wayanad and Idukki districts in Western Ghats of Kerala. It was also recorded from North-east India (Sikkim, Himalaya), China, Bhutan, Nepal and Sri Lanka (Fig. 2W).

Plagiochila fruticosa Mitt. Epiphytic. *Agasthyamalai* peak (1520 m) *MCN & KPR 106656* (CALI). It is widely distributed in the high altitude *Shola* forests of Western Ghats. It is also distributed in North-east India (Assam, Sikkim, Himalaya, Darjeeling, West Bengal), China, Bhutan, Japan, Thailand and Philippines (Fig. 2X).

Plagiochila nepalensis Lindenb. Epiphytic. *Ponkalappara* (1450 m) *MCN & KPR 106665* (CALI). It is widely distributed in North-eastern India (Assam, Darjeeling, Himachal Pradesh, Uttar Pradesh), Southern India (Kerala), China, Bhutan, Japan, Myanmar, Nepal, Philippines, Thailand and Vietnam.

BRYOPHYTA

Polytrichaceae

Pogonatum leucopogon Renauld & Cardot. On land cuttings. *Ponkalappara* (1450 m) *MCN & KPR 106647* (CALI). Gangulee (1969) commented that this species is endemic to Eastern Himalayas. Madhusoodanan et al. (2007) reported this species from Kerala.

Pogonatum microstomum (Schwaegr.) Brid. On land cuttings. *Chemunji* (1300 m), *Sequiera 106699* (CALI). This species has wide distribution in the Western Ghats. It is a South-east Asiatic species reported from Southern India (Kerala, Tamil Nadu, Karnataka), North-eastern India (Darjeeling, Western Himalaya, Meghalaya, Sikkim), Sri Lanka, Bhutan, Taiwan, Nepal, Philippines, Setchwan, Tonkin and Yunnan (Fig. 3A).

Diphysciaceae

Diphyscium mucronifolium Mitt.- On small rocks. *Athirumala* (1250-1300 m) *Stephen 106324, 106327* (CALI). A South-east Asiatic species, in India reported from North-east India (Khasia hills) and South India (Tamil Nadu, Kerala).

Diphyscium sp. On rocky patches. *Ponkalappara* (1250 m) *SVK 106611* (CALI). It is not matching with any of the species of *Diphyscium* known from India. Further studies are required to fix the identity (Fig. 3B).

Funariaceae

Entosthodon wichurae M. Fteisch.- On soil in grasslands. *Pandavamala* (1400 m) *MCN & KPR 106646* (CALI). It is a common species in the grasslands of high altitude areas. It is distributed in Southern India (Kerala, Tamil Nadu), North-east India (Meghalaya, Uttar Pradesh), Sri Lanka, Indonesia and Myanmar (Fig. 3C).

Calymperaceae

Calymperes afzelii Sw. Epiphytic. Near *Agasthyamalai* peak (1500 m) *MCN & KPR 106663* (CALI). A widely distributed species in tropics (Fig. 3E).

Calymperes lonchophyllum C. Mueller. On bark of trees. Way to *Pandavamala* (1350 m) *SVK 106637* (CALI). A widely distributed species (Fig. 3D).

Calymperes sp. On rocky patches. *Chemunji* (1220 m) *Sequiera 106318* (CALI). It is not matching with any of the species of *Calymperes* known from India. Further studies are required to fix the identity.

Fissidentaceae

* *Fissidens anomalus* Mont. Epiphytic and on small branches. Near *Agasthyamalai* peak (1500 m)

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MCN & KPR 106659 (CALI). It is a widely distributed species in the high altitude *Shola* forests of Kerala. It is also distributed in Tamil Nadu, Himachal Pradesh, Darjeeling in India; East Nepal, Sri Lanka, Thailand, Java and the Philippines (Fig. 3F).

Dicranaceae

Dicranum sp. Epiphytic. *Ponkalappara* (1250 m) *SVK 106642* (CALI). It is not matching with any of the species of *Dicranum* known from India. Further studies are required to fix the identity (Fig. 3G).

