

## Bryophyte diversity of Kakkavayal Reserve Forest in the Western Ghats of India

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**Abstract:** An account of 40 species of bryophytes including 24 mosses and 16 liverworts of Kakkavayal Reserve forest in the Western Ghats is provided here. This includes four new records of phytogeographical significance to Kerala viz., *Cololejeunea appressa* (Evans) Benedix, *C. follicola* Srivastava & Srivastava, *C. udarii* Asthana & Srivastava and *Pallavicinia himalayensis* Schiffn.

**Keywords:** Bryophytes, Mosses, Liverworts, Kakkavayal Reserve forest, Western Ghats, Kerala, India

### Introduction

The Kakkavayal Reserve Forest in the Western Ghats of Calicut (Kozhikode) district of Kerala is a left-over forest patch, now recovered to a great extent from the heavy habitat degradation due to over exploitation of the recent past. It now lies amidst the human habitations, cultivated fields and plantations, however, support good assemblage of flora and fauna (Plate 1). More than 290 species of angiosperms, which include 117 trees species, 51 shrubby members, 66 climber species, 58 herbaceous elements, 14 grass species, seven sedge species and two orchid species are known to occur in this small forest patch of 111 ha. Among these 59 species are endemic to the Southern Western Ghats (Augustine *et al.*, 2010). It is equally rich in supporting populations of Gymnosperm (1 species) and Pteridophytes (26 species). The area also supports rich assemblages of Butterflies (158 species with 7 endemics), Dragonflies (27 species), Damselflies (16 species), Fishes (14 species with 5 endemics), Amphibians (15 species with 8 endemics), Reptiles (27 species), Birds (106 species) and Mammals (30 species). The presence of rare animals such as Slender Loris (*Loris tardigradus*), Pangolin (*Manis crassicaudata*), King Cobra (*Ophiophagus hannah*), Indian Cobra (*Naja naja*), Common Krait (*Bungarus caeruleus*), the Russell's Viper (*Vipera russelli*), etc also enhances the conservation potential of the area.

The present paper is an account of the bryophytic exploration conducted in this unique patch of Reserve Forest of the Western Ghats of Calicut (Kozhikode) district of Kerala.

### Study area

Kakkavayal and the adjoining forests constitute an integral part of the Western Ghats, the well known biodiversity 'hot spot' of the country endowed with diverse habitats harbouring rich diversity of species, and as well a geographic tract that is, characteristically, unique by virtue of its geomorphologic and biogeographic antiquity and evolution.

This area lies in the catchments of Chaliyar river, one of the major rivers in northern Kerala. These forests were under private possession prior to 1971. During that period, hectic activities took place in the entire accessible reaches, for timber and other forest produces. These factors along with continued biotic interferences have ultimately caused depletion of luxuriant and diverse tropical evergreen forests from these areas, leaving forests only on the steep slopes as a narrow strip. Now secondary growth has established in most of the area due to the protection given by the Kerala Forest Department, after it came into the possession and ownership of the Government of Kerala.

### Checklist of Bryophytes of Kakkavayal Reserve Forest

The Bryophytes of Kakkavayal Reserve Forest are enumerated based on the classification scheme of Stotler *et al.* (2008). After the scientific name with citation follows the microhabitat, distribution and specimen examined. The new records of the species are given as notes. All the bryophyte specimens collected are deposited in the Herbarium of Zamorin's Guruvayurappan College (ZGC) and the Malabar Botanical Garden (MBG).

#### Marchantiophyta (Liverworts)

##### Pallaviciniaceae Migula

*Pallavicinia himalayensis* Schiffn., Kais. Alad. Wien LXVII p. 183. On land cuttings and rocky patches in moist areas; in India this species is distributed in Kerala, Meghalaya and Tamil Nadu; Kakkavayal Reserve Forest (100 m), *Jitha, Manju & Rajesh 1184, 1164, 1178, 1180* (ZGC).

Note: The present collection is a new record of occurrence for Kerala (Plate 2 A-B).

##### Aneuraceae Klinggr.

*Riccardia multifida* (L.) S.F.Gray, Nat. Arr. Brit. Pl. 1:684.1821; On rocks in moist deciduous forest; in India the species is distributed in Kerala and Tamil Nadu; also extends to Sri Lanka, China, North America, Europe, Alaska and Hawaii; Kakkavayal Reserve Forest (100 m), *Jitha, Manju & Rajesh 1182, 1192, 1063, 1183, 1184* (ZGC).

