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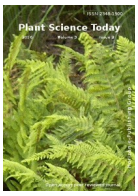

Research Communication

Current status of diversity and distribution of Bryophytes of Odisha

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Abstract

In an attempt to reveal the biodiversity status of one of the least studied plant groups of Eastern Ghats, the authors have catalogued the diversity and distribution of bryoflora of Odisha situated in the Northern Eastern Ghats biogeographic regions of India. One hundred fourty nine species of bryophytes including 102 mosses under 23 families, 41 liverworts under 16 families and 6 hornworts under 2 families were reported from Odihsa as a result of 7 years of primary survey (2008-2015) conducted in some selected bryodiversity rich habitats covering 12 districts of Odisha and also from scrutiny of different research publications including research papers, books and research reports. In terms of species richness, the Deomali hills was found to be the most diverse in terms of bryophytes followed by Similipal biosphere reserve, Mahendragiri hills, Niyamgiri hills, Baphlimali hills and Khandadhar hills. Deomali hills also showed highest diversity in endemic mosses. Five mosses such as *Fissidens orishae* Gangulee, *Erpodium mangiferae* Müll. Hal., *Hyophila comosa* Dixon, *Stereophyllum confusum* Ther., *Neckeropsis exserta* (Hook. ex Schwagr.) Broth. are found to be endemic to India that occur in Odisha. *Aneura pinguis* (L.) Dumort., *Anoectangium stracheyanum* Mitt., *Cyathophorella hookeriana* (Griff.) M. Fleisch., *Cyathophorum adiantum* (Griff.) Mitt., *Distichophyllum schmidtii* Broth., *Eurhynchium striatulum* (Spruce) Schimp., *Hypnum cupressiforme* Hedw., *Leucobryum juniperoideum* (Brid.) Müll. Hal., *Lophocolea bidentata* (L.) Dumort., *Macromitrium sulcatum* (Hook.) Brid., *Notothylas levieri* Schiffner, *Pallavicinia lyellii* (Hook.) Gray *Pellia epiphylla* (L.) Corda., *Philonotis fontana* (Hedw.) Brid., *Pogonatum neesii* (Müll. Hal.) Dozy., *Polytrichum commune* Hedw., *Polytrichum juniperinum* Hedw., *Racopilum cuspidigerum* (Schwagr.) Angstrom, *Racopilum orthocarpum* Wilson ex Mitt., *Riccia beyrichiana* Hampe ex Lehm., *Riccia billardieri* Mont. & Nees., *Spruceanthus semirepandus* (Nees) Verd., *Thuidium cymbifolium* (Müll. Hal.) Paris, *Thuidium koelzii* H. Rob., *Trematodon longicollis* Michx., are some of the new distributional record of occurrence for the Eastern Ghats.The present study reveals that Fissidentaceae, Pottiaceae, Bryaceae, Dicranaceae, Aytoniaceae, Marchantiaceae, Funariaceae and Anthocerotaceae are dominant families in the study area. The authors have also identified few forest pockets and critical habitat in the state where bryophyte diversity shall be very rich that needs a detailed survey in near future. The authors discuss the list of bryophytes of the state in a regional context of rarity, as well as address some general subject matters regarding cryptogam conservation and further work needed in the state of Odisha. The study would provide a prelude data for future bryological studies and bryomonitoring in the Eastern Ghats in general and the state of Odisha in particular.

Keywords
Bryophytes; Diversity; Eastern Ghats; Odisha; Similipal

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Introduction

The bryophytes which comprise liverworts, hornworts, and mosses are widely distributed, generally dominate in between the altitude 1000-8000 meters and they are important components of the vegetation in many regions of the world.

