

Building evidence for conservation globally

Journal of Threatened Taxa

10.11609/jott.2024.16.8.25639-25790

www.threatenedtaxa.org

26 August 2024 (Online & Print)

16(8): 25639-25790

ISSN 0974-7907 (Online)

ISSN 0974-7893 (Print)



Open Access





ISSN 0974-7907 (Online); ISSN 0974-7893 (Print)

Publisher
Wildlife Information Liaison Development Society
www.wild.zooreach.org

Host
Zoo Outreach Organization
www.zooreach.org

43/2 Varadarajulu Nagar, 5th Street West, Ganapathy, Coimbatore, Tamil Nadu 641006, India
Registered Office: 3A2 Varadarajulu Nagar, FCI Road, Ganapathy, Coimbatore, Tamil Nadu 641006, India
Ph: +91 9385339863 | www.threatenedtaxa.org
Email: sanjay@threatenedtaxa.org

EDITORS

Founder & Chief Editor

Dr. Sanjay Molur

Wildlife Information Liaison Development (WILD) Society & Zoo Outreach Organization (ZOO),
43/2 Varadarajulu Nagar, 5th Street West, Ganapathy, Coimbatore, Tamil Nadu 641006, India

Deputy Chief Editor

Dr. Neelesh Dahanukar

Noida, Uttar Pradesh, India

Managing Editor

Mr. B. Ravichandran, WILD/ZOO, Coimbatore, Tamil Nadu 641006, India

Associate Editors

Dr. Mandar Paingankar, Government Science College Gadchiroli, Maharashtra 442605, India

Dr. Ulrike Streicher, Wildlife Veterinarian, Eugene, Oregon, USA

Ms. Priyanka Iyer, ZOO/WILD, Coimbatore, Tamil Nadu 641006, India

Dr. B.A. Daniel, ZOO/WILD, Coimbatore, Tamil Nadu 641006, India

Editorial Board

Dr. Russel Mittermeier

Executive Vice Chair, Conservation International, Arlington, Virginia 22202, USA

Prof. Mewa Singh Ph.D., FASc, FNA, FNAsc, FNAPsy

Ramanna Fellow and Life-Long Distinguished Professor, Biopsychology Laboratory, and
Institute of Excellence, University of Mysore, Mysuru, Karnataka 570006, India; Honorary
Professor, Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore; and Adjunct
Professor, National Institute of Advanced Studies, Bangalore

Stephen D. Nash

Scientific Illustrator, Conservation International, Dept. of Anatomical Sciences, Health Sciences
Center, T-8, Room 045, Stony Brook University, Stony Brook, NY 11794-8081, USA

Dr. Fred Pluthero

Toronto, Canada

Dr. Priya Davidar

Sigur Nature Trust, Chadapatti, Mavinahalla PO, Nilgiris, Tamil Nadu 643223, India

Dr. Martin Fisher

Senior Associate Professor, Battcock Centre for Experimental Astrophysics, Cavendish
Laboratory, JJ Thomson Avenue, Cambridge CB3 0HE, UK

Dr. John Fellowes

Honorary Assistant Professor, The Kadoorie Institute, 8/F, T.T. Tsui Building, The University of
Hong Kong, Pokfulam Road, Hong Kong

Prof. Dr. Mirco Solé

Universidade Estadual de Santa Cruz, Departamento de Ciências Biológicas, Vice-coordenador
do Programa de Pós-Graduação em Zoologia, Rodovia Ilhéus/Itabuna, Km 16 (45662-000)
Salobrinho, Ilhéus - Bahia - Brasil

Dr. Rajeev Raghavan

Professor of Taxonomy, Kerala University of Fisheries & Ocean Studies, Kochi, Kerala, India