*Riccardia tenuicostata* Schiffn., Denskschr. Math. Nat. Cl. Kais. Akad. Wiss. Wien. 67: 166. 1898; On moist rocks and on exposed roots of higher plants and on fern rhizomes in semi shaded areas of moist deciduous and semi-evergreen forests. In India this species is distributed in South India (Kerala, Tamil Nadu; Kodaikanal) and North India (Darjeeling, Western Himalayas); Kakkavayal (100 m), *Jitha, Manju & Rajesh 1164, 1067, 1195, 1199* (ZGC).

*Riccardia villosa* (Steph.) Pande & Srivast., J. Indian Bot. Soc. 37(3): 417. 1958; Thallus grows generally on soil covered rocks near stream or on land cuttings near stream. In India the species is distributed in South India (Kerala, Tamil Nadu) and North India (Eastern Himalayas, West Khasi Hills); Kakkavayal (100 m), *Jitha, Manju & Rajesh 1064* (ZGC).

##### Geocalycaceae H. Klinggr

*Heteroscyphus hyalinus* (Steph.) Srivast. & Srivast., Indian Geocalycaceae (Hepat.), 79. 2002; Plants grow as epiphytic and on rocks near stream; In India this species is distributed in Eastern Himalaya, Meghalaya, Tamil Nadu and Kerala; Kakkavayal RF (100 m), *Jitha, Manju & Rajesh 1181* (ZGC).

##### Lejeuneaceae Casares-Gil.

*Cheilolejeunea intertexta* (Lindenb.) Steph., Bull. Herb. Boiss 5: 79.1897; On tree trunk and on branches; In India this species is distributed in Eastern Himalayas, Meghalaya, East Khasi hills,

Kerala, Tamil Nadu, Andaman and Nicobar Islands; Also distributed in Sri Lanka, Sumatra, Philippines, Malaya, Nigeria and Tanzania; Kakkavayal Reserve Forest (100 m), *Jitha, Manju & Rajesh 1175 b* (ZGC).

*Cheilolejeunea serpentina* (Mitt.) Mizut., J. Hattori Bot. Lab. 26 : 171. 1963; On tree bark and on branches; In India this species is distributed in Eastern Himalaya, Kerala and Tamil Nadu; Kakkavayal Reserve Forest (100 m), *Jitha, Manju & Rajesh 1077, 1187, 1076a, 1071a* (ZGC)

*Cololejeunea appressa* (Evans) Benedix, Fedds Repert. Beih. 134: 31, 1953; Follicolous and Corticolous; in India this species is distributed in Kerala, Tamil Nadu, Karnataka, Meghalaya, Andaman Islands and West Bengal; also distributed in Jamaica, Tropical America, Africa and other Asian countries; Kakkavayal Reserve Forest (100 m) *Jitha, Manju & Rajesh 395, 396* (ZGC).

Note: The present collection is a new record of occurrence for Kerala (Plate 2 C-E).

*Cololejeunea follicola* Srivast. & Srivast., Proc. Indian Acad. Sci. 99(2): 86. 1989; Follicolous; in India it is distributed in Karnataka, Kerala and Tamil Nadu; Kakkavayal Reserve Forest (100 m), *Jitha, Manju & Rajesh 391, 398, 392* (ZGC).

Note: This species was described by Srivastava and Srivastava (1989) from Karnataka and is an endemic to Karnataka State. The present collection is a record of its extended distribution to Kerala State (Plate 2 F-H).

*Cololejeunea furcibulata* (Berrie & Jones) Schust., Nova Hedwig. Beih. 9: 178. 1963; Corticolous, Follicolous and Rupicolous; in India this species is distributed in Kerala and Karnataka. Also distributed in Nigeria, Tanzania and Madagascar; Kakkavayal Reserve Forest (100 m), *Jitha, Manju & Rajesh 1058* (ZGC).

*Cololejeunea latilobula* (Herzog) Tixier, Bryophyte. Biblioth. 27:156. 1985; It is a widely distributed evergreen Follicolous species distributed in India (Kerala, Tamil Nadu, Karnataka, Madhya Pradesh, Manipur and Meghalaya), also extends its distribution to China, Myanmar, Vietnam and Nigeria; Kakkavayal Reserve Forest (100 m), *Jitha, Manju & Rajesh 394* (ZGC).