Table 1: Checklist of Bryophytes of Odisha

Name of the species	Family	Distribution in Odisha
Hornworts		
Anthoceros angustus Steph. (Plate 1: Fig.29)	Anthocerotaceae	KJR, Khandadhar;SGD, Khandadhar, KPT, Deomali
Anthoceros levis L. (Plate 1: Fig.31)	Anthocerotaceae	All sites
Anthoceros punctatus L.	Anthocerotaceae	MBNJ, Similipal
Notothylas levieri Schiffn., (Plate 1: Fig.30)	Notothyladaceae	KRD, Barbara RF
Phaeoceros laevis (L.) Prosk.	Notothyladaceae	All sites
Phaeoceros laevis subsp. *carolinianus*	Notothyladaceae	MBNJ, Similipal
Liverworts		
Aneura pinguis (L.) Dumort.	Aneuraceae	KPT, Deomali
Asterella khasiana (Griff.) Grolle	Aytoniaceae	MGR, Chitrakonda
Asterella angusta (Steph.) Pande, K.P. Srivast. & Sultan Khan (Plate 1: Fig.7)	Aytoniaceae	RGD, Baphlimali, GPT, Mahendragiri
Asterella blumeana (Nees) Pande, K.P. Srivast. & Sultan Khan	Aytoniaceae	MBNJ, Similipal, RGD, Baphlimali
Asterella wallichiana (Lehm.) Grolle (Plate 1: Fig.8)	Aytoniaceae	MBNJ, Similipal, RGD, Baphlimali
Cephalozia connivens (Dicks.) Lindb.	Cephaloziaceae	KJR, Khandadhar
Conocephalum conicum (L.) Underw.	Conocephalaceae	MBNJ, Similipal, KHND, Karlapat, RGD, Baphlimali
Cyathodium cavernarum Kunze (Plate 1: Fig.1)	Cyathodiaceae	All sites
Dumortiera hirsuta (Sw.) Nees (Plate 1: Fig.6)	Marchantiaceae	KJR, Khandadhar, KHND, Karlapat, BGD, Gandhamardan, MBNJ, Similipal
Frullania muscicola Steph.	Jubulaceae	KJR, Khandadhar
Frullania squarrosa Gottsche	Jubulaceae	KJR, Khandadhar
Heteroscyphus argutus (Nees) Schiffn.	Lophocoleaceae	KHND, Karlapat, KJH, Khandadhar
Lejeunea discreta Lindenb.	Lejeuneaceae	RGD, Baphlimali
Lophocolea bidentata (L.) Dumort.	Lophocoleaceae	KJR, Khandadhar, MBHJ, Similipal
Marchantia linearis Lehm. & Lindenb.	Marchantiaceae	MBNJ, Similipal
Marchantia palmata Reinw., Nees & Blume (Plate 1: Fig.4)	Marchantiaceae	MBNJ, Similipal
Marchantia polymorpha L.	Marchantiaceae	MBNJ, Similipal
Metzgeria decipiens (C. Massal.) Schiffn. (Plate 1: Fig.5)	Metzgeriaceae	KPT, Deomali
Metzgeria furcata (L.) Corda	Metzgeriaceae	GPT, Mahendragiri
Metzgeria himalayensis Kash.	Metzgeriaceae	MBNJ, Similipal, KJR, Khandadhar
Pallavicinia lyellii (Hook.) Gray (Plate 1: Fig.13)	Pallaviciniaceae	KJR, Khandadhar
Pellia endiviifolia (Dicks.) Dumort.	Pelliaceae	RGD, Baphlimali
Pellia epiphylla (L.) Corda	Pelliaceae	RGD, Baphlimali, KPT, Deomali
Plagiochasma appendiculatum Lehm. & Lindenb. (Plate 1: Fig.9)	Aytoniaceae	All sites
Plagiochasma rupestre (G. Forst.) Steph.	Aytoniaceae	MBNJ, Similipal, RGD, Baphlimali
Plagiochila porelloides (Torr.) Lindenb.	Plagiochilaceae	Epiphyte on trees at Mahendragiri, Deomali
Plagiomnium rostratum (Schrad.) T.J. Kop.	Aytoniaceae	KPT, Deomali