English Editors

Mrs. Mira Bhojwani, Pune, India

Dr. Fred Pluthero, Toronto, Canada

Mr. P. Ilangoan, Chennai, India

Ms. Sindhura Stothra Bhashyam, Hyderabad, India

Web Development

Mrs. Latha G. Ravikumar, ZOO/WILD, Coimbatore, India

Typesetting

Mrs. Radhika, ZOO, Coimbatore, India

Mrs. Geetha, ZOO, Coimbatore India

Fundraising/Communications

Mrs. Payal B. Molur, Coimbatore, India

Subject Editors 2020–2022

Fungi

Dr. B. Shivaraju, Bengaluru, Karnataka, India

Dr. R.K. Verma, Tropical Forest Research Institute, Jabalpur, India

Dr. Vatsavaya S. Raju, Kakatiya University, Warangal, Andhra Pradesh, India

Dr. M. Krishnappa, Jnana Sahyadri, Kuvempu University, Shimoga, Karnataka, India

Dr. K.R. Sridhar, Mangalore University, Mangalagangothri, Mangalore, Karnataka, India

Dr. Gunjan Biswas, Vidyasagar University, Midnapore, West Bengal, India

Dr. Kiran Ramchandra Ranadive, Annasaheb Magar Mahavidyalaya, Maharashtra, India

Plants

Dr. G.P. Sinha, Botanical Survey of India, Allahabad, India

Dr. N.P. Balakrishnan, Ret. Joint Director, BSI, Coimbatore, India

Dr. Shonil Bhagwat, Open University and University of Oxford, UK

Prof. D.J. Bhat, Retd. Professor, Goa University, Goa, India

Dr. Ferdinando Boero, Università del Salento, Lecce, Italy

Dr. Dale R. Calder, Royal Ontario Museum, Toronto, Ontario, Canada

Dr. Cleofas Cervancia, Univ. of Philippines Los Baños College Laguna, Philippines

Dr. F.B. Vincent Florens, University of Mauritius, Mauritius

Dr. Merlin Franco, Curtin University, Malaysia

Dr. V. Irudayaraj, St. Xavier's College, Palayamkottai, Tamil Nadu, India

Dr. B.S. Kholia, Botanical Survey of India, Gangtok, Sikkim, India

Dr. Pankaj Kumar, Department of Plant and Soil Science, Texas Tech University, Lubbock, Texas, USA.

Dr. V. Sampath Kumar, Botanical Survey of India, Howrah, West Bengal, India

Dr. A.J. Solomon Raju, Andhra University, Visakhapatnam, India

Dr. Vijayasankar Raman, University of Mississippi, USA

Dr. B. Ravi Prasad Rao, Sri Krishnadevaraya University, Anantpur, India

Dr. K. Ravikumar, FRLHT, Bengaluru, Karnataka, India

Dr. Aparna Watve, Pune, Maharashtra, India

Dr. Qiang Liu, Xishuangbanna Tropical Botanical Garden, Yunnan, China

Dr. Noor Azhar Mohamed Shazili, Universiti Malaysia Terengganu, Kuala Terengganu, Malaysia

Dr. M.K. Vasudeva Rao, Shiv Ranjani Housing Society, Pune, Maharashtra, India

Prof. A.J. Solomon Raju, Andhra University, Visakhapatnam, India

Dr. Mandar Datar, Agharkar Research Institute, Pune, Maharashtra, India

Dr. M.K. Janarthanam, Goa University, Goa, India

Dr. K. Karthikeyan, Botanical Survey of India, India

Dr. Errol Vela, University of Montpellier, Montpellier, France

Dr. P. Lakshminarasimhan, Botanical Survey of India, Howrah, India

Dr. Larry R. Noblick, Montgomery Botanical Center, Miami, USA

Dr. K. Haridasan, Pallavur, Palakkad District, Kerala, India

Dr. Analinda Manila-Fajard, University of the Philippines Los Banos, Laguna, Philippines

Dr. P.A. Sinu, Central University of Kerala, Kasaragod, Kerala, India

Dr. Afroz Alam, Banasthali Vidyapith (accredited A grade by NAAC), Rajasthan, India