*Cololejeunea lanciloba* Steph., Nova Hedwig. 34: 250. 1895; Follicolous and Corticolous; in India this species is distributed in Kerala and Tamil Nadu, also extends to Japan, China, Philippines, Malaya, Bangladesh and Australia; Kakkavayal Reserve Forest (100 m), *Jitha, Manju & Rajesh 917, 918* (ZGC).

*Cololejeunea planissima* (Mitt.) Mizut., J. Hattori, Bot. Lab. 24: 189; Plants grow epiphytically on bark and on leaves; in India this species is distributed in Kerala, Tamil Nadu, Eastern Himalayas and Meghalaya; Kakkavayal Reserve Forest (100 m), *Jitha, Manju & Rajesh 390, 397* (ZGC).

*Cololejeunea udarii* Asthana & Srivast., Indian Cololejeunea 40. 2003; Follicolous and Corticolous; in India this species is distributed in Kerala, Karnataka, Tamil Nadu, Arunachal Pradesh, Assam; Kakkavayal Reserve Forest (100 m), *Jitha, Manju & Rajesh 389, 400* (ZGC).

Note: The present collection is a new record of occurrence of this Indian Endemic species from Kerala (Plate 2 I).

*Lejeunea cocoes* Mitt., J. Proc. Linn. Soc. (London) 5: 114. 1861; Corticolous and on small branches; in India this species was earlier recorded from Kerala and Eastern Himalayas, also distributed in Sri Lanka and Java; Kakkavayal Reserve Forest (100 m), *Jitha, Manju & Rajesh 1069b, 1071b*; Pannikottoor Reserve Forest (60m), *Leena 723/l, 10b*, (ZGC, CALI).

Note: This species was earlier collected from the Peruvannamuzhi area of Kozhikode district. Leena *et al.* (communicated) reported the occurrence of this species from to Peninsular India.

*Leptolejeunea follicola* Steph., Hedwigia 106. 1896; Follicolous; in India it is distributed in Kerala and Tamil Nadu. Also distributed in Japan, Java and Philippines; Kakkavayal (100 m), *Jitha, Manju & Rajesh 393* (ZGC).

### **Bryophyta (Mosses)**

**Fissidentaceae** *Fissidens diversifolius* Mitt., Musc. Ind. Or. 140. 1859; common in soil with sand or clay, rocks and stones; it was earlier recorded from Peninsular India (Kerala,

Karnataka: Mysore, Tamil Nadu: Palni hills, Nilgiri hills), Central India (Madhya Pradesh, Orissa), and North east India (Assam, Arunachal Pradesh, Bengal, Bihar, Chhotanagpur); Kakkavayal (100 m), *Reshma, Manju & Rajesh 1072*, (ZGC).

*Fissidens intromarginatulus* Bartr., Rev. Bryol. Lichen, 23: 242. 1954; on moist soil and rocks; South India (Kerala, Tamil Nadu, Karnataka), North East India (Darjeeling, Orissa), Nepal, Western Himalaya and Myanmar; Kakkavayal (100 m), *Reshma, Manju & Rajesh 1186* (ZGC).

*Fissidens pulchellus* Mitt. In Musc. Ind. Or.: 140. 1859; on moist soil near stream side; India: South India (Kerala, Tamil Nadu), North East India (Assam); Kakkavayal (100 m), *Reshma, Manju & Rajesh 1185* (ZGC).

*Fissidens polysetulus* C.Mueller, Gen. Musc. Fr.: 63. 1900; on soil and land cuttings; South India (Kerala, Tamil Nadu), North East India (Darjeeling, Sikkim), Nepal and Thailand; Kakkavayal (100 m), *Reshma, Manju & Rajesh 1165e* (ZGC).

*Fissidens serratus* C. Mueller, [Bot. Zeitung \(Berlin\)](#) 5: 804. 1847; this species frequently occur as dense mats on soil, rock, tree trunks, etc.; South India (Kerala; Tamil Nadu: Madras, Tirunelvely, Nilgiri; Karnataka: Coorg; Maharashtra: Bombay), East Nepal, Darjeeling, Bihar, Chhotanagpur, Orissa, Andaman Islands, Sri Lanka, Myanmar and Thailand; Kakkavayal (100 m), *Reshma, Manju & Rajesh 1193, 1042, 1196 a* (ZGC).