Table 1: Checklist of Bryophytes of Odisha **(Contd.)**

Name of the species	Family	Distribution in Odisha
Plagiothecium denticulatum (Hedw.) Schimp. (Plate 1: Fig.17)	Aytoniaceae	KPT, Deomali, MBNJ, Similipal, GPT, Debgiri
Riccardia levieri Schiffn.	Aneuraceae	KHND, Karlapat, KJH, Khandadhar, RGD, Baphlimali, GJM, Budhakhol
Riccia beyrichiana Hampe ex Lehm.	Ricciaceae	GPT, Mahendragiri
Riccia fluitans L.	Ricciaceae	All sites
Riccia pathankotensis Kash.	Ricciaceae	MGR, Chitrkonda
Riccia billardieri Mont. & Nees. (Plate 1: Fig.3)	Ricciaceae	MGR, Chitrkonda
Riccia crystallina L. (Plate 1: Fig.2)	Ricciaceae	MGR, Chitrkonda
Riccia discolor Lehm. & Lindenb.	Ricciaceae	MBNJ, Similipal
Riccia frostii Austin	Ricciaceae	KPT, Deomali
Riccia glauca L.	Ricciaceae	KPT, Deomali, GPT, Mahendragiri, MGR, Chitrakonda
Riccia trichocarpa M. Howe	Ricciaceae	KJR, Khandadhar
Spruceanthus semirepandus (Nees) Verd. (Plate 1: Fig.12)	Lejeuneaceae	GPT, Mahendragiri
Targionia hypophylla L. (Plate 1: Fig.10)	Targioniaceae	AGL, Satkosia, MBNJ, Similipal, AGL
Targionia indica Udar & A. Gupta	Targioniaceae	RGD, Baphlimali
Mosses		
Aerobryopsis longissima (Dozy & Molk.) M. Fleisch	Meteoriaceae	KHND, Karlapat
Anoectangium stracheyanum Mitt.	Pottiaceae	KPD, Deomali; GPT, Mahendragiri, KJR, Khandadhar
Anoectangium walkeri Broth.	Pottiaceae	MBNJ, Similipal, KHND, Karlapat
Barbula arcuata Griff.	Pottiaceae	RGD, Baphlimali
Barbula javanica Dozy & Molk. (Plate 1: Fig.2)	Pottiaceae	MBNJ, Similipal
Brachymenium exile (Dozy & Molk.) Bosch & Sande Lac.	Bryaceae	KPT, Deomali
Brachymenium microstomum Harv.	Bryaceae	KPT, Deomali
Brachythecium rutabulum (Hedw.) Schimp.	Bryaceae	KPT, Deomali
Brachythecium albicans (Hedw.) Schimp.	Bryaceae	SGD, Khandadhar
Bryum apiculatum Schwagr.	Bryaceae	CTC, Mahanadi river bed
Bryum argenteum Hedw.	Bryaceae	All sites
Bryum argenteum var. *lanatum* (P. Beauv.) Hampe	Bryaceae	GJM, Chilika
Bryum capillare Hedw. (Plate 1: Fig.18)	Bryaceae	KPT, Deomali, GPT, Mahendragiri
Bryum cellulare Hook.	Bryaceae	RGD, Baphlimali
Bryum coronatum Schwagr. (Plate 1: Fig.19)	Bryaceae	RGD, Baphlimali. KPT, Deomali, RGD, Niyamgiri
Bryum plumosum Dozy & Molk.	Bryaceae	MBNJ, Similipal
Campylopus ericoides (Griff.) A. Jaeger	Leucobryaceae	MBNJ, Similipal, KPT, Deomali, GPT, Mahendragiri
Campylopus gracilis (Mitt.) A. Jaeger	Leucobryaceae	KPT, Deomali, GPT, Mahendragiri
Cyathophorella hookeriana (Griff.) M. Fleisch.	Cyathophoraceae	KPT, Deomali
Cyathophorum adiantum (Griff.) Mitt. (Plate 1: Fig.11)	Cyathophoraceae	KPT, Deomali

Table 1: Checklist of Bryophytes of Odisha **(Contd.)**

Name of the species	Family	Distribution in Odisha
Dicranella heteromalla (Hedw.) Schimp.	Dicranaceae	KPT, Deomali
Distichophyllum schmidtii Broth.	Hookeriaceae	MBNJ, Similipal
Entodon flavescens (Hook.) A. Jaeger	Entodontaceae	MBNJ, Similipal
Entodon plicatus Müll. Hal.	Entodontaceae	KPT, Deomali
Entodontopsis wightii (Mitt.) W.R. Buck & R.R. Ireland	Entodontaceae	KPT, Deomali
Erpodium mangiferae Müll. Hal.	Erpodiaceae	RGD, Baphlimali
Erythrodontium julaceum (Hook. ex Schwagr.) Paris	Erpodiaceae	GPT, Mahendragiri
Eurhynchium muelleri (A. Jaeger) EB Bartram	Brachytheciaceae	KRD, RPRC Campus Orchid Garden, Bhubaneswar
Eurhynchium striatulum (Spruce) Schimp.	Brachytheciaceae	GJM, Budhhakhol
Fissidens ceylonensis Dozy & Molk., (Plate 1: Fig.27)	Fissidentaceae	KHND, Karlapat
Fissidens sylvatus var. *zippenlianus* Gangulee	Fissidentaceae	BGD, Gandhamardan
Fissidens sylvatus var. *calcuttense* Gangulee	Fissidentaceae	RGD, Baphlimali
Fissidens bryoides Hedw.	Fissidentaceae	KJR, Khandadhar, SGD, Khandadhar
Fissidens crenulatus Mitt.	Fissidentaceae	KHND, Karlapat, KJH, Khandadhar, KPT, Deomali
Fissidens crispulus Brid.	Fissidentaceae	KPT, Deomali
Fissidens diversifolius Mitt.	Fissidentaceae	RGD, Baphlimali
Fissidens incurvus Starke ex Rohl.	Fissidentaceae	RGD, Baphlimali
Fissidens intromarginatulus E.B. Bartram	Fissidentaceae	RGD, Baphlimali
Fissidens involutus Wilson ex Mitt.	Fissidentaceae	RGD, Baphlimali
Fissidens orishae Gangulee	Fissidentaceae	KPT, Deomali
Fissidens schmidii Müll. Hal.	Fissidentaceae	MBNJ, Similipal
Fissidens serratus Müll. Hal.	Fissidentaceae	GPT, Mahendragiri
Fissidens serrulatus Brid.	Fissidentaceae	GPT, Mahendragiri
Fissidens sylvaticus Griff.	Fissidentaceae	GPT, Mahendragiri
Fissidens taxifolius Hedw.	Fissidentaceae	KPT, Deomali
Floribundaria walkeri (Renauld & Cardot) Broth.	Meteoriaceae	KJR, Khandadhar
Foreauella orthothecia (Schwagr.) Dixon & P. de la Varde	Sematophyllaceae	KJR, Khandadhar
Funaria hygrometrica Hedw.	Funariaceae	All sites
Funaria hygrometrica var. *calvescens* (Schwagr.) Mont.	Funariaceae	MBNJ, Similipal, KPT, Deomali
Grimmia funalis (Schwagr.) Bruch & Schimp.	Grimiaceae	KPT, Deomali
Grimmia indica (Dixon & P. de la Varde) Goffinet & Greven	Grimiaceae	KPT, Deomali, Mahendragiri, GPT
Herpetineuron toccoae (Sull. & Lesq.) Cardot (Plate 1: Fig.21)	Sematophyllaceae	All sites
Himantocladium plumula (Nees) M. Fleisch.	Neckeraceae	BGD, Gandhamardan
Hydrogonium arcuatum (Griff.) Wijk & Margad.	Pottiaceae	BGD, Gandhamardan
Hydrogonium consanguineum (Thwaites & Mitt.) Hilp.	Pottiaceae	KPT, Deomali

