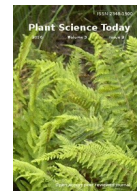




ISSN: 2348-1900

**Plant Science Today**

<http://horizonepublishing.com/journals/index.php/PST>



Research Article

# Some noteworthy and new records of Liverworts from Barail Wildlife Sanctuary, Assam, India

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Article history

Received: 9 February 2016

Accepted: 30 March 2016

Published: 04 April 2016

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Special Section: New Frontiers in  
Cryptogamic Botany

Section Editor

Afroz Alam

Publisher

Horizon e-Publishing Group

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Abstract

Barail Wildlife Sanctuary (BWS) is situated in Southern Assam, India between the coordinates 24°58' – 25°5'N and 92°46' – 92°52'E covering an area of about 326.24 sq. km. During subsequent explorations in the present study on the liverworts of Barail Wildlife Sanctuary, a total of 14 species have been recorded as new for the state of Assam; 12 species have been found rare within the study area; four species have been recorded as threatened due to various natural and anthropogenic factors and eight species have been found which are endemic to India.

Keywords

Bryophytes; Endemic, Marchantiophyta; Southern Assam; Threatened

Das, S and G. D. Sharma. 2016. Some noteworthy and new records of Liverworts from Barail Wildlife Sanctuary, Assam, India. *Plant Science Today* 3(2): 100-108. <http://dx.doi.org/10.14719/pst.2016.3.2.193>

## Introduction

Barail Wildlife Sanctuary (BWS) (Map 1) is situated in Southern Assam, India between the coordinates 24°58' – 25°5'N and 92°46' – 92°52'E covering an area of about 326.24 sq. km. The sanctuary enjoys tropical climate coupled with heavy showers and high percentage of humidity. These conditions have helped the sanctuary to be a good abode of bryophytes.

Recently, during the present study on the group Hepaticae of Barail Wildlife Sanctuary, 14 species distributed under 10 genera and seven families have been found new for the state of Assam. 12 species have been found rare within the study area; four species as threatened due to various natural and anthropogenic factors and eight species have been found which are endemic to India.

The present communication provides an enumeration of new records of liverworts for the

state of Assam reported from BWS along with rare and threatened taxa, and taxa endemic to India found within the expand of sanctuary.

## Materials and Methods

This observation is based on a survey, collection and observation of liverwort taxa from different eco-regions of the study area during the years 2011 – 2014. Collection and preservation of specimens and recording of field data have been done following standard methods. Photographs of the plants had been taken in the field in their natural habitat. Identification of the specimens has been done through critical morpho-taxonomic analysis under Olympus stereo zoom dissecting microscope and labomade compound microscope. Help from standard relevant literature like protologues, monographs and floras (Sharma and Srivastava, 1993, Zhu and So, 2001, Srivastava and Srivastava,

2002, Rawat and Srivastava, 2007, etc.) have also been taken during the identification process and also for global distribution of the taxa. Distributions are also checked from the website discoverlife.org. Threat statuses of the taxa are assessed upon personal observations of the authors. The whole work has been done following conventional methods of taxonomic study.

## Results and Discussion

### Enumeration of Taxa

1. *Bazzania sikkimensis* (Steph.) Herzog (Lepidoziaceae) (Fig.1 A).

**Habitat:** Terrestrial. Growing in moist rock crevices under shady and extremely waterlogged condition.

**Specimen examined:** India, Assam, Cachar district, Barail Wildlife Sanctuary, Indranagar, ca 70 m, S. Das 25075, Assam University Herbarium.

**Distribution:** It is distributed in Arunachal Pradesh, Assam (present study), Meghalaya, Sikkim and West Bengal in India and also in Nepal, Bhutan, China, Taiwan, Philippines and Thailand (Sharma and Srivastava, 1993; Zhu, 2006; Lai *et al.*, 2008; Singh, Singh and Dey, 2008; Das, 2009; Pradhan and Joshi, 2009; Wang *et al.*, 2011).

**Current status:** New record for the state of Assam. Rare.

2. *Cephalozia pandei* Udar & D. Kumar (Cephaloziaceae).

**Habitat:** Terrestrial. Growing on a thin film of loose sandy soil over rock in moist & shady places.

**Specimen examined:** India, Assam, Cachar district, Barail Wildlife Sanctuary, Malidar, ca 70 m, S. Das 25036a, Assam University Herbarium.