#### **Leucobryaceae** Schimp.

*Leucophanes albescens* C.Muell., Bot. Zeit., 22: 347. 1864; on logs; it is an Indo-pacific species distributed in South India (Kerala, Nicobar Islands), North east India, Thailand, Borneo and Philippines; Kakkavayal (100 m), *Reshma, Manju & Rajesh 1194* (ZGC).

*Octoblepharum albidum* Hedw., Sp. Musc. 50. 1801; On logs Widely distributed species; Kakkavayal (100 m) *Reshma, Manju & Rajesh 1167* (ZGC).

#### **Calymperaceae** Kindb.

*Calymperes afzelii* Sw., Jahrb. Gewachsk. 1: 3. 1818; commonly occurs on shaded tree trunks and logs including rotting stumps and fern rhizomes in moist deciduous forests; It is a common species in the study area. This species is distributed in South India (Goa, Kerala, Tamil Nadu), Sri Lanka and China; Kakkavayal (100 m), *Reshma, Manju & Rajesh 1076 b* (ZGC).

*Calymperes andamense* Besch., Ann. Sci. Nat. Bot. Ser. 8, 1: 272. 276. 1895; Epiphytic, found on dried twig; South India (Kerala), Andaman Islands; Kakkavayal (100 m), *Reshma, Manju & Rajesh 1055* (ZGC).

*Calymperes erosum* C.Muell., Linnaea 21: 182. 1848; Epiphytic and also on logs and as epiphylls; it is a common species distributed in South India (Goa, Kerala, Tamil Nadu), Sri Lanka, Myanmar, China, Africa and America; Kakkavayal (100 m), *Reshma, Manju & Rajesh 1062, 1175 (a)* (ZGC).

*Calymperes hampei* Dozy & Molk., Bryol. Jav., 1: 48. 1856; Occurs on tree trunks and logs; It is distributed in South India (Kerala), Myanmar, Sumatra, Java, Borneo, Timor, etc. It is an Indo-malesian species; Kakkavayal (100 m), *Reshma, Manju & Rajesh 1073* (ZGC).

*Calymperes vriesei* Besch., Ann. Sci. Nat. Bot. Ser. 8, 1: 268, 307. 1895; Epiphytic, found on twigs; South India (Kerala), Upper Assam, Java, Celebes, Samoa. It is an Indo-pacific species; Kakkavayal (100 m), *Reshma, Manju & Rajesh 1075, 1163* (ZGC).

#### **Pottiaceae** Schimp.

*Hyophila involuta* (Hook.) A.Jaeger, Ber. Senckenburg. Naturf. Ges. 1871-72: 356. 1873; It is seen in a variety of habitats such as on soil, logs, rocks, etc.; It was earlier recorded from Peninsular India (Kerala, Tamil Nadu, Karnataka and Gujarat), Central India (Madhya Pradesh, Orissa), North East India (Assam, Arunachal Pradesh, Bengal, Bihar, Chhota Nagpur, Darjeeling, Western Himalayas); Kakkavayal (100 m), *Reshma, Manju & Rajesh 1080* (ZGC).

#### **Bryaceae** Schwaegr

*Brym cellulare* Hook., Sp. Musc. Suppl. 3 (1): 214. 1827; On land cuttings along with other mosses; a wide spread species distributed in South India (Kerala, Tamil Nadu), North India

(Western Himalayas), Myanmar, China, Japan, Sumatra, Java, Philippines, Taiwan, Europe, North & Central Africa and Australia; Kakkavayal (90 m), *Reshma, Manju & Rajesh 1065* (ZGC)

**Hookeriaceae** Schimp.

*Distichophyllum schmidtii* Broth., Bot. Tidskar. 24: 122. 1901; epiphytic on base of trunk as well as on logs; it is reported as distributed in South India (Kerala), Bangladesh, Thailand etc. It is a South east Asiatic species; Kakkavayal (100 m), *Reshma, Manju & Rajesh 1198, 1176, 1068, 1190* (ZGC).