Table 1: Checklist of Bryophytes of Odisha **(Contd.)**

Name of the species	Family	Distribution in Odisha
*Hymenostomum edentulu*m (Mitt.) Besch.	Meteoriaceae	KPT, Deomali
Hyophila comosa Dixon	Pottiaceae	GPT, Mahendragiri; KPT, Deomali
Hyophila involuta (Hook.) A. Jaeger (Plate 1: Fig.2)	Pottiaceae	GPT, Mahendragiri; KPT, Deomali
Hyophila nymaniana (M. Fleisch.) M. Menzel	Pottiaceae	KPT, Deomali
Hyophila rosea R.S. Williams	Pottiaceae	KPT, Deomali
Hypnum cupressiforme Hedw.	Hypnaceae	RGD, Niyamgiiri, MBNJ, Similipal
Isopterygium micans (Sw.) Kindb. Verd.	Hypnaceae	MBNJ, Similipal, KPT, Deomali
Leucobryum juniperoideum (Brid.) Müll. Hal. (Plate 1: Fig.16)	Dicranaceae	GPT, Mahendragiri; KPT, Deomali
Macromitrium sulcatum (Hook.) Brid. (Plate 1: Fig.20)	Orthotrichaceae	GPT, Mahendragiri
Meteoriopsis reclinata (Mull. Hal.) M. Fleisch.	Meteoriaceae	SGD, Khandadhar
Meteoriopsis squarrosa (Hook. ex Harv.) M. Fleisch.	Meteoriaceae	KJR, Khandadhar
Neckeropsis crinita (Griff.) M. Fleisch.	Neckeraceae	KPT, Deomali
Neckeropsis exserta (Hook. ex Schwagr.) Broth.	Neckeraceae	KPT, Deomali
Octoblepharum albidum Hedw.	Leucobryaceae	KPT, Deomali, GPT, Mahendragiri, MBNJ, Similipal
Oxystegus tenuirostris (Hook. & Taylor) A.J.E. Sm.	Pottiaceae	BGD, Gandhamardan
Papillaria crocea (Hampe) A. Jaeger	Meteoriaceae	SGD, Khandadhar
Philonotis falcata (Hook.) Mitt.	Bartramiaceae	GJM, Budhhakhol
Philonotis fontana (Hedw.) Brid.	Bartramiaceae	KHND, Karlapat
Philonotis mollis (Dozy & Molk.) Mitt. (Plate 1: Fig.28)	Bartramiaceae	GJM, Budhhakhol
Philonotis hastata (Duby) Wijk & Margad.	Bartramiaceae	MBNJ, Similipal, KPT, Deomali, GPT, Mahendragiri
Philonotis thwaitesii Mitt.	Bartramiaceae	MBNJ, Similipal, KPT, Deomali, GPT, Mahendragiri
Physcomitrium pyriforme (Hedw.) Hampe	Funariaceae	SGD, Khandadhar
Pinnatella alopecuroides (Mitt.) M. Fleisch.	Neckeraceae	MBNJ, Similipal, KPT, Deomali, GPT, Mahendragiri
Pinnatella calcutensis M. Fleisch. (Michx.) Prosk.	Neckeraceae	MBNJ, Similipal, KPT, Deomali, GPT, Mahendragiri
Pogonatum neesii (Mull. Hal.) Dozy. (Plate 1: Fig.23)	Polytrichaceae	GPT, Mahendragiri
Pogonatum microstomum (R. Br. ex Schwägr.) Brid.	Polytrichaceae	MBNJ, Similipal
Pohlia flexuosa Harv.	Bryaceae	GPT, Mahendragiri
Polytrichum commune Hedw.	Polytrichaceae	KPT, Deomali
Polytrichum juniperinum Hedw.	Polytrichaceae	RGD, Baphlimali, KPT, Deomali
Racopilum cuspidigerum (Schwagr.) Angstrom (Plate 1: Fig.14)	Racopilaceae	KPT, Deomali
Racopilum orthocarpum Wilson ex Mitt.	Racopilaceae	KPT, Deomali
Rhynchostegiella divaricatifolia (Renauld & Cardot) Broth.	Brachytheciaceae	KPT, Deomali
Semibarbula orientalis (F. Weber) Wijk & Margad.	Pottiaceae	KPT, Deomali
Splachnobryum indicum Hampe & Mull. Hal.	Pottiaceae	RGD, Baphlimali

