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Bryodiversity of Eastern Ghats (India)

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ABSTRACT

Eastern Ghats contribute considerably to both species richness and endemicity of the India. However, the forests of Eastern Ghats are comparatively under-studied, under-explored and have received less consideration for conservation compared to the fairly better-known Western Ghats, the hot spot of biodiversity. Eventually, Eastern Ghats is left with inadequate data for several groups of organisms. The data insufficiency is prominent, particularly in the case of cryptogams, especially Bryophytes. In this chapter an attempt has been made to fill this lacuna to some extent by providing an updated checklist of bryophytes of southern most part of Eastern Ghats, comes under Tamil Nadu, based on several published old and recent sporadic reports along with available literature on web sources.

Keywords: Bryophyta, Distribution, Diversity, Eastern Ghats, Tamil Nadu

INTRODUCTION

The Eastern Ghats are sporadic mountain ranges along the east coast of Peninsular India, running parallel to the Bay of Bengal about 1750 km from Odisha through Andhra Pradesh to Tamil Nadu and also transitory in a few parts of Karnataka state. Some perennial rivers originated from the Western Ghats and cut through the Eastern Ghats ranges, particularly Mahanadi, Godavari, Krishna and Kaveri, to end their flow into the Bay of Bengal. The rocks of Eastern Ghats are supposed Gondwana origin and made up of granite gneiss, charnokites, metamorphic gneiss khondalites, and quartzite. Numerous hill ranges and hillocks of Eastern Ghats locally divided into three parts viz. northern Eastern Ghats (mostly

in Odisha and northern Andhra Pradesh), middle Eastern Ghats (Andhra Pradesh) and southern Eastern Ghats (Tamil Nadu). The vegetation of Eastern Ghats typically encompassed with deciduous and scrub forests scattered with grassy open canopies. In this article bryodiversity of Eastern Ghats has been provided.

Characteristics of Eastern Ghats:

Eastern Ghats are older than Western Ghats. The elevation of Eastern Ghats is lower than the Western Ghats. They are located between 11° 30' and 22° N latitude and 76° 50' and 86° 30 E longitude in a North-East to South-West strike. It covers a total area of around 75,000 sq. km. Sirumalai and Karanthamalai hills of Tamil Nadu lies in the southern most part of the Eastern Ghats. North of Kaveri River is higher Kollimalai, Pachaimalai, Shevaroy, Kalrayan Hills, Palamalai and mettur hills in north Tamil Nadu. The average elevation of the mountain range is about 600 m and the utmost peak is Shevaroy Hills that reaches up to a height of 1700 m. Eastern Ghats hold a rich range of tropical forests, including pockets of soggy deciduous, evergreen and semi-evergreen forests (Champion and Seth, 1968).

One of the biggest characteristics of Eastern Ghats lies in its being extremely fertile. In fact, the Ghat is said to be the watershed of many rivers as the Ghat gets higher average waterfall. Due to higher rainfall, the fertile land results in better crops. Often referred as "Estuaries of India", Eastern Ghats gift its inhabitant the popular profession of fisheries as its coastal area is full of fishing opportunity. Like Western Ghats, thus, Eastern Ghats also carry a heap of ecological importance. All these distinctiveness of Eastern Ghats guarantees an exciting bio-physical environments and wealthy biodiversity.

Approximately 2600 angiosperms, gymnosperms, pteridophytes and 160 cultivated plants are known from the Eastern

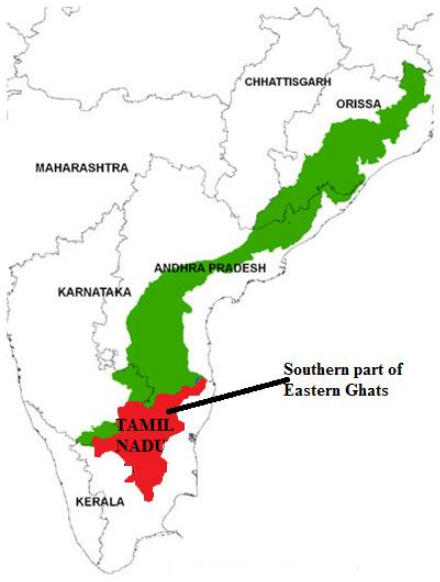


Figure 1: Map of Peninsular India showing expand of Eastern Ghats (graceindia.info)

Ghats (Nayaka, 2013), which also includes over 530 tree species, 1800 medicinal and 450 endemic plants (Jonathan, 2006). The biodiversity wealth in the region can be illustrated with an example from six hill complexes of the southern Eastern Ghats in which 143 lianas and 272 tree species are reported (Muthumperumal, 2010). The forests of Eastern Ghats are relatively under-studied and have received less attention for conservation compared to the relatively better-known Western Ghats (Srinivasalu, 2008). Ultimately Eastern Ghats is left with insufficient data for several groups of organisms. The data deficiency is prominent in the case of cryptogams, especially bryophytes and lichens (Singh and Sinha, 1997).

