

observed results, it is strongly suggested that simple dust masks need to be used as a preventive measure in construction work. If the concentration level crosses the upper safety limit of 6.0 mg/m^3 , simple mask protection might not help reduce exposure sufficiently. The combined use of dust masks with filters can reduce exposures to acceptable levels.

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Eastern Ghats' biodiversity reserves with unexplored lichen wealth

The Eastern Ghats (EG) is a discontinuous range of mountain situated along eastern coast of India (Figure 1). It stretches from Mahanadi Basin in the north to Nilgiri Hills in the south, covering a distance of 1700 km and spreading over an area of 75,000 sq. km. The average elevation of the mountain range is about 600 m and the highest peak is Shevaroy Hills that reaches up to a height of 1700 m. EG supports a rich array of tropical forests including pockets of moist deciduous, evergreen and semi-evergreen forests. About 2600 angiosperms, gymnosperms, pteridophytes and 160 cultivated plants are known from EG¹, which also includes over 530 tree species, 1800 medicinal and 450 endemic plants². The biodiversity richness in the region can be illustrated with an example from six hill complexes of the southern EG wherein 143 lianas and 272 tree species are reported^{3,4}. The EG is home to several unique taxa such as *Shorea roxburghii* G. Don (*S. talura* Roxb.), *S. tumbagaia* Roxb., *Pterocarpus santalinus* L. f. (red sanders), *Cycas beddomei* Dyer and some wild varieties of rice (*Oryza granulata* Nees & Arn., *O. sativa* Thw. and *O. malampuzhaensis* Krish. & Chand.)^{5,6}. EG is also a region for discoveries of taxonomic novelties; for example *Corallodiscus* Batalin, a new generic record of plant and *Phallus industius* Vent. & Pers., a new generic record under fungus are reported from Odisha^{7,8}; *Clarkeinda trachodes* (Berk.)

Singer, a rare tropical Asian monotypic mushroom was recorded from Tamil Nadu (TN)⁹. Apart from plants, Rao and Krishna¹⁰ recently discovered two species of spider and one each species of scorpion and mantis from the Nallamala Hills.

EG contributes significantly to both species richness and endemicity of the Indian region. However, the forests of EG are relatively under-studied and have

received less attention for conservation compared to the relatively better-known Western Ghats^{3,11}. Ultimately EG is left with insufficient data for several groups of organisms. This is one of the reasons that phytogeographers were forced to merge EG with the Deccan Plateau and call it the Deccan peninsular biogeographic zone¹². The data deficiency is prominent in the case of cryptogams, especially lichens. Singh and Sinha¹³

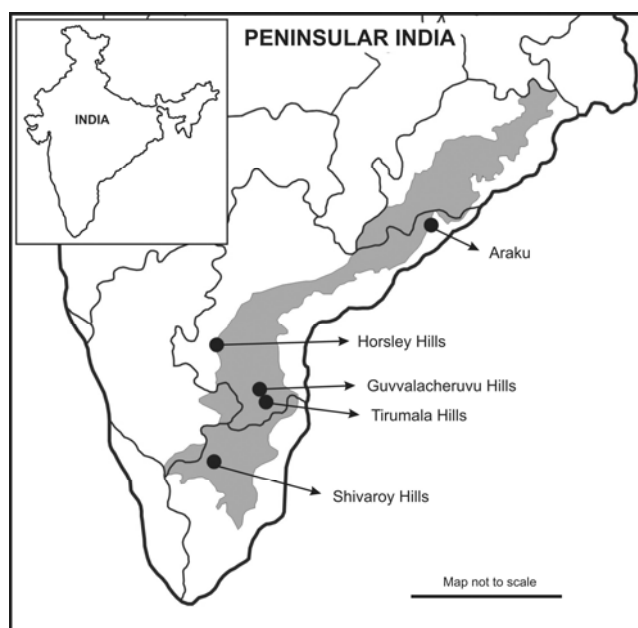


Figure 1. Schematic presentation of Eastern Ghats and some important localities surveyed for lichen collection in the present study.