Table 1: Checklist of Bryophytes of Odisha **(Contd.)**

Name of the species	Family	Distribution in Odisha
Stereophyllum radiculosum (Hook.) Mitt.	Stereophyllaceae	GPT Mahendragiri
Stereophyllum confusum Ther. (Plate 1: Fig.24)	Stereophyllaceae	KPT, Deomali
Stereophyllum wightii (Mitt.) A. Jaeger	Stereophyllaceae	KPT, Deomali
Taxiphyllum giraldii (Mull. Hal.) M. Fleisch.	Sematophyllaceae	KPT, Deomali
Taxiphyllum taxirameum (Mitt.) M. Fleisch.	Sematophyllaceae	KPT, Deomali
Taxithelium nepalense (Schwagr.) Broth.	Sematophyllaceae	KPT, Deomali
Thuidium cymbifoliolum (Müll. Hal.) Paris (Plate 1: Fig.15)	Leucodontaceae	KPT, Deomali
Thuidium koelzii H. Rob.	Leucodontaceae	KPT, Deomali
Trachyphyllum inflexum (Harv.) A. Gepp	Entodontaceae	RGD, Baphlimali
Trachyphyllum jeyporense Ther. & Dixon	Entodontaceae	KPT, Deomali, RGD, Baphlimali
Trematodon longicollis Michx. (Plate 1: Fig.25)	Bruchiaceae	KJR, Khandadhar
Weissia edentula Mitt.	Ditrichaceae	KRD, Barbara
Wilsoniella decipiens var. acutifolia (Dixon) Wijk & Margad.	Ditrichaceae	KRD, Barbara

Abbreviations: MBNJ: Mayurbhanj, SGD, Sundargarh, RGD: Rayagada, KPT: Koraput, KJR: Keonjhar, AGL: Angul, NGD: Nayagarh, KHND: Kalahandi, MGR: Malkangiri, GPT: Gajpati, BGD: Bargarh, CTC: Cuttack, GJM: Ganjam, KRD: Khurda

They are one of the important components in many forest ecosystems and constitute a major part of the biodiversity in moist environments, wetland, and mountain ecosystems (Hallingback and Hotsgetts, 2000).

They are the second largest group of plants, with about 25,000 species worldwide (Buck and Goffinetnet, 2000). Our knowledge on the taxonomy and distribution of bryophytes are far from adequate and still relies on the work done during the last 20th and early 21st centuries. So far, 2489 taxa of bryophytes recorded from India, comprising 1786 species in 355 genera of mosses, 675 species in 121 genera of liverworts and 25 species in six genera of hornworts of which approximately 72% are mosses, 27% are liverworts and 1% hornworts. About 340 species as endemic of which 269 species are of mosses, 67 are of liverworts and 4 are of hornworts (Dandotiya *et al*., 2011). Out of 133 rare species 78 are of mosses and 53 are liverworts and nearly 14 species are recorded as endangered. The percentage occurrence of mosses in India is quite high when compared to any other plant group. About 27.5% of the world's mosses and 11.26% of liverworts are present in India. In India they are distributed in Eastern and Western Himalayas, South India and Central India (Nath and Asthana, 2005).

Being one of the East Indian state Odisha's unique locations in Peninsular India has blessed it with an interesting assemblage of floral and faunal diversity. With an unindented coastline of nearly 480 km, drained by several large and perennial rivers, altitudinal variation from sea level up to 5000 feet above MSL, varied geography and the confluence of two major biogeographic provinces of India-the Eastern Ghats and Chhotanagpur Plateau–make Odisha a rich biodiversity repository. Of the state's total geographical area, 32.33 % is covered with forests. This works out to be about 7.21 % of the India's total forest area (FSI, 2013). The vegetation of Odisha comes under four types: (i) Odisha Semi-evergreen forests (ii) Tropical moist deciduous forests (iii) Tropical dry-deciduous forests and (iv) Littoral and Tidal swamp forests. The state is an abode for around 3000 species of plants which includes 138 species of Orchids, 170 species of pteridophytes, 10 species of gymnosperms, 71 species of mangroves and their associates and 7 species of sea grasses. Apart from angiosperms, gymnosperms and pteridophytes lower group of plants like algae, bryophytes and lichens also contribute substantially to the floral richness of the state. But the studies on cryptogams in general and Bryophytes in particular are insufficient as compared to other groups of plants. Except Gangulee's work (Gangulee, 1969–1980) where bryoflora of some parts of the Eastern Ghats in general and a few localities of Odisha state in particular were mentioned, no other researchers have made any attempt to document the bryoflora of the state. The first systematic studies on Bryophytes of Odisha were conducted by Dash *et al*. (2007) and reported 23 species of bryophytes from Similipal biosphere reserve. Latter Dash and Saxena, 2009 reported 29 species from Khandadhar hills, Dash *et al*. (2009) reported 31 species from Baphlimali hills of Eastern Ghats. Dash and Saxena (2011) documented the bryoflora