**Distribution:** It is distributed in Arunachal Pradesh, Assam, Meghalaya and West Bengal in India (Udar and Kumar, 1976; Singh, Nath and Asthana, 2003; Das, 2009; Das and Sharma, 2013).

**Current status:** Endemic.

3. *Jungermannia gollanii* Steph. (Jungermanniaceae).

**Habitat:** Terrestrial. Growing on loose soil over rock and limestone rock along the river.

**Specimen examined:** India, Assam, Cachar district, Barail Wildlife Sanctuary, Indranagar, ca 70 m, S. Das 25076, 25086, Assam University Herbarium.

**Distribution:** It is distributed in Assam (present study), Sikkim and Uttarakhand in India and also in Nepal, Bhutan and China (Pradhan and Joshi, 2009; Vaña and Long, 2009).

**Current status:** New record for the state of Assam.

4. *Solenostoma clavellatum* Mitt. ex Steph. (Jungermanniaceae).

**Habitat:** Terrestrial. Growing on bare moist rock or on a thin film of sandy soil over rock, near a ditch.

**Specimen examined:** India, Assam, Cachar district, Barail Wildlife Sanctuary, Marwachhera, ca 50 m, S. Das 25055, 25059, Assam University Herbarium.

**Distribution:** It is distributed in Assam (present study), Meghalaya and Sikkim in India and also in Nepal, Bhutan and China (Zhu, 2006 as '*Jungermannia clavellata* (Mitt. ex Steph.) Amakawa'; Singh *et al.*, 2008 as '*J. clavellata*'; Pradhan and Joshi, 2009 as '*J. clavellata*'; Vaña and Long, 2009).

**Current status:** New record for the state of Assam.

5. *Solenostoma sikkimensis* (Schiffn. ex Steph.) Vaña et D.G.Long (Jungermanniaceae).

**Habitat:** Terrestrial. Growing on thin film of sandy soil over rock, near a ditch.

**Specimen examined:** India, Assam, Cachar district, Barail Wildlife Sanctuary, Marwachhera, ca 50 m, S. Das 25055a, Assam University Herbarium.

**Distribution:** It is distributed in Assam (present study), Meghalaya and West Bengal in India and also in Bhutan and China (Vaña and Long, 2009).

**Current status:** New record for the state of Assam.

6. *Chiloscyphus campanulatus* Steph. (Geocalycaceae).

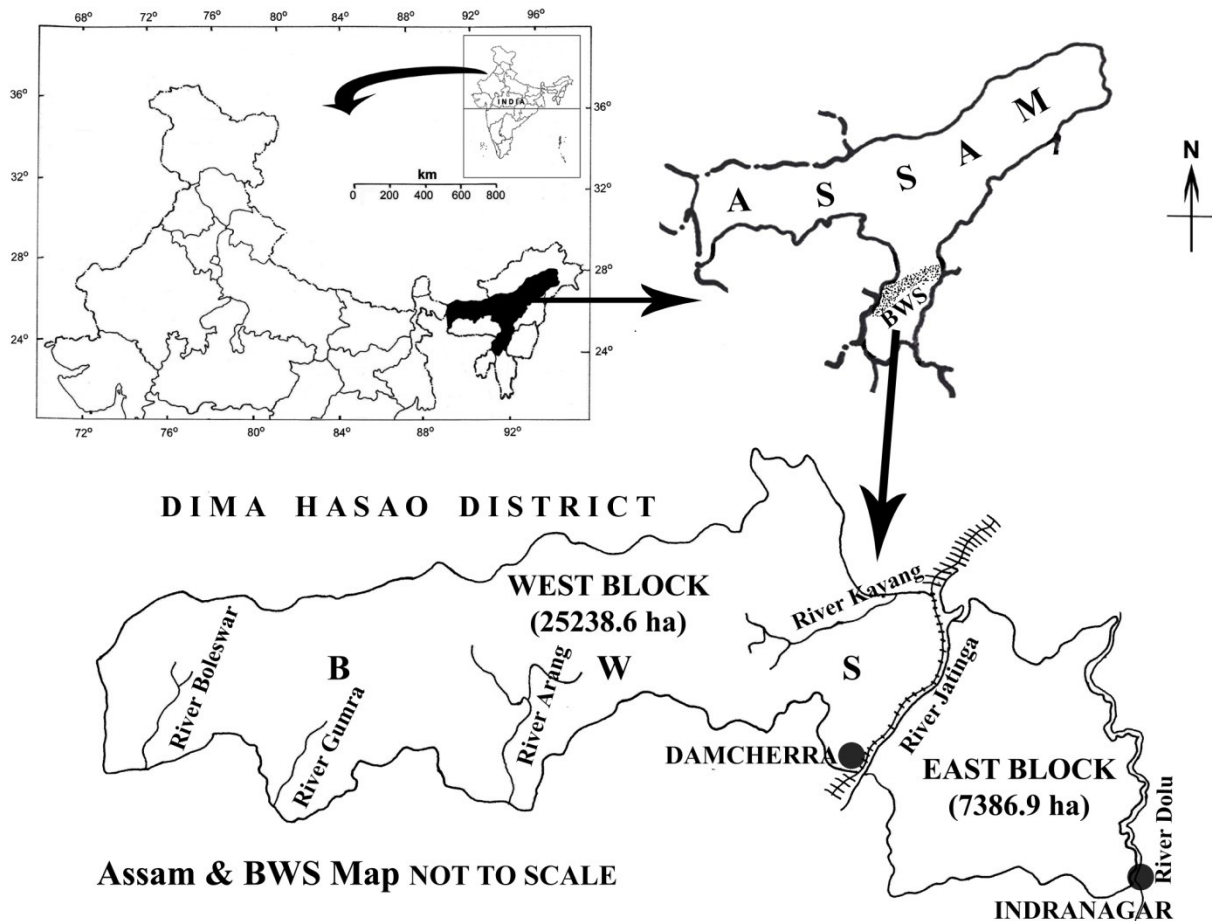
**Habitat:** Terrestrial. Growing on moist soil in shady places or on a thin film of soil over a rock wall exposed to sunlight, along the roadside.