Table 1. List of lichens as new records for Andhra Pradesh

Lichen	Distribution
<i>Bulbothrix isidiza</i> (Nyl.) Hale	Horsley Hills, Tirumala Hills
<i>Caloplaca cinnabarina</i> (Ach.) Zahlbr.	Tirumala Hills
<i>Collema nigrescens</i> (Huds.) DC.	Horsley Hills
<i>Cryptothecia subnidulans</i> Stirton	Araku (Visakhapatnam)
<i>Dirinaria applanata</i> (Fée) D.D. Awasthi	Talakona (Chittoor)
<i>Heterodermia dissecta</i> (Kurok.) D.D. Awasthi	Tirumala Hills
<i>H. hypocaesia</i> (Yasuda) D.D. Awasthi	Araku (Visakhapatnam)
<i>H. speciosa</i> (Wulf.) Trevis.	Tirumala Hills
<i>Lecanora achroa</i> Nyl.	Tirumala Hills
<i>Parmelia sulcata</i> Taylor	Horsley Hills
<i>Parmelinella wallichiana</i> (Taylor) Elix & Hale	Tirumala Hills, Horsley Hills, Talakona (Chittoor)
<i>Parmotrema austrosinense</i> (Zahlbr.) Hale	Tirumala Hills, Horsley Hills
<i>P. crinitoides</i> J.C. Wei	Tirumala Hills
<i>P. defectum</i> (Hale) Hale	Tirumala Hills, Talakona (Chittoor)
<i>P. grayanum</i> (Hue) Hale	Tirumala Hills, Horsley Hills
<i>P. indicum</i> Hale	Araku (Visakhapatnam)
<i>P. nilgherrense</i> (Nyl.) Hale	Tirumala Hills, Horsley Hills, Guvvala Cheruvu Hills
<i>P. stuppeum</i> (Taylor) Hale	Tirumala Hills, Horsley Hills
<i>P. subtinctorium</i> (Zahlbr.) Hale	Araku (Visakhapatnam)
<i>Peltula farinosa</i> Büdel*	Horsley Hills
<i>Pertusaria leucosora</i> Nyl.	Horsley Hills
<i>Pyxine petricola</i> Nyl.	Sundupalli (Kadapa)
<i>P. subcinerea</i> Stirt.	Horsley Hills
<i>Phaeophyscia hispidula</i> (Ach.) Moberg	Horsley Hills
<i>Roccella belangeriana</i> D.D. Awasthi	Horsley Hills
<i>Xanthoparmelia pseudocoogensis</i> Hale	Talakona (Chittoor)

*New record for India.

divided India into eight lichenogeographic regions and merged EG with the Deccan Plateau from where only 31 lichen species under 23 genera were known at that time. It is also true that localities for many lichens collected from EG before 1950s by European lichenologists, botanists and naturalists are annotated as 'South India' and hence their exact locality is untraceable, which adds to data-deficient quotient. There has been a lot of exploration in EG and Deccan Plateau in recent times. For example, 32 species of lichens are reported from Bangalore city¹⁴, 118 species from Shevaroy Hills¹⁵, 50 lichen species from Chennai area, including Guindy National Park^{16,17} and 48 species from Kolli Hills¹⁸. Reddy *et al.*¹⁹ listed 43 lichen taxa from Andhra Pradesh (AP), which included 12 new records for the state. At the same time Manoharachary *et al.*²⁰ reported 48 species of lichens from various parts of AP. However, their study included several temperate or alpine species and their occurrence in the tropical EG is doubtful. Recently, there was a report on biodiversity assessment of a few hills in south Odisha and 13 lichen species were reported from the region²¹. Here again the identity of lichens is erro-

neous or doubtful. The above-mentioned studies over a period of 15 years accumulated more than 180 lichen taxa for the region 'Eastern Ghats and Deccan Plateau', which is a clear indication of both lichen richness in the area as well as inadequate exploration. Keeping this in view, thorough lichen exploration in the EG has been initiated in AP and TN.

Yogi Vemana University (Kadapa) in collaboration with CSIR-National Botanical Research Institute (Lucknow) has initiated documentation of lichens in the state. For this purpose a systematic exploration of lichens was carried out in Rayalaseema and neighbouring localities, and a large number of lichen samples were collected which resulted in many interesting taxa, either new to science or new records for India. The identification of interesting specimens is still in progress. Meanwhile, a total of 26 new records for AP and a new record for India (*Peltula farinosa* Büdel) are reported here (Table 1). These species are mostly macrolichens (foliose and fruticose) belonging to families Parmeliaceae (12 spp.) and Physciaceae (6 spp.). The Parmelioid lichens are more common in the hilly area and are often represented by *Parmotrema austrosinense*, *Parmotrema*

grayanum, *Parmotrema nilgherrense* and *Parmelinella wallichiana*.