In case of lichen, progress is notable and recently 26 species of lichens recorded as new for Andhra Pradesh, and 40 species were newly added to the lichen flora of Shevaroy Hills (Nayaka 2013). While, as far as bryophytes are concerned, only sporadic attempts have been made in past (Dash *et al.*, 2007; Dash *et al.* 2009; Alam *et al.*, 2012) but mainly from Odisha part of Eastern Ghats. However, regarding bryophytes considerable and consolidated assessment of bryophytes of all the regions of Eastern Ghats is still desirable.

Bryophytes are one of the important contributors to the global plant diversity by virtue of being pioneers of terrestrial ecosystem. They represent a somewhat heterogeneous assemblage of plants, including liverworts, hornworts, and mosses that impart lush greenery, a verdant cover, spongy bed or carpet in every possible habitat. Irrespective to their small size, they encompass major components of the biomass and photosynthetic production in forest ecosystems (Frego, 2007). Bryophytes are also widely used as metal-accumulator and bio-indicators of environment for their unique morphology and anatomical responses as some species are extremely sensitive to pollutants like lichens and reveal visible symptoms even in the presence of very minute quantities of pollutants (Alam and Srivastava, 2009; Sahu et al., 2007). They have several biological features, making them particularly suited to serve as study organism in macro-evolutionary, population genetics and ecological research. Bryophytes are used in medicines, household purposes, horticulture, agriculture, fuel in industries and as ecological indicators throughout the world (Glime 2006; Nath and Asthana 2005). Bryophytes are the second largest group of plants, with about 25,000 species worldwide (Buck and Goffinet 2000). The plants are distributed in Eastern and Western Himalayas, Southern India (Western and Eastern Ghats) and Central India (Nath and Asthana 2005).

Although in India the work of bryophyte's diversity is on a call and most of the well known regions have been explored such as Eastern Himalayas, Western Himalayas, Nilgiri and Palni hills (South India), and Central India (Singh, V. B. 1966; Singh, D. K. 1997; Srivastava, 1998; Parihar et al., 1994; Alam, 2011; Gangulee, 1969-1980). Now it is critical to explore those areas of the country where exploration regarding bryodiversity is less known such as Eastern Ghats. Work is going on this direction, and several regions of Tamil Nadu come under Eastern Ghats have been explored recently (Alam and Srivastava 2011; Alam *et al*. 2011).

2. MATERIALS AND METHOD

On the basis of few past and recent studies, as an initiative effort, the following checklist of bryophytes of Eastern Ghats has been provided. The checklist is based on almost all available documentation (Gangulee, 1969-1980; Parihar *et al.,* 1994; Lal, 2005; Alam and Srivastava, 2007; Alam, 2011; Alam and Srivastava, 2012; Verma *et al*., 2013).

CHECKLIST OF BRYOPHYTES

BRYOPHYTA (MOSSES)

A. ORDER HYPNALES (M. Fleisch.) W. R. Buck & Vitt.

I. Meteoriaceae Kindb.

a. ***Diaphanodon*** Renauld & Cardot.

1. *Diaphanodon procumbens* (Müll. Hal.) Ren. & Cord.

b. ***Meteorium*** (Brid.) Dozy & Molk.

2. *Meteorium brevirameum* (Müll. Hal.) Broth.

c. ***Aerobryidium*** M. Fleisch

3. *Aerobryidium punctlatum* (Müll. Hal.) Dixon

4. *Aerobryidium filamentosum* (Hook.) M. Fleisch.

II. Entodontaceae Kindb.

d. ***Entodon*** Müll. Hal.

5. *Entodon plicatus* Müll. Hal.

e. ***Erythrodontium*** Hampe

6. *Erythrodontium julaceum* (Schwaegr.) Par.

III. Pterobryaceae Kindb.

f. ***Floribundaria*** M. Fleisch.