Dicranoloma subreflexifolium (C. Mueller) Paris. On rocky patches. *Chemunji* (1250 m) *Sequiera 106303* (CALI). It was earlier recorded from Assam and Khasi hills in India and from Nepal. The present collection is a new record for its extended distribution to the Western Ghats of Peninsular India (Fig. 3H).

* *Campylopus ericoides* (Griff.) A. Jaeger- On rocky patches. *Chemunji* (1250 m) *Sequiera 106302a* (CALI). It is a South-east Asiatic species distributed in Southern India (Kerala, Tamil Nadu), North-eastern India (Darjeeling, Khasi hills, Manipur, Meghalaya, West Bengal), Sri Lanka, Nepal, Myanmar, Thailand, Vietnam, Java and Philippines (Fig. 3I).

Campylopus flexuosus (Hedw.) Brid. On rocky patches in grasslands. *Chemunji* (1300 m) *Sequiera 106309* (CALI). This is a cosmopolitan species mostly occurring in high altitude areas. It has been reported earlier from Southern India (Kerala: Eravikulam National Park - Idukki district), Northern India (Western Himalaya), China, East Nepal, Algeria, Abyssinia, Madagascar, New Zealand, Oceania and Siberia (Fig. 3J).

Campylopus involutus (C. Mueller) A. Jaeger. On rocky patches. *Ponkalappara* (1300 m) *SVK 106618* (CALI). An Indo-Malesian species distributed in North India (Darjeeling), Southern India (Tamil Nadu: Nilgiri hills; Kerala: present collection). The present collection is a new record for Kerala state (Fig. 3K).

Campylopus pilifer Brid. Terrestrial and lithophytic. *Ponkalappara* (1300 m) *SVK 106640* (CALI). Widespread and frequent through the neotropics, also reported in North America, West Europe, Africa, India and Sri Lanka. Nair et al. (2005) reported this species from Kerala state (Fig. 3L).

Symblepharis vaginata (Hook. ex Harv.) Wijk & Margad.- On rocky patches in grasslands. *Chemunji* (1250 m) *Sequiera 106315* (CALI). It is distributed in Northeastern India (Sikkim, Darjeeling, Naga hills, Western Himalayas), China, Nepal and Central America. The present collection is a new record for its extended distribution to the Western Ghats of Peninsular India.

Leucobryaceae

* *Leucobryum cucullifolium* Cardot. On base of tree trunks and on exposed roots. *Ponkalappara* (1300 m) *SVK 106623* (CALI). Gangulee (1969) commented that the species is endemic to eastern Nepal and Darjeeling. The present collection is a new record for its extended distribution to the Western Ghats of Peninsular India (Fig. 3N).

Leucobryum juniperoideum (Brid.) C. Mueller. On logs. *Chemunji* (1300 m) *Sequiera 106314 a, Ponkalappara* (1300 m) *MCN & KPR 106582* (CALI). It is a common species in the Western Ghats. It was recorded earlier from Southern India (Tamil Nadu, Kerala), Eastern India (Khasi hills) and Japan (Fig. 3O).

Leucobryum mittenii Besch. On rocky patches. *Athirumala* (1300 m) *Sequiera 106328* (CALI). It is distributed in Eastern India (Khasi hills), Southern India (Tamil Nadu; Kerala: present collection) and Japan. The present collection is a new record for Kerala state.

* *Leucoloma amoene-virens* Mitt.- On bark. *Ponkalappara* (1400 m) *MCN & KPR 106645* (CALI). It is an Indo-Sri Lankan species distributed in Southern India (Tamil Nadu, Kerala), Eastern India (Khasi hills) and Sri Lanka.

Leucoloma taylorii (Schwaegr.) Mitt. Epiphytic. *Athirumala* (1300 m) *Sequiera 106329* (CALI). It is a South-east Asiatic species distributed in India (Kerala), Nepal, Malaya and Myanmar.

Leucoloma sp. On bark. *Pandavamala* (1400 m) *MCN & KPR 106650* (CALI). It is not matching with any of the species of *Leucoloma* known from India. Further studies are required to fix the identity.