**Specimen examined:** India, Assam, Cachar district, Barail Wildlife Sanctuary, 25 km away from Kumbirgram, ca 70; Marwachhera, ca 50 m, S. Das 25008; S. Das 25051a, Assam University Herbarium.

**Distribution:** It is distributed in Assam, Jammu & Kashmir, Himachal Pradesh and Uttarakhand in India (Srivastava and Srivastava, 2002; Singh and Singh, 2009; Das Bhattacharyya, Bhattacharyya and Sharma, 2011; Das and Sharma, 2013).

**Current status:** Endemic.

7. *Heteroscyphus bescherellei* (Steph.) S. Hatt. (Geocalycaceae).



Map 1: Barail Wildlife Sanctuary (BWS), Assam. (Map Source: Das & Sharma, 2013)

**Habitat:** Terrestrial. Growing in moist and shady place under rock crevices.

**Specimen examined:** India, Assam, Cachar district, Barail Wildlife Sanctuary, Indranagar, ca 80 m, S. Das 25174, Assam University Herbarium.

**Distribution:** It is distributed in Arunachal Pradesh, Assam (present study), Manipur, Meghalaya, Sikkim and West Bengal in India and also in Nepal, China, Japan, Philippines, New Guinea and Australia (Srivastava and Srivastava, 2002; Singh *et al.*, 2008; Das, 2009; Singh *et al.*, 2010).

**Current status:** New record for the state of Assam.

**8. *Heteroscyphus orbiculatus*** Abha Srivast. & S.C. Srivast., (Geocalyceae).

**Habitat:** Terrestrial. Growing on loose soil over rock.

**Specimen examined:** India, Assam, Cachar district, Barail Wildlife Sanctuary, Malidar, ca 70 m, S. Das 25041, Assam University Herbarium.

**Distribution:** It is distributed in Arunachal Pradesh, Assam, Himachal Pradesh and Tamil Nadu in India (Srivastava and Srivastava, 2002;

Singh and Singh, 2003; Das, 2009; Das and Sharma, 2013).

**Current status:** Endemic and Rare.

**9. *Heteroscyphus palniensis*** Abha Srivast. & S.C. Srivast. (Geocalyceae).

**Habitat:** Terrestrial. Growing on bare moist rock beneath River bed; occasionally submerged during monsoon.

**Specimen examined:** India, Assam, Cachar district, Barail Wildlife Sanctuary, Malidar, ca 80 m, S. Das 25030, Assam University Herbarium.