of Keonjhar district of Odisha and reported 33 species. Nath *et al*. (2007) reported 28 species of mosses from Amarkantak (MP) and mentioned the range distribution of 7 species from Odisha. Later on, Dandotiya *et al*. (2011) published a checklist on Bryoflora of India, where he mentioned about the presence of 47 species from Odisha following mainly Gangulee's record. Nath *et al*. (2011) presented an overview of family Pottiaceae (Bryopsida) in Central India and reported on the distribution of 3 species of mosses from Odisha. Alam *et al*. (2013) reported 33 species of bryophytes from Similipal Biosphere Reserve with some new additions to the bryoflora reported by Dash *et al*. (2007). Bansal and Nath (2014) reported 26 species of the genus *Bryum* from peninsular India and mentioned about the presence of 4 species from Odisha.

Materials and Methods

In an attempt to document the bryoflora of the state field survey was conducted in some selected biodiversity rich areas in 12 districts of Odisha, namely Mayurbhanj (Similipal Biosphere Reserve), Kalahandi (Karlapat Wild Life Sanctuary), Rayagada (Niyamgiri hills and Baphlimali hills), Angul (Satkoshia Wild Life Sanctuary) Keonjhar and Sundargarh (Khandadhar hills), Koraput (Deomali hills), Gajapati (Mahendragiri hills), Malkangiri (Chitrakonda), Khurda (Barbara RF and RPRC, Campus, Bhubaneswar), Cuttack (Mahanadi river bed), Ganjam (Budhhakhol) and Dhenkanal (Saptasajya and Kapilas hill (Map 1). The study sites include open, dense and scrub forests, grasslands and degraded forests, mining areas, waterfalls, dead logs, old trees and old monuments.

For sample collection, plants were scraped out along with little substrate with the help of sharp edged knife and a small portion of stem bark having good number of plants were peeled off with a sharp knife for the corticolous bryophytes (growing on tree bark). The aquatic, terrestrial and epiphytic bryophytes were collected in the polythene bags and brought to the laboratory, washed and dried. Collected samples are placed properly in standard Herbarium packets (4"x6" in size) in dried form. A printed label of 3"x5" size is glued on the front flap of packet with field data. The dried specimens are deposited in the newly created herbarium of Odisha Biodiversity Board, Bhubaneswar (OBB).

Identification of the specimens was based on the gametophytic and sporophytic characters and special features like elaters, rhizoids, sporophyte diameter, etc. using the standard manuals and by referring the literatures of Chopra and Kumar (1988); Kashyap (1929), Kashyap and Chopra (1932); Gangulee (1969 – 1980), Nair *et al*. (2005), Satisha (2007). The doubtful specimens were identified by matching with the herbarium specimens at National Botanical Research Institute, Lucknow and Botanical survey of India, Kolkata during the initial stages of the study period and the other and recently collected doubtful specimens are identified by the authors on the basis of available literature.