Dr. K.P. Rajesh, Zamorin's Guruvayurappan College, GA College PO, Kozhikode, Kerala, India

Dr. David E. Boufford, Harvard University Herbaria, Cambridge, MA 02138-2020, USA

Dr. Ritesh Kumar Choudhary, Agharkar Research Institute, Pune, Maharashtra, India

Dr. A.G. Pandurangan, Thiruvananthapuram, Kerala, India

Dr. Navendu Page, Wildlife Institute of India, Chandrabani, Dehradun, Uttarakhand, India

Dr. Kannan C.S. Warriar, Institute of Forest Genetics and Tree Breeding, Tamil Nadu, India

Invertebrates

Dr. R.K. Avasthi, Rohtak University, Haryana, India

Dr. D.B. Bastawade, Maharashtra, India

Dr. Partha Pratim Bhattacharjee, Tripura University, Suryamaninagar, India

Dr. Kailash Chandra, Zoological Survey of India, Jabalpur, Madhya Pradesh, India

Dr. Ansie Dippenaar-Schoeman, University of Pretoria, Queenswood, South Africa

Dr. Rory Dow, National Museum of Natural History Naturalis, The Netherlands

Dr. Brian Fisher, California Academy of Sciences, USA

Dr. Richard Gallon, Llandudno, North Wales, LL30 1UP

Dr. Hemant V. Ghate, Modern College, Pune, India

Dr. M. Monwar Hossain, Jahangirnagar University, Dhaka, Bangladesh

For Focus, Scope, Aims, and Policies, visit https://threatenedtaxa.org/index.php/JoTT/aims_scope
For Article Submission Guidelines, visit <https://threatenedtaxa.org/index.php/JoTT/about/submissions>
For Policies against Scientific Misconduct, visit https://threatenedtaxa.org/index.php/JoTT/policies_various

continued on the back inside cover

Cover: Watercolour illustrations—Striped Tiger *Danaus genutia*, Common Silverline *Cigaritis vulcanus*, Tamil Lacewing *Cethosia mahratta*. © Mayur Nandikar.



Diversity of vascular epiphytes on preferred shade trees in tea gardens of sub-Himalayan tracts in West Bengal, India

Roshni Chowdhury¹ & M. Chowdhury²

^{1,2}Taxonomy of Angiosperm and Biosystematics Laboratory, Department of Botany, University of North Bengal, Darjeeling, West Bengal 734014, India.

¹rchowdhury268@gmail.com, ²mono_malda@yahoo.co.in (corresponding author)

Abstract: Tea gardens are the main economic backbone of the Terai & Dooars region and intermingle with forest areas of northern Bengal in India. The study aims to explore the vascular epiphytic diversity and their zone-wise assemblage pattern on 10 dominant shade trees in the tea gardens. Four years (March 2018–September 2022) of surveys recorded a total of 6,704 individuals that belong to 74 species of 20 families of vascular epiphytes. Considering life forms, the majority of them are holoepiphytes (62.16%), followed by hemiepiphytes (20.27%), accidental epiphytes (13.51%), and facultative epiphytes (2.7%). The predominantly recorded families are Orchidaceae (21 spp.), Araceae (11 spp.), Apocyanaceae with six species, and Piperaceae & Pteridaceae with three species each. *Albizia lebbeck* (L.) Benth. hosts a maximum of 737 vascular epiphytic assemblages (VEAs), whereas, *Gmelina arborea* Roxb. has a minimum of 450 VEAs. Vascular epiphytes were also studied for their host specificity using interpolation and extrapolation analyses. The findings of the study show that vascular epiphytic assemblage upon the shade trees of the tea garden has a remarkably high potential to contribute toward epiphytic diversity of this region other than forest and contribute significant ecological impacts.

Keywords: Diameter at breast height, Orchidaceae, Shannon-Weiner index, vascular epiphytic assemblages, vertical distribution, zonation pattern.