**Distribution:** It is distributed in Assam, Sikkim and Tamil Nadu in India (Srivastava and Srivastava, 2002, Dey, Singh and Singh, 2009; Singh and Barbhuiya, 2012; Das and Sharma, 2013).

**Current status:** Endemic.

**10. *Heteroscyphus pandei*** S.C. Srivast. & Abha Srivast. (Geocalyceae).

**Habitat:** Terrestrial. Growing on damp soil in shady places in association with mosses.

**Specimen examined:** India, Assam, Cachar district, Barail Wildlife Sanctuary, Marwachhera, ca 50 m, S. Das 25023, Assam University Herbarium.

**Distribution:** It is distributed in Assam, Manipur, Sikkim, West Bengal, Himachal Pradesh and Uttarakhand in India and also in Nepal (Srivastava and Srivastava, 2002; Singh *et al.*, 2008; Singh and Singh, 2009; Singh, Dey and Singh, 2010; Das and Sharma, 2012, 2013).

**Current status:** Rare and Threatened.

**11. *Heteroscyphus parvus*** Abha Srivast. & S. C. Srivast. (Geocalycaceae).

**Habitat:** Terrestrial. Growing on damp, the extremely moist soil along the ditch.

**Specimen examined:** India, Assam, Cachar district, Barail Wildlife Sanctuary, Kaong, ca 70 m, S. Das 25121, Assam University Herbarium.

**Distribution:** It is distributed in Arunachal Pradesh, Assam (present study), Madhya Pradesh and Sikkim in India and also in Nepal (Srivastava and Srivastava, 2002; Singh *et al.*, 2008; Das, 2009).

**Current status:** New record for the state of Assam.

**12. *Plagiochila defolians*** Grolle & M.L.So (Plagiochilaceae) (Fig.1 B).

**Habitat:** Epiphytic. Growing on branches of Fig tree and rough stem bark of other angiosperms in dense forest.

**Specimen examined:** India, Assam, Cachar district, Barail Wildlife Sanctuary, Lakhichhera, ca 90 m, S. Das 25218, 25222a, 25272, Assam University Herbarium.

**Distribution:** It is distributed in Assam (present study) and West Bengal in India and also in China (So, 2001; Zhu, 2006; Rawat and Srivastava, 2007).

**Current status:** New record for the state of Assam.

**13. *Plagiochila grollei*** Inoue (Plagiochilaceae).

**Habitat:** Terrestrial. Growing in crevices of rocks under shady condition.

**Specimen examined:** India, Assam, Cachar district, Barail Wildlife Sanctuary, Marwachhera, ca 50 m, S. Das 25071, Assam University Herbarium.

**Distribution:** It is distributed in Assam and West Bengal in India and also in Bhutan, Nepal, China and Vietnam (So, 2001; Rawat and Srivastava, 2007; Das and Sharma, 2013).

**Current status:** Rare.

**14. *Archilejeunea apiculifolia*** Steph. (Lejeuneaceae) (Fig.1 C).

**Habitat:** Epiphytic. Growing on the stem bark of the fig tree in the vicinity of the forest, under exposed condition.

**Specimen examined:** India, Assam, Cachar district, Barail Wildlife Sanctuary, Indranagar, ca 80 m, S. Das 25080, Assam University Herbarium.

**Distribution:** It is distributed in Assam (present study), Kerala, Tamil Nadu (Udar and Awasthi 1981, 1981a; Nair, Rajesh and Madhusoodanan, 2008).

**Current status:** New record for the state of Assam. Endemic and Rare.

**15. *Archilejeunea minutilobula*** Udar & U.S. Awasthi (Lejeuneaceae).

**Habitat:** Epiphytic. Growing on the bark of angiosperms.

**Specimen examined:** India, Assam, Cachar district, Barail Wildlife Sanctuary, 25 km away from Kumbirgram, ca 70 m, S. Das 25010a, Assam University Herbarium.

**Distribution:** It is distributed in Arunachal Pradesh, Assam, Maharashtra and Tamil Nadu in India (Udar and Awasthi, 1981; Das and Singh, 2007; Singh and Barbhuiya, 2012; Das and Sharma, 2013).