The species of genus *Peltula* are squamulose cyanolichens represented by six species in India and are found growing mostly on rocks and on lime plasters of monuments in North India^{22,23}. Recently, Khare *et al.*²⁴ reported *P. corticola* Büdel and R. Sant., a bark inhabiting species of the genus from Madhya Pradesh and Uttar Pradesh as a new record for India. *P. farinosa* is a further addition to the genus characterized by strikingly grey colour and pruinose thallus, undulating and sorediate margins, and orange to orange-brown lower surface (Figure 2). It closely resembles *P. euploca* (Ach.) Poelt., which also has sorediate thallus but differs in having olive-brown to brownish upper side and brown to reddish-black lower surface. The squamules in *P. farinosa* are circular to irregular in shape and range from 1.5 to 10 mm in size. Most of the *Peltula* species have *Anacystis* as their cyanobiont, but in *P. farinosa* it may be *Chroococcidiopsis* or *Myxosarcina*²⁵. *P. farinosa* has both tropical and temperate distribution earlier recorded from South Africa, North America and the Himalayan part of Pakistan. In AP, the species has been

collected from Horsley Hill at an altitude of 1200 m and it was found growing luxuriantly on rock slopes. By the addition of 26 species the list of lichens for AP has grown up to 69 species.

Among all the states, TN records the maximum number of lichens with 785 taxa. It can be noted that a major portion of the Western Ghats passes through TN and includes lichen-rich areas such as Nilgiri and Palni Hills. In addition, the state also encompasses considerably large portion of EG, which is again well represented by lichens. Out of total lichens known from TN, about 150 belong to EG and Deccan Plateau region¹³. The Shevaroy Hills (also called as 'Shervarayan Hills') is one of the biodiversity-rich areas in the state, which is a westward extension of EG and lies close to the Western Ghats. Sometimes Yercaud, a hill station located near Salem town, is referred to as the crown of Shevaroy Hills. A major part of the hills (49.5%) is occupied by forests followed by villages (38.12%) and forest plantations (12.37%)²⁶, which harbour 80 species of trees and lianas²⁷.

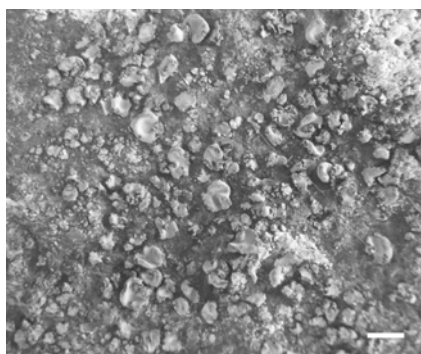


Figure 2. *Peltula farinosa* Büdel, a new record for India (scale bar = 10 mm).

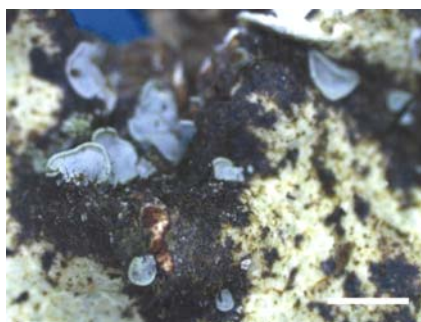


Figure 3. *Normandina pulchella* (Borrer) Nyl., growing on *Parmelinella wallichiana* (Taylor) Elix & Hale (scale bar = 2 mm).

Hariharan *et al.*¹⁵ intensively collected lichens from various altitudes and across the entire width of Shevaroy Hills, and reported 118 taxa which actually included 109 well-identified species. Recently, a group of researchers from K. S. Rangasamy College of Technology, Tiruchengode visited Yercaud area of Shevaroy Hills and collected a total of about 80 lichen samples, which resulted in 65 species. It is interesting to note that even after meticulous exploration by Hariharan *et al.*¹⁵, a total of 40 species are added as new to Shevaroy Hills. The study also added 15 taxa as new to lichen flora of TN (Table 2). The new additions almost equally represented both micro and macrolichens. An interesting specimen collected from Yercaud is *Normandina pulchella* (Borrer) Nyl. (Figure 3). Re-

cently, this species has been reported as a new record for India from the Nilgiri Biosphere Reserve part of TN²⁸. It is cosmopolitan in distribution and usually a free-living species, but in Yercaud it is found growing on the thallus of lichen *P. wallichiana* (Taylor) Elix & Hale, at an altitude of 1500 m.