**Plagiotheciaceae** (Broth.) M. Fleisch.

*Entodontopsis nitens* (Mitt.) W.R.Buck & R.R. Ireland, Nova Hedwigia 41: 104. 1985; on logs in semi-evergreen forest; South India (Tamil Nadu, Kerala), North east India (Darjeeling, Assam, Khasi hills, Orissa), Nepal, Thailand, Philippines and the Pacific Ocean islands; Kakkavayal (100 m), *Reshma, Manju & Rajesh 1043, 1196 b* (ZGC).

**Hypnaceae** Schimp.

*Isopterygium albescens* (Hook.) A.Jaeger, Ber. S. Gall. Naturw. Ges. 1876-77: 433. 1878; On bark of trees; common in the study area. It was earlier recorded from South India (Kerala, Tamil Nadu), North East India (Khasi hills), Sri Lanka, Myanmar, Thailand, Vietnam, Singapore, Philippines, Japan and New Zealand; Kakkavayal (100 m), *Reshma, Manju & Rajesh 1053, 1161, 1172* (ZGC).

*Isopterygium minutirameum* (C.Mueller) Jaeger, Ber. S. Gall. Naturw. Ges. 1876-77: 434. 1878; on bark of trees; South India (Kerala, Tamil Nadu), Thailand, Sri Lanka and Myanmar; Kakkavayal (100 m), *Reshma, Manju & Rajesh 1074, 1078* (ZGC).

*Isopterygium lignicola* (Mitt.) Jaeger, Ber. S. Gall. Naturw. Ges., 1876-77: 432. 1878; on bark of trees; South India (Kerala, Tamil Nadu), North East India (Sikkim, Khasia hills), Sri Lanka and Myanmar; Kakkavayal (100 m), *Reshma, Manju & Rajesh 1201*, (ZGC).

*Vesicularia levieri* Card. in Dix., J. Indian Bot. 2: 187. 10. 1921; on rocks in semi-evergreen and evergreen forests; South India (Kerala), North East India, Andaman Islands. This species is endemic to India; Kakkavayal (100 m), *Reshma, Manju & Rajesh 1179, 1169, 1170, 1171* (ZGC).

**Sematophyllaceae** Broth.

*Sematophyllum subhumile* (C. Muell.) Fleisch., Musci Fl. Buitenz. 4: 1264, 205. 1923; on trunk and branches of trees; It has earlier reported from Kerala, Tamil Nadu (Nilgiris and Palni), Assam, Myanmar, Thailand and Java; Kakkavayal (100 m), *Reshma, Manju & Rajesh 1057* (ZGC).

*Taxithelium nepalense* (Schwaerg.) Broth. in Monsunia 1: 51. 1899; Epiphytic on twigs and trunk; South India (Kerala, Karnataka, Tamil Nadu), North East India (Assam, Orissa, Nepal), Thailand, Africa and Java; Kakkavayal (100 m), *Reshma, Manju & Rajesh 1059, 1079, 1174, 1069 (a)* (ZGC).

*Clastobryopsis muelleri* (Dix.) Tix. in Rev. Bryol. Lichenol, 43: 413. 1977; Epiphytic, found on tree bark; South India (Kerala, Tamil Nadu), North East India (Darjeeling, Assam), Nepal, Philippines; Kakkavayal (100 m), *Reshma, Manju & Rajesh 1162* (ZGC).

*Acroporium stramineum* (Reinw. & Hornsch.) M. Fleisch., Musci Buitenzorg 4: 1301. 1923; on logs in semi evergreen forests; found very rare in the study area; Kakkavayal (100 m), *Reshma, Manju & Rajesh 1061 (b)* (ZGC).

**Discussion**

The critical study of about 120 specimens of bryophytes collected from the Kakkavayal Reserve Forest yielded 40 species of mosses and liverworts growing in different microhabitats. Among the 40 species 24 are mosses and 16 species are liverworts. Among the 40 species four species viz., *Cololejeunea appressa* (Evans) Benedix, *Cololejeunea follicola* Srivastava & Srivastava, *Cololejeunea udarii* Asthana & Srivastava and *Pallavicinia himalayensis* Schifffn. are new records for Kerala. *Cololejeunea udarii* described by Asthana and Udar (2003) from Karnataka could be collected from the present locality and it is an Indian endemic species. *Cololejeunea follicola* was described by Srivastava and Srivastava (1989) from Karnataka and it is

described as endemic to Karnataka. The present collection from Kakkavayal extends its distribution to Kerala as new record of occurrence. Among the 40 species distributed under different families, Lejeuneaceae and Sematophyllaceae are the most widely distributed family with 4 genera. Of which the genus viz., *Cololejeunea* represents seven species and *Fissidens* represents four species respectively.