**Current status:** Endemic.

**16. *Caudalejeunea reniloba*** (Gottsche) Steph. (Lejeuneaceae).

**Habitat:** Epiphytic. Growing on the stem bark of the angiospermic plant in dense forest.

**Specimen examined:** India, Assam, Cachar district, Barail Wildlife Sanctuary, Indranagar, ca 80 m, S. Das 25079, Assam University Herbarium.

**Distribution:** It is distributed in Assam, Karnataka, Kerala and Andaman & Nicobar Islands in India and also in China, Taiwan; Java, Malaysia, Africa (Kitagawa, 1971; Udar, Awasthi and Shaheen, 1982 as *C. pluriplicata*; Joshi, Wani and Chavan, 1989; Luo, 1990; Nair *et al.*, 2008; Wigginton, 2009 as *Caudalejeunea recurvistipula*; Soderstrom, Gradstein and Hagborg, 2010 as *Caudalejeunea recurvistipula*; Wang *et al.*, 2011; Sing and Barbhuiya, 2012).

**Current status:** Threatened.

**17. *Cheilolejeunea girdiana*** (C. Massal) Mizut. (Lejeuneaceae).



A



B



C



D



E



F

Fig. 1. A. *Bazzania sikkimensis*; B. *Plagiochila defolians*; C. *Archilejeunea apiculifolia*; D. *Cololejeunea siangensis*; E. *Lejeunea alata*; F. *Riccardia levieri*.

**Habitat:** Terrestrial. Growing on loose soil over rock in moist & shady places.

**Specimen examined:** India, Assam, Cachar district, Barail Wildlife Sanctuary, 25 km away from Kumbirgram, ca 70 m, S. Das 25009b, Assam University Herbarium.

**Distribution:** It is distributed in Assam (present study), Manipur, Meghalaya, Sikkim and West Bengal in India and also in Nepal, China, Japan and Phillipines (Mizutani, 1972; Asthana *et al.*, 1995; Singh and Nath, 2007; Singh *et al.*, 2010).

**Current status:** New record for the state of Assam. Rare.

**18. *Cheilolejeunea intertexta*** (Lindenb.) Steph. (Lejeuneaceae).

**Habitat:** Terrestrial. Growing on loose, moist soil in rock crevices under shady condition.

**Specimen examined:** India, Assam, Cachar district, Barail Wildlife Sanctuary, Malidar, ca 70 m, *S. Das* 25039b, Assam University Herbarium.

**Distribution:** It is distributed in Assam (present study), Meghalaya, Kerala, Tamil Nadu and Andaman & Nicobar Islands in India and also in Sri Lanka, China, Hong Kong, Singapore, Indonesia, Malaysia, Japan, Taiwan, Micronesia, Nigeria and Philippines (Mizutani, 1972, 1982; Asthana *et al.*, 1995; So and Zhu, 1996; Piippo *et al.*, 2002; Zhu, 2006; Singh and Nath, 2007; Nair *et al.*, 2008; Daniels, 2010; Chuah-Petiot, 2011; Wang *et al.*, 2011).

**Current status:** New record for the state of Assam. Rare.

**19. *Cololejeunea latilobula*** (Herzog) Tixier (Lejeuneaceae).

**Habitat:** Epiphytic. Growing on the bark of angiosperms.

**Specimen examined:** India, Assam, Cachar district, Barail Wildlife Sanctuary, 25 km away from Kumbirgram, ca 70 m, *S. Das* 25010b, Assam University Herbarium.

**Distribution:** It is distributed in Arunachal Pradesh, Assam, Manipur, Meghalaya, Sikkim, Uttarakhand, Madhya Pradesh, Karnataka, Kerala and Tamil Nadu in India and also in China, Taiwan, Myanmar, Fiji, Africa (Asthana and Srivastava, 2003; Zhu, 2006; Nair *et al.*, 2008; Singh *et al.*, 2008; Das, 2009; Wigginton, 2009; Daniels, 2010; Singh *et al.*, 2010; Pócs *et al.*, 2011; Wang *et al.*, 2011; Nair *et al.*, 2012; Singh and Barbhuiya, 2012;).

**Current status:** Rare.

**20. *Cololejeunea siangensis*** G. Asthana & S.C. Srivast. (Lejeuneaceae) (Fig.1 D).

**Habitat:** Epiphytic. Appressed to the rough stem bark of angiosperms.

**Specimen examined:** India, Assam, Cachar district, Barail Wildlife Sanctuary, 25 km away from Kumbirgram, ca 70 m, *S. Das* 25001, Assam University Herbarium.