Pottiaceae

Tortella tortuosa (Hedw.) Limpr. On tree trunks. *Chemunji* (1250 m) *Sequiera 106316/a, 106317* (CALI). It is a cosmopolitan species distributed in Northeast India (Western Himalaya, Kashmir), Southern India (Kerala), Nepal, China, Iran, Japan, Ciberia, Central Asia, Caucasus, Europe and North Africa.

Bryaceae

Bryum paradoxum Schwaegr. On rocks where water drips regularly. *Chemunji* (1300 m) *Sequiera 106698* (CALI). A species distributed in Africa, South and Southeastern Asia and South America. In India it is known from Kerala and Tamil Nadu.

Bryum wightii Mitt.- On rocky patches along with other mosses. *Chemunji* (1350 m), *Sequiera 106697* (CALI). It is distributed in Southern India (Tamil Nadu, Kerala and Maharashtra), Sri Lanka and Nepal.

Rhodobryum roseum (Hedw.) Limpr. On land cuttings. *Chemunji* (1300 m) *Sequiera 106306*(CALI).

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It is a cosmopolitan species distributed in Northeast India (Darjeeling, Khasi hills, Western Himalayas, Kumaon, Garhwal), Southern India (Kerala) Nepal, Sri Lanka, Vietnam, Tibet, Siberia, Japan, China, Taiwan, Europe, Caucasus, Central & South Africa, North America and Mexico.

Rhizogoniaceae

Pyrrhobryum spiniforme (L. ex Hedw.) Mitt.- Epiphytic as well as on rocky patches. *Chemunji* (1300 m) *Sequiera 106308, Ponkalappara* (1300-1400 m) *SVK 106622/b, 106645/a* (CALI). It is distributed in Southern India (Tamil Nadu, Kerala), North-eastern India (Darjeeling, Sikkim, Khasi hills, Assam, Arunachal Pradesh), Sri Lanka, Japan, China, Korea, New Guinea, Java, Borneo, Vietnam, New Caledonia and Philippines.

Racopilaceae

Racopilum orthocarpum Wils. & Mitt. On base of tree trunks. *Chemunji* (1250 m) *Sequiera 106307/b* (CALI). It is a widely distributed species in the high altitude areas. A South-east Asiatic continental species earlier reported from Southern India (Kerala, Tamil Nadu), North-eastern India (Western Himalaya, Khasi hills, Sikkim), Sri Lanka, Nepal, Vietnam and Myanmar.

Orthotrichaceae

Macromitrium sulcatum (Hook.) Brid. Epiphytic. *Chemunji* (1250 m) *Sequiera 106302/b, 106313, Pandavamala* (1250 m) *SVK 106641, 106642/b, MCN & KPR 106587, 106662* (CALI). It is common in the high altitude evergreen and *Shola* forests. This species is widely distributed in Southern India (Kerala; Western Ghats of Maharashtra; Tamil Nadu), Sri Lanka, Nepal, Borneo, Kampuchea, Madagascar, Malaysia, Myanmar, Philippines, Thailand and Vietnam.

Macromitrium moorcroftii (Hook. & Grev.) Schwaegr.- Epiphytic. *Agasthyamalai* peak (1500 m) *MCN & KPR 106660* (CALI). An Indo-Chinese species distributed in North eastern India (Western Himalayas, Sikkim, Darjeeling, Khasi), Southern India (Karnataka; Kerala: present collection), Nepal, Myanmar and Yunnan. The present collection is a new record for its extended distribution to the Western Ghats of Peninsular India (Fig. 3P).

Pterobryaceae

Garovaglia plicata (Brid.) Bosch & Sande-Lac.- Epiphytic. *Ponkalappara* (1250 m) *SVK 106617/a* (CALI). It is distributed in India (Sikkim), Sumatra, Indonesia, Cera and the Philippines. Nair et al. (2005) reported this species as new record to Peninsular India.

Garovaglia sp. Epiphytic. *Ponkalappara* (1400 m) *MCN & KPR 106652* (CALI). It is not matching with any of the species of *Garovaglia* known from India. Further studies are required to fix the identity.

Pterobryopsis sp. Epiphytic. Way to *Pandavamala* (1250 m) *SVK 106616/b* (CALI). It is not matching with any of the species of *Pterobryopsis* known from India. Further studies are required to fix the identity.