Ecology of bryoflora: The maximum diversity of Bryophytes was reported in Deomali followed by Similipal as both these areas offer suitable climatic conditions like good rainfall, moderate temperature, encouraging light intensity, high humidity, etc. Other factors such as age and composition of forest, moisture regime and substrate characteristics like pH and nutrient that are considered decisive for the growth of bryophytes (Rhoades, 1995; Richards, 1996; Gabriel and Bates, 2005) are also amiable in this part of country. Altitude, an important factor related to diversity and distribution pattern of bryophytes is an influential factor in Odisha. The bryophyte diversity is generally negatively correlated with altitude (Gabriel and Bates, 2005), and this is evident here also by the pervasiveness of thalloid species at lower altitude and of leafy forms at higher altitude in the studied areas of Odisha. The bryophyte composition is related to the physiognomy of the forest and hence the distribution of bryophyte in the forest types of Odisha is governed by many factors related to water availability and nature of the forest types. Species like *Anthocerous angustus*, *Conocephalum conicum*, *Pallavicinia lyellii*, *Pellia epiphylla*, *Polytrichum juniperinum* and *Targionia indica* were found between altitudes of 550 m to 870 m at places where the forest is of mostly moist deciduous or semi-evergreen having compact canopy. Five species like *Riccia trichocarpa*, *Riccia glauca*, *Herpetineuron toccoae*, *Cyathodium cavernarum* and *Funaria hygrometrica* and were collected from the vicinity of mining areas which harbouring dry deciduous forest with more open canopy. Two thalloid species *viz*. *Dumortiera hirsuta* and *Plagiochasma appendiculatum* showed a wide range of morphological variations along the altitudinal gradient among all sites. *Spruceanthus semirepandus*, *Thuidium cymbifoliolum*, *Thuidium koelzii*, *Floribundaria walkeri*, *Macromitrium sulcatum*, *Hyophila comosa*, *Hyophila nymaniana*, *Racopilum cuspidigerum*, *Racopilum orthocarpum*, *Campylopus ericoides*, *Octoblepharum albidum*, *Entodontopsis wightii*, and *Bryum coronatum* are found in Mahendragiri and Deomali hills above 1200 m and *Hydrogonium consanguineum*, *Plagiochasma rupestre*, *Cyathophorum adiantum*, *Cyathophorella hookeriana* usually spotted above 1300 m from msl. Mosses like *Octoblepharum albeidum* usually prefer old trees and Mahendragiri hills, Deomali hills and Similipal biosphere reserve are three most important habitats for this species. Other substrates like old rocks, rocks, stones and pebbles provide suitable habitat for many mosses and liverworts like *Aerobryopsis longissima*, *Stereophyllum*

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radiculosum, *Bryum* sp. *Meteoriopsis* sp. *Rhynchostegiella* sp. *Trematodon longicollis*. Annual rainfall above 1500 mm might also be one of the key environmental factors for a high diversity of epiphytic moss in places like Similipal and Mahendragiri hills.

Result and Discussion

Diversity: The bryoflora of Odisha consists of 149 species under 76 genera comprising 102 mosses under 23 families and 52 genera, 41 liverworts under 16 families and 22 genera and 6 hornworts under 2 families and 2 genera (Table 1). Among mosses, Fissidentaceae is found to be the dominant family with 16 species followed by Pottiaceae with 14 species and Bryaceae with 12 species and Bartramiaceae and Entodontaceae with 5 and 4 species each are the other dominant families in mosses. Similarly, Ricciaceae outnumbered the liverwort family with 9 species as compared to Aytoniaceae with 8 species and Marchantiaceae with 4 species. Out of 36 species of *Riccia* reported from India (Singh, 2014), Odisha harbours 8 species showing the availability of favourable conditions for thalloid liverworts.

Distribution pattern: Two hornworts *viz*. *Anthoceros laevis*, and *Phaeoceros laevis*, three liverworts *viz*. *Riccia fluitans*, *Cyathodium cavernarum*, *Plagiochasma appendiculatum*, and three moss taxa *viz*. *Bryum argenteum*, *Funaria hygrometrica*, and *Herpetineuron toccoae* are the common species in all the sites studied. Interestingly, 63 species of bryophytes are found alone in Deomali hill of Koraput followed by 3 species in Similipal Biosphere Reserve (SBR), Mayurbhanj; 34 species in Mahendragiri hills of Gajpati; 20 species each in Baphlaimali hill ranges of Rayagada and Khandadhar hills of Keonjhar and Sundargarh districts. Among mosses, *Distichophyllum schmidtii*, *Thuidium cymbifoliolum*, *Thuidium koelzii*, *Floribundaria walkeri*, *Macromitrium sulcatum*, *Cyathophorum adiantum*, *Cyathophorella hookeriana*, *Polytrichum commune*, *Polytrichum juniperinum*, *Hyophila comosa*, *Hyophila nymaniana*, *Racopilum cuspidigerum*, *Racopilum orthocarpum* can be considered as rare moss taxa for Odisha due to their site specific and limited occurrence. Similarly liverworts *viz*. *Spruceanthus semirepandus*, *Plagiochasma rupestre*, *Lophocolea bidentata*, *Pallavicinia lyellii*, *Riccia pathankotensis*, and *Asterella wallichiana* may be considered as rare in the studied areas of Odisha.