7. *Floribundaria floribunda* (Doz. et Molk) M. Fleisch.

g. ***Meteoriopsis*** Broth.

8. *Meteoriopsis squarrosa* (Hook.) M. Fleisch.

h. ***Symphysodon*** Dozy & Molk.

9. *Symphysodon perrottetii* Mont.

IV. Miyabeaceae Enroth *et al.*

i. ***Homaliadelphus*** Dixon & P. de la Varde

10. *Homaliadelphus targionianus* (Mitt.) Dix. &Verd.

V. Neckeraceae Schimp.

j. ***Neckera*** Hedw.

11. *Neckera goughiana* Mitt.

12. *Neckeropsis exserta* (Scwaegr.) Broth.Neckeraceae

VI. Sematophyllaceae Broth.

k. ***Sematophyllum*** Mitt.

13. *Sematophyllum caespitosum* (Hedw.) Broth.

14. *Sematophyllum subhumile* (Müll. Hal.) M. Fleisch.

VII. Hylocomiaceae M. Fleisch.

l. ***Thamnium*** Müll. Hal.

15. *Thamnium schmidii* (Müll. Hal.) Jaeg.

VIII. Thuidiaceae Schimp

m. ***Thuidium*** Bruch & Schimp.

16. *Thuidium cymbifolium* Doz. *et* Molk.

17. *Thuidium glaucinum* (Mitt.) Bosh. *et* Lac.

IX. Hypnaceae Schimp.

n. ***Isopterygium*** Mitt.

18. *Isopterygium albescens* (Hook.) Jaeg.

19. *Isopterygium serrulatum* M. Fleisch.

X. Stereophyllaceae W. R. Buck & Ireland

o. ***Entodontopsis*** Broth.

20. *Entodontopsis wightii* (Mitt.) W.R. Buck & Ireland.

B. ORDER BRYALES Limpr.

XI. Bartramiaceae Schwägr.

p. ***Bartramia*** Hedw.

21. *Bartramia dicranacea* Müll. Hal.

22. *Bartramia leptodonta* Wils.

q. ***Breutelia*** (Bruch & Schimp.) Schimp

23. *Breutelia dicranacea* (Müll. Hal.) Mitt.

r. ***Philonotis*** Brid.

24.*Philonotis pseudofontana* (Müll. Hal.) Jaeg.

XII. Bryaceae Schwägr.

s. ***Anomobryum*** Schimp.

25. *Anomobryum schmidii* (Müll. Hal.) Jaeg.

t. ***Brachymenium*** Schwägr.