Moss taxa are represented by 15 acrocarpic and 10 pleurocarpic species. The members of the family Sematophyllaceae are pleurocarpic and prefer to grow on bark, which is mostly appressed to the substratum. The acrocarpic mosses such as species of *Calymperes* grows mostly on bark but some species prefer to grow on logs, rocks and on small branches. *Hyophila* prefer to grow on land cuttings, on logs and on small rocks. *Leucophanes* generally grows on logs, in the present study area also this genus is found on logs. The genus *Vesicularia* is mostly aquatic, in the present area also the species *V. levieri* prefer to grow on rocks on streams which is submerged.

Among the 18 species of liverworts the members of the family Lejeunaceae prefer to grow on bark, on leaf surface and on small branches. Generally the genus *Cololejeunea* prefers to grow as foliicolous. In the present study area also all the seven species collected were prefer their microhabitats as leaves. Some species such as *C. appressa*, *C. furcibulata*, *C. udarii*, *C. planissima* and *C. lanciloba* grows on leaves as well as on bark. *C. furcibulata* prefer to grow on rocks also. Except for *C. furcibulata* no other species is found on rocks. One viz., *Lejeunea* sp. is found on logs.

The area has not been subjected to bryophytic explorations earlier. The study indicates the biological richness of this area. The presence of large number of trees and shrubs of this area support rich growth of epiphytic species. The leaves of plants growing near the riverine area have greater light availability and which shows rich growth of foliicolous species. Rocks also provided support for bryophytes, but in rocks mosses are the predominant species.

The present collection from a small area yielded 40 species, which also indicates the effectiveness of intensive exploration. This is the first study on the Bryophytes of Kakkavayal Reserve Forest and the present work is also relevant as it contains some contribution towards the better documentation of the bryowealth of the nation.

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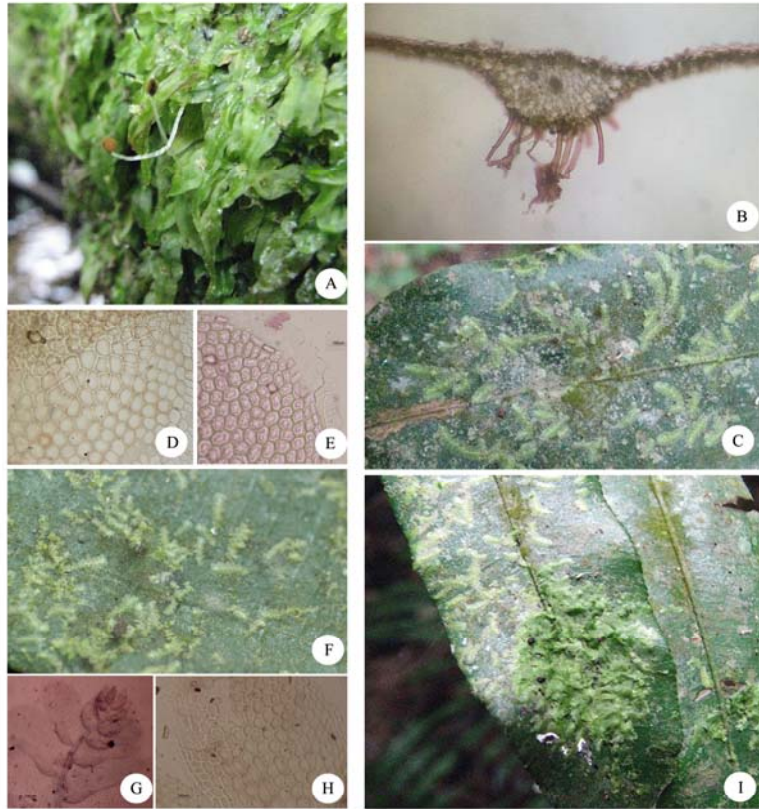


Plate-2 A-B. *Pallavicinia himalayensis*, C-E. *Cololejeunea appressa*, F-H. *C. follicola*, I. *C. udarii*