**Distribution:** It is distributed in Arunachal Pradesh and Assam in India (Asthana and Srivastava, 2003; Das and Sharma, 2012, 2013).

**Current status:** Endemic and Rare.

**21. *Lejeunea alata*** Gottsche (Lejeuneaceae) (Fig.1 E).

**Habitat:** Epiphytic. Growing on bark in dense forest.

**Specimen examined:** India, Assam, Cachar district, Barail Wildlife Sanctuary, Lakhichhera, ca 90 m, *S. Das* 25196, Assam University Herbarium.

**Distribution:** It is distributed in Arunachal Pradesh, Assam (present study), Manipur, Sikkim and West Bengal in India and also in China, Indonesia, Malaysia, Papua New Guinea, Vietnam and Africa (Zhu and So, 2001; Dey and Singh, 2008; Das, 2009; Dey *et al.*, 2009; Wigginton, 2009; Singh *et al.*, 2010; Chuah-Petiot, 2011).

**Current status:** New record for the state of Assam.

**22. *Trocholejeunea infuscata*** (Mitt.) Verd. (Lejeuneaceae).

**Habitat:** Epiphytic, on bark of higher plants under moist condition.

**Specimen examined:** India, Assam, Cachar district, Barail Wildlife Sanctuary, Marwacherra ca 50 m, *S. Das* 25067, Assam University Herbarium.

**Distribution:** It is distributed in Arunachal Pradesh, Assam, Manipur, Meghalaya, Sikkim, West Bengal, Himachal Pradesh in India and also in Sri Lanka, Nepal, Bhutan, China, Myanmar, Philippines, Thailand (Mitten, 1861; Awasthi and Srivastava, 1988; Singh and Singh, 2007; Singh *et al.*, 2008; Das, 2009; Singh *et al.*, 2010; Singh and Barbhuiya, 2012; Das and Sharma, 2013).

**Current status:** Rare.

**23. *Riccardia levieri*** Schiffn. (Aneuraceae) (Fig.1 F).

**Habitat:** Epiphytic on twig and lignicolous on rotten wood. Growing along small water fall.

**Specimen examined:** India, Assam, Cachar district, Barail Wildlife Sanctuary, Ditekchhera, ca 90 m, *S. Das* 25123, 25124, Assam University Herbarium.

**Distribution:** It is distributed in Arunachal Pradesh, Assam (present study), Himachal Pradesh, Karnataka, Madhya Pradesh, Manipur, Tamil Nadu, Uttarakhand and West Bengal in India and also in Bhutan (Srivastava and Udar, 1976; Das, 2009; Singh and Singh, 2009; Singh *et al.*, 2010).

**Current status:** New record for the state of Assam.

**24. *Riccardia sikkimensis***(Steph.) Pande & K.P. Srivast. (Aneuraceae).

**Habitat:** Terrestrial. Growing in the groove of boulders along small water fall.

**Specimen examined:** India, Assam, Cachar district, Barail Wildlife Sanctuary, Ditekchhera, ca 90 m, S. Das 25126, Assam University Herbarium.

**Distribution:** It is distributed in Arunachal Pradesh, Assam (present study), Manipur, Meghalaya, Sikkim, West Bengal and Western Himalayas in India (Srivastava and Udar, 1976; Singh, 1996; Singh *et al.*, 2010).

**Current status:** New record for the state of Assam. Endemic.

**25. *Riccardia tenuicostata*** Schiffn. (Aneuraceae).

**Habitat:** Terrestrial, on bare shady rock along roadside.

**Specimen examined:** India, Assam, Cachar district, Barail Wildlife Sanctuary, Malidar, ca 80 m, S. Das 25047, Assam University Herbarium.

**Distribution:** It is distributed in Arunachal Pradesh, Assam, Manipur, Meghalaya, Sikkim, West Bengal, Himachal Pradesh, Uttarakhand and Tamil Nadu in India and also in Singapore, Indonesia, Malaysia (Srivastava and Udar, 1976; Singh and Nath, 2007; Das, 2009; Singh and Singh, 2010; Singh *et al.*, 2010; Söderström *et al.*, 2010; Das and Sharma, 2013).