Recently, Nayaka *et al.*²⁹ described two new species of *Pyxine* having saxicolous habitat and yellow medulla from southern India. One of the new species (*Pyxine* sp. 1; 12-017394 LWG) was described out of the Yercaud collection mentioned above (Figure 4a). It was growing luxuriantly on rocks on the way to Yercaud from Salem at an altitude of 500 m. It is characterized by having yellow medulla, smaller ascospores and lacking vegetative propagules and

Table 2. New addition to the lichen flora of Shevaroy Hills

<i>Anisomeridium tamarindi</i> (Fée) R.C. Harris
<i>Bacidia personata</i> Malme
<i>Buellia ceylonensis</i> Zahlbr.
<i>Buellia indica</i> S.R. Singh & D.D. Awasthi
<i>Buellia lauri-cassiae</i> (Fée) Müll. Arg.*
<i>Bulbothrix isidiza</i> (Nyl.) Hale
<i>Candelaria concolor</i> (Dicks.) Stein*
<i>Canoparmelia crozalsiana</i> (de Lesd.) Elix & Hale*
<i>Diorygma heiroglyphicum</i> (Pers.) Staiger & Kalb*
<i>Diploschistes megalosporus</i> Lumbsch & H. Mayrhofer
<i>Dirinaria applanata</i> (Fée) D.D. Awasthi
<i>Dirinaria confusa</i> D.D. Awasthi*
<i>Graphis assimilis</i> Nyl.*
<i>Graphis brittanica</i> Staiger*
<i>Graphis intermediella</i> Stirt.*
<i>Graphis lineola</i> Ach.
<i>Graphis subserpentina</i> Nyl.*
<i>Heterodermia obscurata</i> (Nyl.) Trevis.
<i>Heterodermia pellucida</i> (D.D. Awasthi) D.D. Awasthi*
<i>Heterodermia togashii</i> (Kurok.) D.D. Awasthi
<i>Hyperphyscia adglutinata</i> (Flörke) H. Mayrhofer & Poelt
<i>Hypotrachyna immaculata</i> (Kurok.) Hale
<i>Lecanora subimmersa</i> (Fée) Vain.
<i>Leptogium austroamericanum</i> (Malme) C.W. Dodge*
<i>Myelochroa entotheiochroa</i> (Hue) Elix & Hale*
<i>Normandina pulchella</i> (Borrer) Nyl.
<i>Opegrapha vulgata</i> (Ach.) Ach.
<i>Parmotrema crinitum</i> (Ach.) M. Choisy
<i>Pertusaria concinna</i> Erichsen
<i>Pertusaria leucosorodes</i> Nyl.
<i>Phaeophyscia hispidula</i> (Ach.) Moberg
<i>Phyllopsora furfuracea</i> (Pers.) Zahlbr.*
<i>Pyxine cocoes</i> (Sw.) Nyl.
<i>Ramalina leiodea</i> (Nyl.) Nyl.
<i>Ramalina nervulosa</i> (Müll. Arg.) Abbayes
<i>Ramalina pacifica</i> Asahina
<i>Sigridea glaucomoides</i> (Nyl.) Tehler*
<i>Thecaria austroindica</i> (D.D. Awasthi & Upreti) Kr.P. Singh & G.P. Sinha*
<i>Usnea perplexans</i> Stirt.*
<i>Usnea thomsonii</i> Stirt.*

*New addition to Tamil Nadu.

lichexanthone. It closely resembles *P. himalayensis* D.D. Awasthi, which is a temperate species reported from Darjeeling Hills and further differs in having corticolous habitat and slightly larger ascospores. The type locality of the other new *Pyxine* species (*Pyxine* sp. 2; 06-005070 LWG) is Pune; however, later it was collected from Horsley Hills in AP (2201 YVU). *Pyxine* sp. 2 is characterized by isidiate thallus with a yellow medulla and UV + cortex. The isidia are nodular to dactylate and do not produce soredia. *Pyxine* sp. 2 is close to *P. physciaeformis* (Malme) Imshaug, a corticolous species, where the dactyls ultimately produce soredia (Figure 4b).