26. *Brachymenium bryoides* Hook. *ex* Schwaegr.
27. *Brachymenium buchananii* var. *cuspidatum*
u. ***Bryum*** Hedw.
28. *Bryum alpinum* With.
XIII. Mniaceae Schwägr.
v. ***Mielichhoferia*** Nees & Hornsch.
29. *Mielichhoferia schmidii* Müll. Hal.
x. ***Mnium*** Hedw.
30. *Mnium shynehophorum* Hook.
y. ***Pohlia*** Hedw.
31. *Pohlia flexuoasa* W.J. Hook.
C. ORDER HOOKERIALES M. Fleisch.
XIV. Hypopterygiaceae Mitt.
z. **Hypopterygium** Brid.
32. *Hypopterygium tenellum* Müll. Hal.
D. ORDER ORTHOTRICHALES Dixon
XV. Orthotrichaceae Arn.
aa. ***Ulota*** D. Mohr
33. *Ulota schmidii* (Müll. Hal.) Mitt.
ab. ***Zygodon*** Hook. & Taylor
34. *Zygodon cylindrocarpus* Müll. Hal.
ac.**Macromitrium** Brid.
35. *Macromitrium nilgherrense* Müll. Hal.
E. ORDER GRIMMIALES M. Fleisch.
XVI. Ptychomitriaceae Schimp.
ad. ***Ptychomitrium*** Fürnr.
36. *Ptychomitrium tortula* (Harrey) Jaeg.
XVII. Ptychomitriaceae Schimp.
ae. ***Ptychomitrium*** Fürnr.
37. *Ptychomitrium tortula* (Harrey) Jaeg.
F. ORDER DICRANALES H. Philib. ex M. Fleisch.
XVIII. Ditrichaceae Limpr.
af. ***Ditrichum*** Hampe
38. *Ditrichum heteromallum* (Hedw.) Hamp.
ag. ***Pleuridium*** Rahb.
39. *Pleuridium denticulatum* (Müll. Hal.) Mitt.
XIX. Fissidentaceae Schimp.
ah. ***Fissidens*** Hedw.
40. *Fissidens ceylonensis* var. *ceylonensis*
41.*Fissidens ceylonicus* Dozy et al.
42. Fissidens *wilsoni* Mont.
43. *Fissidens anomalus* Mont.
XX. Dicranaceae Schimp.
ai. ***Campylopodium*** (Müll. Hal.) Besch.
44.*Campylopodium nodiflorum* Müll. Hal.
aj.***Campylopus*** Brid.
45. *Campylopus introflexus* (Hedw.) Brid.
XXI. **Leucobryaceae** Schimp.
ak. ***Leucobryum*** Hampe
46. *Leucobryum nilgherense* Müll. Hal.
G. ORDER POLYTRICHALES M. Fleisch.
XXII. Polytrichaceae Schwägr.
al. ***Pogonatum*** P. Beauv.
47. *Pogonatum aloides* (Hedwig.) Palisot Beauv.
H. ORDER POTTIALES M. Fleisch.
XXIII. Pottiaceae Schimp.
am. ***Bryoerythrophyllum*** P.C. Chen
48. *Bryoerythrophyllum recurvistrum* (Hedw.) Chen
an. ***Hyophila*** Brid.
49. *Hyophila involuta* (Hook.) Jaeg.
50. *Hyophila kurziana* Gangulee
ao. ***Trichostomum*** Bruch.
51. *Trichostomum orthodontum* (Mitt.) Broth.
I. ORDER FUNARIALES M. Fleisch.
XXIV. Funariaceae Schwägr.
ap. ***Funaria*** Hedw.
52. *Funaria hygrometrica* Hedw.
aq. ***Entosthodon*** Schwägr.
53. *Entosthodon perrottatii* Müll. Hal.
ar. ***Physcomitrium*** (Brid.) Brid.,
54. *Physcomitrium curgens* Broth.

PHYLUM MARCHANTIOPHYTA (LIVERWORTS)

CLASS: JUNGERMANNIOPSIDA

A. ORDER: FOSSOMBRONIALES Schljakov

I. Fossombroniaceae Hazsl.

a. *Fossombronia* Raddi
1. *F. cristula* Aust.
2. *F. foreaui* Udar et S. C. Srivast.
3. *F. himalayaensis* Kashyap
4. *F. wondraczekii* (Corda) Dum.
II. Pallaviciniaceae Mig.
b. *Pallavicinia* Gray
5. *P. crispatus* (Mont.) Steph.
B. ORDER: METZGERIALES Chalaud
III. Metzgeriaceae H. Klinggr.
c. *Metzgeria* Raddi
6. *M. consanguinea* Schiffn.
7. *M. himalayensis* Udar et S. C. Srivast.
8. *M. indica* Udar et S. C. Srivast.
9. *M. nilgiriensis* Udar et S. C. Srivast.
IV. Aneuraceae H. Klinggr.
e. *Aneura* Dumort.
10. *A. maxima* (Schiffn.) Steph.
11. *A. pinguis* (L.) Dumort.
f. *Riccardia* Gray
12. *R. levieri* Schiffn.
13. *R. multifida* (L.) Gray
14. *R. perssonii* S. C. Srivast et Udar
15. *R. tenuicostata* Schiffn.
C. ORDER: PORELLALES Schljakov
V. Porellaceae Cavers
g. *Porella* L.
16. *P. campylophylla* (Lehm. & Lindenb.) Trevis
17. *P. perottetiana* (Mont.) Trevis
VI. Radulaceae Müll. Frib.
h. *Radula* Dumort.
18. *R. kurzii* Steph.
19. *R. meyeri* Steph.
20. *R. tabularis* Steph.
VII. Frullaniaceae Lorch in G. Lindau
i. *Frullania* Raddi
21. *F. acutiloba* Mitt.
22. *F. arecae* (Spreng.) Gottsche
23. *F. campanulata* Taylor
24. *F. ericoides* (Nees) Mont.
25. *F. muscicola* Steph.
26. *F. neurota* Talyor
27. *F. tamarisci* var. *obscura* (L.) Dumort.
VIII. Lejeuneaceae Cavers
j. *Cololejeunea* (Spruce) Schiffn.
28. *C. cordiocarpa* (Mont.) Steph.
k. *Cheilolejeunea*
C. imbricata (Nees) S. Hatt.
l. *Lejeunea* Lib.
29. *L. aloba* Sande Lac.
30. *L. discreta* Lindenb.
31. *L. flava* (Sw.) Nees
32. *L. neelgherriana* Gottsche
33. *L. perrottetii* Steph.
34. *L. tenirrima* Lindenb.
35. *L. wightii* Lindenb.
m. *Leucolejeunea* A. Evans
36. *L. xanthocarpa* (Lehm. & Lindenb.) A. Evans
n. *Lopholejeunea* (Spruce) Schiffn.
37. *L. sikkimensis* Steph.
38. *L. subfusca* (Nees) Steph.
n. *Microlejeunea* Steph.
39. *M. ulicina* (Taylor) A. Evans
o. *Schiffneriolejeunea* Verd.
39. *S. polycarpa* (Nees) Gradst.
IX. Lophocoleaceae Vanden Berghen in Robyns
p. *Lophocolea* (Dumort.) Dumort.
40. *L. bidentata* (L.) Dumort.
41. *L. heterophylla* (Lehm.) Nees
42. *L. muricata* (L.) Dumort.
q. *Heteroscyphus* Schiffn.
43. *H. argutus* (Reniw., Blume & Nees) Schiffn.
44. *H. orbiculatus* Abha Srivast. et S.Cc. Srivast.
45. *H. palniensis* Abha Srivast. et S. C. Srivast.
X. Scapaniaceae Mig.
r. *Gottschelia* Grolle
46. *G. schizopleura* (Spruce) Grolle