Himantocladium cyclophyllum (C. Mueller) M.Fleisch. Epiphytic. *Ponkalappara* (1300 m) *SVK 106624/b* (CALI). It is an Indo-Pacific species distributed in eastern India (Assam), Java, Celebes, Borneo, New Guinea, Taiwan and Philippines. The present collection is a new record for its extended distribution to the Western Ghats of Peninsular India (Fig. 3R).

Homaliodendron flabellatum (Sm.) M. Fleisch. On base of tree trunk. *Chemunji* (1250-1300 m) *Sequiera 106397/a, 106321; Ponkalappara* (1250 m) *SVK 106614* (CALI). On rocky patches near streams and also as epiphytic along with other mosses. It is a common species distributed in India, Sri Lanka, Thailand, Sumatra, Australia and Pacific Ocean Islands.

Homaliodendron microdendron (Mont.) M.Fleisch.- On small twigs. *Agasthyamalai* (1500 m) *MCN & KPR 106671* (CALI). It is distributed in Northeast India (Sikkim, Darjeeling, Khasi hills, Manipur, Western Himalaya), Southern India (Tamil Nadu; Kerala), Nepal, Myanmar, Thailand, Vietnam, Borneo, Philippines, Yunnan, Taiwan and Rikyus. Nair et al. (in press) reported this species as new record for Kerala.

Trachypodaceae

Trachypus bicolor Reinw. & Hornsch.- Epiphytic. *Chemunji* (1350 m) *Sequiera 106301* (CALI). It is a widely distributed species reported earlier from Southern India (Tamil Nadu, Kerala), North-east India (Western Himalayas, Assam, Sikkim), Sri Lanka, China, Nepal, Barnes, Brazil, Celebes, French Guinea, Guatemala, Indonesia, Japan, Korea, Mexico, Myanmar, Thailand, New Guinea, Philippines and Sumatra.

Meteoriaceae

Aerobryum speciosum Dozy & Molk.- Epiphytic. *Ponkalappara* (1350 m) *MCN & KPR 106585, 106586* (CALI). This species is common in the high altitude areas of he Western Ghats. An east and southeast Asiatic species earlier reported from Southern India (Western Ghats of Tamil Nadu; Kerala), North-eastern India (Darjeeling, Arunachal Pradesh, Khasi hills, Manipur, Meghalaya, Sikkim), Sri Lanka, Bhutan, Celebes, China, Taiwan, Indonesia, Japan, Philippines, New Guinea and Tonkin.

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Meteoriopsis squarrosa (Hook.) M. Fleisch.- On logs. *Chemunji* (1300 m) *Sequiera 106314/b* (CALI). It is widely distributed in Southern India (Tamil Nadu, Karnataka, Kerala), North-east India (Sikkim, Darjeeling, Himalaya, Arunachal Pradesh, Khasi hills, Manipur), Sri Lanka, Nepal, Bhutan, Myanmar, Thailand, Vietnam, Sumatra, Java, New Guinea, Philippines, Taiwan and Yunnan.

Neckeraceae

Pinnatella calcutensis M. Fleisch.- On rocky patches. *Ponkalappara* (1400 m) *MCN & KPR 106671* (CALI). It is a South-east Asiatic species reported from Southern India (Kerala, Karnataka), North-eastern India (West Bengal, Darjeeling, Orissa) and Thailand.

Thuidiaceae

* *Thuidium cymbifolium* (Dozy & Molk.) Dozy & Molk.- Base of tree trunk. *Ponkalappara* (1250 m) *SVK 106612* (CALI). A widely distributed very common species in the tropics (Fig. 3S).

Thuidium pristocalyx (C.Muell.) A. Jaeger- Base of tree trunk. *Athirumala* (1300 m) *Sequiera 106326* (CALI). It was earlier recorded from India (Kerala), Thailand, Vietnam, Indonesia, Malaysia and Philippines. Nair et al. (2005) recorded this species as new record for India.