The studies from AP and TN added over 50 lichens to the present flora of EG. The lichen flora of EG is dominated by crustose lichens, but has good representation of foliose lichens too. In comparison to other lichen-deprived regions, the EG has good number of fruticose lichens represented by 22 taxa. Most of the lichens in the EG region are bark-inhabiting, but many also occur on rock and soil. A total of four foliicolous lichens are also reported from this area (*Coenogonium luteum* (Dicks.) Kalb & Lücking, *Porina tetracerae* (Afz.) Müll. Arg., *Strigula nemathora* Mont. and *S. smaragdula* Fr.) which are considered as indicators of healthy forests³⁰. The Pyrenocarpous, Parmelioid and Physcioid lichens are most common in the area. The EG also has about 15 endemic lichen species; however, their conservation status is not clear.

The above studies clearly indicate the lichen richness of EG and the need for intensive lichenological studies at the backdrop of deteriorating forest conditions in the region. A study based on satellite data between 1973 and 2004 in

Odisha revealed the significant environmental consequences, including decline in forest cover, soil erosion and loss of biodiversity, and there is an urgent need for rational management of the remaining forest for it to be able to survive beyond the next decade³¹. Similarly, 13-year satellite data for TN part of EG showed that forests in this region are changing at an alarming rate and these changes have occurred after implementation of a forest conservation act³². The dependence of local people on forests for various purposes is viewed as a key factor for the changes in the forests^{5,32}.

Keeping in view the biodiversity uniqueness and ecological sensitivity in EG, the conservation is gaining prime importance in the region. So far about 14 protected areas (PAs) have been notified by the Indian Government and several new ones are being proposed. However, over the years it is felt that these PAs are ineffective and more realistic and effective forest management strategies are needed for conservation. Balaguru *et al.*³³ identified several biodiversity conservation priority zones in EG based on species richness, levels of endemism and concentration of Red Listed plants. Babar *et al.*³⁴ used ecological niche modelling with an example of *P. santalinus* for predicting potential areas of occurrence of endemic and endangered plants. The traditional conservation system involving sacred groves prevails in EG since time immemorial. Hundreds of such forests are distributed throughout the region and AP alone harbours over 500 sacred groves which are better managed than the other PAs³⁵. For effective conservation and sustainable management of biodiversity, accurate estimation of forest condition through field assessments, remote sensing and understanding

the socio-economic variables associated with forest loss and degradation are needed³⁶. At this point the lichens can play an important role either directly or as surrogates for the application of conservation strategies. Lichens are more sensitive to threats like climate change and air pollution³⁷. They are better known as bioindicators and utilized as biomonitors of air pollution, environmental changes, ecological continuity of a forest, anthropogenic disturbances, etc. Lichens are ubiquitous; they grow on rock, soil, tree trunks, twigs, leaves and are a convenient system for quantitative study. Studies have shown that lichen families like Thelotremaaceae can be effective bioindicators of ecological continuity and undisturbed tropical forests³⁸. The changes in species richness, abundance, distribution and the ecological preferences of lichens due to climate change or global warming have been noted in several studies³⁹⁻⁴¹. Such studies are helpful in prioritizing areas for conservation and similar studies have to be carried out in EG for better management of the remaining forests. At present generation of baseline data for lichens in EG is of prime importance. While lichens of the AP part of EG are now being explored thoroughly, there are no authentic records of lichens from Odisha and biologically important hills of TN (Bodamalai, Chitteri, Kalrayan, Pachaimalai, Piranmalai).

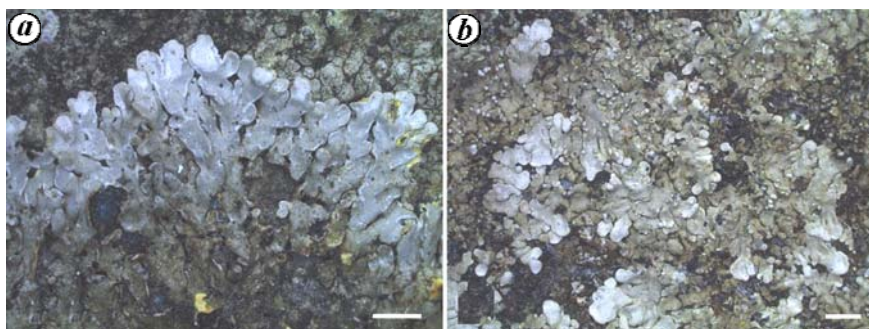


Figure 4. Two new species of saxicolous *Pyxine* with yellow medulla recently described from South India. *a*, *Pyxine* sp. 1 from Yercaud (06-005070 LWG); *b*, *Pyxine* sp. 2 from Horsley Hills (2201 YVU). Scale bar = 1 mm.

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