XI. Plagiochilaceae Müll. Frib. & Herzog in Müller
s. *Plagiochila* (Dumort.) Dumort.
47. *P. elegans* Mitt.
48. *P. indica* Mitt. & Steph.
49. *P. nepalensis* Lindenb.
50. *P. peradenyensis* Schiffn.
XII. Cephaloziaceae Mig.
t. *Cephalozia* (Dumort.) Dumort.
51. *C. hamatiloba* Steph.
XIII. Cephaloziellaceae Douin
u. *Cephaloziella* (Spruce) Schiffn.
52. *C. kiaerii* (Austin) Arnell
XIV. Calypogeiaceae Arnell
v. *Calypogeia* Raddi
53. *C. azurea* Stotler & Crotz.
XV. Family Jungermanniaceae Rchb.,
w. *Jungermannia* L.
54. *J. lanceolata* L. emend Schrad.
55. *J. truncata* Nees
56. *J. pyriflora* Steph.
XVI. Geocalycaceae H. Klinggr.
x. *Notoscyphus* Mitt.
57. *N. darjeelingensis* Udar and A. Kumar
58. *N. pandei* Udar and A. Kumar
59. *N. paraoicous* Schiffn.
XVII. Lepidoziaceae Limpr. in Cohn
y. *Bazzania* Gray
60. *B. tridens* (Reinw., Blume et Nees) Trevis.
D. ORDER MARCHANTIALES Limpr. in Cohn
XVII. Cleveaceae Cavers
***z. Athalamia* Falconer**
61. *A. pusilla* (Steph.) Kashyap
XVIII. Aytoniaceae Cavers
a1. *Asterella* P. Beauv
62. *A. khasyana* (Griff.) Pande et al.
a2. *Mannia* Opiz
63. *M. foreaui* Udar & V. Chnadra
a3. *Plagiochasma* Lehm. & Lindenb.
64. *P. cordatum* Lehm. & Lindenb.
65. *P. rupestre* (J.R. Frost. & G. Frost.) Steph.
a4. *Reboulia* Raddi
66. *R. hemisphaerica* (L.) Raddi
XVIV. Lunulariaceae H. Klinggr.
a5. *Lunularia* Adans.
67. *L. cruciata* (L.) Dumort.
XVV. Marchantiaceae Lindl.
a6. *Marchantia* L.
68. *M. paleacea* Bertol.
69. *M. palmata* Nees
XVVI. Dumortieraceae D. G. Long
a7. *Dumortiera* Nees
70. *D. hirsuta* (SW.) Nees
XVVII. Targioniaceae Dumort.
a8. *Targionia* L.
71. *T. hypophylla* L.
XVVIII. Ricciaceae Rchb.
a9. *Riccia* L.
72. *R. fluitans* L.
73. *R. grollei* Udar

HORNWORT
PHYLUM (DIVISION) ANTHOCEROTOPHYTA
CLASS ANTHOCEROTOPSIDA Jancz. ex Stotl. & Crand.-Stotl.
E. ORDER ANTHOCEROTALES Limpricht in Cohn.
XVIX. Anthocerotaceae Dumort.,
a10. *Anthoceros* L.
74. *A. angustus* Steph.
75. *A. subtilis* Steph.