Symphyodontaceae

Symphyodon echinatus (Mitt.) A. Jaeger- On branches. *Athirumala* (1300 m) *Stephen 106325* (CALI). It is distributed in India (Sikkim, Darjeeling and Manipur). The present collection is a new record for peninsular India (Fig. 3M).

Hypopterigiaceae

Cyathophorum adiantum (Griff.) Mitt. On bark of higher plants near streams. *Agasthyamalai* peak (1500 m) *MCN & KPR 106667* (CALI). It is distributed in North-eastern India (Sikkim, Darjeeling, Khasi hills, Western Hiamalayas), Bhutan, Nepal and Philippines. The present collection is a new record for its extended distribution to the Western Ghats of Peninsular India (Fig. 3Q).

Hypopterygium aristatum Bosch. & Sande-Lac.- On rocky patches. *Ponkalappara* (1270 m) *SVK 106627* (CALI). This species is distributed in Southern India (Tamil Nadu, Kerala), Northern India (Himalayas), China, Java, New Guinea and Indo-Malayan region (Fig. 3T).

Sematophyllaceae

Chionostomum rostratum (Griff.) C. Mueller- On small branches. *Chemunji* (1300 m) *Stephen 106310* (CALI). It is distributed in India (Kerala, Andaman & Nicobar Islands) Nepal, Bhutan, Bangladesh, China, Taiwan and Philippines.

Clastobryopsis muelleri (Dix.) Tix.- On branches. *Chemunji* (1300 m) Stephen 106305 (CALI). It is distributed in Eastern Nepal and Darjelling. The present collection is a new record for Peninsular India.

Foreauella orthothecia (Schwaegr.) Dixon & Vard.- On branches. *Chemunji* (1300 m) *Stephen 106320* (CALI). This Indo-Malesian species was earlier recorded from South India (Tamil Nadu, Kerala), North-east India (Darjeeling, Assam, Khasi hills, Orissa), Nepal, Thailand, Philippines and the Pacific Ocean Islands.

Taxiphyllum taxirameum (Mitt.) M. Fleisch.- On logs. *Agasthyamalai* peak (1500 m) *MCN & KPR 106666* (CALI). Widely distributed in the tropics including North-east India (Mussoorie, Simla, Nainital, Ranikhet, Almora, Sikkim, Abor, Assam, Khasi hills), Southern India (Tamil Nadu, Kerala), Sri Lanka, Nepal, Bhutan, Indonesia, Japan, Myanmar, New Guinea, Philippines, Sumatra, Taiwan and Tonkin.

Trichostelium boschii (Dozy & Molk.) A. Jaeger- On logs. *Ponkalappara* (1350 m) *MCN & KPR 106584* (CALI). It is an Indo-Malesian species distributed in India (Assam), Nepal, Annam, Malay, Sumatra, Java, Borneo and Fiji. The present collection is a new record for its extended distribution to the Western Ghats of Peninsular India (Fig. 3U).

Isopterygiaceae

Isopterygium albescens (Hook.) A.Jaeger- On logs. *Ponkalappara* (1400 m) *MCN & KPR 106653* (CALI). This species is common in the *Shola* forests of high altitude areas. It was earlier recorded from Southen India (Tamil Nadu, Kerala), North-eastern India (Khasi hills), Sri Lanka, Myanmar, Thailand, Vietnam, Singapore, Sumatra, Java, Borneo, Celebes, Philippines, Japan and New Zealand.

Wijkia surcularis (Mitt.) H. A. Crum. Epiphytic. *Ponkalappara* (1250 m) *SVK 106616, Chemunji* (1250 m) *Stephen 106322* (CALI). It was reported from Nepal, China, Myanmar and Thailand and in India (North-east India: Sikkim and Khasia hills). Nair et al. (in press) reported this species as new record for Southern India from Kerala state (Fig. 3V).

Ctenidium lychnites (Mitt.) Broth. On land cuttings. *Ponkalappara* (1300 m) *SVK 106624/a* (CALI). It is distributed in India (Kerala, Tamil Nadu, Meghalaya, Andaman Islands, Nicobar Islands), Nepal, Bhutan, Bangladesh, China, Taiwan, Sri Lanka and Malaysia (Fig. 3W).