Moss species *viz*. *Plagiothecium denticulatum*, *Philonotis thwaitesii*, *Brachythecium albicans*, *Cyathophorum adiantum*, *Neckeropsis exserta*, *Floribundaria walkeri*, *Hypnum cupressiforme*, *Leucobryum juniperoideum*, *Octoblepharum albidum*, *Trachyphyllum jeyporense*, *Fissidens crenulatus*, *Hyophila involuta* and *Macromitrium sulcatum*; liverworts like *Lophocolea bidentata*, *Riccardia levieri*, *Lejeunea discreta*, *Spruceanthus semirepandus*, *Frullania squarrosa*, etc. preffered to grow in barks of old trees and usually considered as corticolous. Similarly, thalloid forms *viz*. *Plagiochasma appendiculatum*, *Conocephalum conicum*, *Cyathodium cavernarum*, *Targionia indica*, *Riccia pathankotensis*, *Riccia glauca*, *Riccia billardieri*, *Pallavicinia lyellii*, *Pellia epiphylla*, *Notothylas levieri*, *Metzgeria himalayensis*, *Marchantia linearis*, *Marchantia polymorpha*, *Dumortiera hirsuta*, *Thuidium cymbifoliolum*, *Thuidium koelzii*, *Heteroscyphus argutus*, *Barbula javanica*, *Anoectangium stracheyanum*, *Racopilum cuspidigerum*, *Racopilum orthocarpum* etc. are found to grow on rocks, stones and pebbles and may be considered as rupicolous and saxicolous taxa. Some species preffered to grow in old trees/fallen logs as lignicolous forms. Species like *Riccia* grows on river banks and roadside cuts/on soil as terricolous form. While *Riccia fluitans*, *Fissidens* sp. and *Eurhynchium striatulum* are the aquatic forms. *Trematodon* sp., are lignicolous in nature. The epiphytic mosses and liverworts preferred some specific trees like *Acronychia pedunculata*, *Michelia champaca*, *Drypetes assamica*, *Glochidion lanceolarium*, *Litsea glutinosa*, *Litsea laeta*, *Litsea monopetala*, *Neocinnamomum caudatum*, *Neolitsea cassia*, *Neolitsea foliosa*, *Syzygium caryophyllifolium*, *Syzygium cerasoides*, *Callicarpa macrophylla* Vahl., *Machilus macranthus* etc., which are mostly found on shola forests above 1000 m msl.

Moss species *viz*. *Distichophyllum schmidtii*, *Thuidium cymbifolium*, *Thuidium koelzii*, *Macromitrium sulcatum*, *Polytrichum commune*, *Polytrichum juniperinum*, *Pogonatum neesii*, *Racopilum cuspidigerum*, *Racopilum orthocarpum*, *Cyathophorum adiantum*, *Trematodon longicollis*, *Eurhynchium striatulum*, *Philonotis fontana*, *Cyathophorella hookeriana*, *Hypnum cupressiforme*, *Leucobryum juniperoideum*, *Anoectangium stracheyanum* have been reported for the first time in the studied sites. While in case of liverworts *Lophocolea bidentata*, *Spruceanthus semirepandus*, *Pellia epiphylla*, *Aneura pinguis*, *Riccia beyrichiana*, *Riccia billardieri* and *Pallavicinia lyellii* are the new entries to the region. Hornwort *Notothylas levieri* is also a new record for the Eastern Ghats.

Conclusion

Bryophytes are one of the neglected groups of plants in Odisha. Lack of taxonomic expertise and proper information about their diversity, distribution and ecology might be the reason of negligence for these amphibians of plant kingdom. In the past only sporadic work was done by only a few researchers, as a result of that our knowledge regarding bryophytes of this particular region of India is much lesser than the other bryological regions. To fill this lacuna regarding the diversity

and distribution of these plants, a detailed taxonomic survey and documentation of bryoflora of the state has been performed in present study. The results of this study clearly indicate that earlier explorations related to bryophytes in the state were inadequate and several potential localities remain untouched. The current report of 149 species in the form of a checklist from Odisha is still a meager estimate. This number is only a basic estimate and it would certainly increase after frequent and extensive bryofloristic survey of all regions of this state that will certainly provide many new reports from this potential but neglected state in terms of bryoflora. Neglected areas like Rebena Reserve Forest, Core areas of Similipal (Meghasini, Barhkamara, and Devasthali etc.), Kuldiha wildlife sanctuary, Barbara-Dhuanali RF, South Odisha in general and Ganjam, Rayagada and Malkangiri district in particular should be given priority for future bryfloristic explorations. Due to inaccessibility, time constrain and lack of funding these areas could not be accessed thoroughly during the present bryofloristic survey. Also, seasonal visits to forests immediately after the rains have to be done because they are also helpful in locating the epiphytic forms, as many of which disappear from the forest on the onset of the dry season.

Generally, the conservation measures have been taken in India mainly for the higher plants. In the case of lower plant groups, very less importance is given by the taxonomist as well as the policy makers. However, these small plants are also facing the potential risks in the form of habitat loss and ever increasing pollution due to unplanned developmental activities. These issues are mainly societal, and the fate of these special plants is dependent upon the overall conservation strategy that must include these small creations of nature. This preliminary study indicates that many localities of Odisha state are rich in bryophytes. As most of the species are found in the hills and mountains where mining is inevitable, a detailed survey and documentation of the bryoflora is needed before they perish due to anthropocentric land use changes in these ecosystems. Since herbarium for lower plants like bryophytes and lichens are not yet been established in Odisha hence steps must be taken to develop herbaria for the preservation of this rich bryoflora. As habitat replacement is rapidly going on and land use changes are almost inevitable, therefore *ex-situ* conservation of bryophytes especially focusing on region specific threatened species is essential for their conservation.

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