3. RESULTS AND DISCUSSION

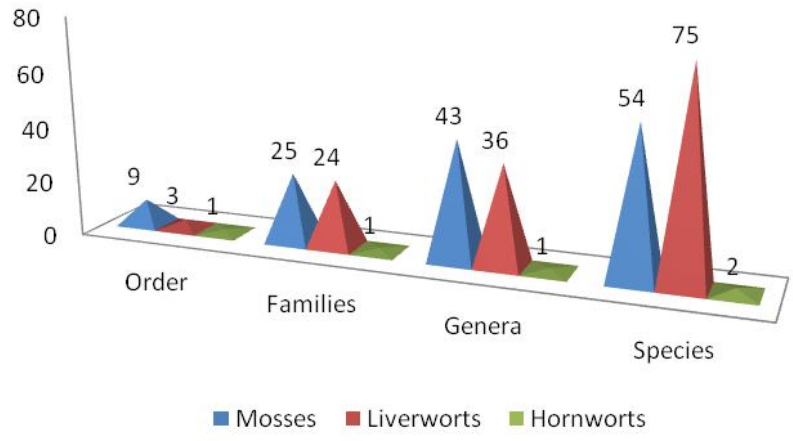
On the basis of above checklist, the occurrence of 9 orders, 25 families, 43 genera and 54 species of mosses in eastern ghats can be elucidated (Fig. 2). The order Hypnales is most

diversified with 10 families having 15 genera and 20 species followed by order Dicranales with 6 families (7 genera and 10 species) and order Bryales is next to them consisting of 3 families (9 genera and 11 species). The most prominent family is Pottiaceae Schimp. (3 genera and 4 species) followed by Orthotrichaceae Arn. (3 genera and 3 species). Genus *Fissidens* Hedw. having the maximum 4 species Interestingly, the moss flora of the region has significant similarities with the Western Ghats (Verma et al, 2011) exhibiting more or less similar environmental conditions and microclimate as well as niche. The study revealed that like Western Ghats, Eastern Ghats is a remarkable place for the diversity of mosses and need further exploration in future also that would provide some more interesting results.

In case of Liverwort diversity, it is represented by 3 orders, 24 families, 36 genera and 75 species (Fig. 2). The order Porellales is maximally diversified with 13 families. The largest and most diversified family is Lejeuneaceae with 6 genera and 12 species. Likewise, the most diversified genus is *Frullania* (7 species) followed by *Lejeunea* (6 species). The order Marchantiales is represented by 7 families with 10 genera and 13 species. Aytoniaceae is the most diversified family and represented by 4 genera. While among genera, *Marchantia*, *Riccia* and *Plagiochasma* are most diversified with 2 species each.

Hornworts are of least occurrence in this region of Eastern Ghats and order Anthocerotales (Fig. 2) is just represented by a single family with is sole genus *Anthoceros* (2 species).

Figure 2: Histogram showing distribution of bryophytes in the region



4. CONCLUSION

Eastern Ghats, a long range of variable habitats, have received very lesser attention than the and Western Ghats in terms of diversity study, conservation and protection planning. In this study bryodiversity of the region has been compiled. It has been reveled that habitat destruction without any prior knowledge of bryodiversity eliminates bryophytes earlier than many other phanerogams in Eastern Ghats because they are more sensitive to environmental change. Some species straight away require protection and conservation to save them from extermination. Eastern Ghats is filled with lush green vegetation and highly diversified habitats. The peculiar conditions of these areas occur at high frequency and density, providing an excellent environment for growth of bryophytes; they may serve in *in situ* conservation of these plants. After a consolidated assessment of bryodiversity of Eastern Ghats, one can know the changes in the habit, habitat, growth rate and pattern of a particular species and their classification under threatened plant's categories of IUCN, and can be used to predict the growth potential of bryophytes during climatic change in the area. Selected rare, Endangered and threatened (RET) bryophyte species may be grown in a natural conservatory for their *in situ* conservation.

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