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Vesicularia vesicularis (Schwaegr.) Broth.- Epiphytic. *Ponkalappara* (1400 m) *MCN & KPR 106649* (CALI). It is rare in the study area. This south & east Asiatic-Pacific species is distributed in Southern India (Kerala), North-eastern India (Western Himalaya, West Bengal, Arunachal Pradesh), China, Thailand, Vietnam, Sumatra, Java, Borneo, Philippines, Australia and Oceania.

Hypnaceae

Hypnum plumaeforme Wilson. On rocky patches. *Ponkalappara* (1450 m) *MCN & KPR 106648* (CALI). An east Asiatic species distributed in eastern India (Sikkim), Nepal, China, Japan, Philippines, Taiwan, Korea and Tonkin. The present collection is a new record for its extended distribution to the Western Ghats of Peninsular India (Fig. 3X).

Hypnum sikkimense Ando. On base of tree trunk. *Chemunji* (1300 m) *Sequiera 106312* (CALI). It is recorded from Sikkim in India and from Nepal and Bhutan. The present collection is a new record for its extended distribution to the Western Ghats of Peninsular India.

Ectropothecium sikkimense (Renauld & Cardot) Renauld & Cardot, On logs. *Agasthyamalai* peak (1300 m) *MCN & KPR 106581* (CALI). It has earlier reported from North-east India (Darjeeling, Sikkim, Western Himalayas), Bhutan and Thailand. Nair et al. (2005) recorded this species as new record to Peninsular India.

Hylocomiaceae

Macrothamnium macrocarpum (Reinw. & Hornsch.) M. Fleisch. On tree trunks. *Chemunji* (1350 m) *Stephen 106696* (CALI). A widespread Indo-Pacific species distributed in Southern India (Tamil Nadu, Kerala), North-eastern India (Abor, Khasi, Kumaon, Sikkim), Sri Lanka, Java, Thailand, Borneo, Yunnan, Japan, Hawaii, Myanmar, Pacific Ocean Islands, Taiwan, Philippines and Siam.

DISCUSSION

A total of 90 taxa were found in the western slopes of Agasthiamalai belonging to the Kerala State, which include 16 new distribution records (*Asterella reticulata, Bazzania sumbavensis, Cephalozia pandei, Clastobryopsis muelleri, Cyathophorella adiantum, Dicranoloma subreflexifolium, Herbertus dicranus, Himantocladium cyclophyllum, Hypnum plumaeforme, H. sikkimense, Leucobryum cucullifolium, Radula grandifolia, Symblepharis vaginata, Symphyodon echinatus, Trichocolea udarii* and *Trichostelium boschii*) to Western Ghats of Peninsular India and 6 are new to the Kerala State (*Campylopus involutus, Cephaloziella willisiana, Frullania ericoides, Macromitrium moorcroftii, Metzgeria decipiens* and *Leucobryum mittenii*). Pocs et al. (2007) reported *Lejeunea eifrigii* Mizut. as new to the Indian subcontinent. The identity of some species such as *Frullania* sp., *Lophocolea* sp., *Diphyscium* sp., *Calymperes* sp., *Dicranum* sp., *Leucoloma* sp., *Garovaglia* sp. and *Pterobryopsis* sp. could not be found at this time. Further studies are needed to fix the correct identity of the species. The presence of 90 species indicates the bryophyte richness of the area. Out of the 24 species reported by Daniels (2003) from the eastern and southern slopes, eight were found in the present study. Further detailed explorations in the western slopes may result in recording of other species reported by Daniels (2003) and further new additions from the area.

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印度西高止山脈 Agasthyamalai 生物圈保護區苔蘚植物之研究

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摘要：本研究乃建立 Agasthyamalai 的生物圈保護區的苔蘚植物誌。此份名錄共記錄了 90 個分類群，其中 58 個苔類分類群，以及 32 個蘚類分類群，而為印度半島的新記錄的分類群有 16 個，另外有 6 個喀拉拉邦 (Kerala State) 的新記錄種。

關鍵詞：苔蘚植物誌、Agasthyamalai 的生物圈保護區、西高止山脈、印度。

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