**Current status:** Rare.

**26. *Conocephalum japonicum*** (Thunb.) Grolle (Conocephalaceae).

**Habitat:** Terrestrial. Growing on bare moist rock beneath the riverbed.

**Specimen examined:** India, Assam, Cachar district, Barail Wildlife Sanctuary, Malidar, ca 70 m, S. Das 25033c, Assam University Herbarium.

**Distribution:** It is distributed in Arunachal Pradesh, Assam, Sikkim and West Bengal in India and also in Nepal, Bhutan, Taiwan, Korea, Japan and China (Singh, 1996; Singh and Singh, 2003a; Zhu, 2006; Das, 2009; Pradhan and Joshi, 2009; Wang *et al.*, 2011; Das and Sharma, 2013).

**Current status:** Rare.

**27. *Marchantia geminata*** Reinw. *et al.* (Marchantiaceae).

**Habitat:** Terrestrial. Growing on loose sandy soil over rock.

**Specimen examined:** India, Assam, Cachar district, Barail Wildlife Sanctuary, Indranagar, ca 80 m, S. Das 25082, Assam University Herbarium.

**Distribution:** It is distributed in Andaman & Nicobar Islands, Assam (present study) and Meghalaya in India and also in Indonesia, Malaysia and Philippines (Tan and Engel, 1986; Bischler-Causse, 1989; Singh and Nath, 2007; Söderström *et al.*, 2010; Chuah-Petiot, 2011).

**Current status:** New record for the state of Assam. Threatened.

**28. *Marchantia papillata*** Raddi subsp. *grossibarba* (Steph.) Bischl. (Marchantiaceae).

**Habitat:** Terrestrial. Growing on moist soil of the riverbed, in the crevice of a boulder and also on loose sandy soil over rock.

**Specimen examined:** India, Assam, Cachar district, Barail Wildlife Sanctuary, Indranagar, ca 80 m, S. Das 25083, 25088, Assam University Herbarium.

**Distribution:** It is distributed in Arunachal Pradesh, Assam, Meghalaya, Nagaland, Sikkim, West Bengal, Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Odisha, Madhya Pradesh, Uttar Pradesh, Punjab, Rajasthan, Kerala and Tamil Nadu in India and also in Sri Lanka, Bangladesh, Nepal, Bhutan, Pakistan, Afganistan, China, Myanmar and Thailand (Kashyap, 1929; Pande and Srivastava, 1952; Udar and Jain, 1984; Bischler-Causse, 1989; Barukial, Gogoi and Barua, 2002 as *M. palmata*; Singh and Nath, 2007; Lai *et al.*, 2008; Singh *et al.*, 2008; Pradhan and Joshi, 2009; Daniels, 2010; Singh and Singh, 2010; Singh and Barbhuiya, 2012; Alam *et al.*, 2013 as *M. palmata*).

**Current status:** Threatened.

## Conclusion

During our survey, we have identified several detrimental effects on the liverworts growing in BWS due to various anthropogenic activities, mainly on those, growing in the buffer and transition zones of the sanctuary. Each rare taxon has been found restricted in a single small locality. Whereas, in case of the threatened taxa, some of them were reported from more than one locally within the study area during initial visits. But in subsequent explorations to those localities, they couldn't be relocated in some of their early locations. Cutting of roadside rock walls and the destruction of forests due to construction of highways through the forest is the main cause of threat for the plants. Apart from that, cutting of trees and logs for unauthorized wood trade by the local people and villagers living in the vicinity of forest is also destroying the microhabitat of tiny epiphytic taxa. Attempts for *in situ* and *ex situ* conservation of the rare and threatened taxa have been done in the field and in the laboratory, respectively to check further decline in the liverwort diversity of BWS.

## Authors' Contribution

SD carried out the whole research, including field exploration, plant collection, identification, assessment and manuscript preparation. GDS is the mentor of SD. Both SD and GDS have gone through the final manuscript, read and approved it.

## Acknowledgements

The authors are grateful to the Head, Department of Life Science and Bioinformatics, Assam University, Silchar for facilities. They also thank the Officer in-charge, Forest Department, Cachar & Karimganj Division of Barail Wildlife Sanctuary, Assam for permitting exploration work within the sanctuary. One of the authors (SD) is thankful to University Grants Commission, New Delhi, India for financial assistance under the UGC-Dr. D. S. Kothari Postdoctoral Fellowship Scheme.

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