Editor: Pankaj Kumar, Institute of Environment, Florida International University, Miami, Florida, USA.

Date of publication: 26 August 2024 (online & print)

Citation: Chowdhury, R. & M. Chowdhury (2024). Diversity of vascular epiphytes on preferred shade trees in tea gardens of sub-Himalayan tracts in West Bengal, India. *Journal of Threatened Taxa* 16(8): 25720–25729. <https://doi.org/10.11609/jott.8660.16.8.25720-25729>

Copyright: © Chowdhury & Chowdhury 2024. Creative Commons Attribution 4.0 International License. JoTT allows unrestricted use, reproduction, and distribution of this article in any medium by providing adequate credit to the author(s) and the source of publication.

Funding: This research was funded by CSIR– NFSC fellowship from the Department of Social Justice & Empowerment, Government of India.

Competing interests: The authors declare no competing interests.

Author details: ROSHNI CHOWDHURY, M.Sc.—engaged as senior research scholar in the Department of Botany, University of North Bengal. She has been working on the vascular epiphytic flora of Terai and Dooars and their ecological impacts on this region since 2019. Her main focus is to study vascular epiphytic assemblages in forest, urban, rural, and tea gardens of the study area. DR. MONORANJAN CHOWDHURY, Ph.D.—works as a professor in the Department of Botany at the University of North Bengal. His research team is currently working on taxonomy & systematic studies on the disputed families, like Polygonaceae, Linderniaceae, Arecaceae, Fagaceae, and Urticaceae; Rubus, Artemisia; ethnobotany of Himalayan tribes; forest & Wetland ecosystems; epiphytes; pharmacognostic characterization and evaluation of medicinal plants and their conservation in eastern Himalaya.

Author contributions: RC—contributed to data collection, field visits, sampling, data analysis, map making, and manuscript preparation. MC—contributed to data analysis, taking photographs, graph making, and study site explorations

Acknowledgements: We would like to express our sincere gratitude to the tea garden officials for permitting us to carry out the studies. The first author is obliged to CSIR– NFSC Fellowship from the Department of Social Justice & Empowerment, Government of India. We are also thankful to ICAR Central Tobacco Research Institute, Dinahata for providing meteorological data on the study area. We take this opportunity to express our gratitude to the tea workers of this region for their tremendous support and help throughout the studies. The author wants to convey their thanks to the subject editor and reviewers for their valuable suggestions which turned this manuscript into its best form.



INTRODUCTION

Vascular epiphytes are a conspicuous and highly diverse group in nature (Benzing 1987). Epiphytes are found to grow at the base of tree trunks up to as high as 50 m or even higher favouring the discussion of canopy access, ecological role, ecophysiology, and conservation of epiphytes. The major groups with epiphytic genus are ferns, gymnosperms, monocots (especially orchids, bromeliads, and aroids), and dicots. Epiphytes are not restricted to living hosts only, instead, they can also grow on the non-living substrate with adequate moisture content and favourable environmental conditions (Madison 1977). They are a significant component of tropical and subtropical forests, not just because of their diverse species, but also for their huge biomass accumulation (Gentry & Dodson 1987; Benzing 1990; Nadkarni 1994; Isaza et al. 2004). In relation to their habitat, they are not only part of forest flora but also an inevitable part of the urban localities, and tea gardens of this region. The tropical climate of the West Bengal supports more than 300 tea gardens (Terai, Dooars, and Darjeeling) according to the Tea Board of India mainly due to appropriate rainfall, soil character (clay to sandy loam in texture), and high humidity present in this region (<https://www.teaboard.gov.in/> as retrieved on 30 July 2023). The tea-growing areas of this region range 90–1,750 m with annual rainfall of around 350 cm. These tea gardens play a significant role in the economy of this region and also support enriching the green coverage of the area. The trees adjacent to the tea gardens show immense epiphytic diversity and are an important part of increasing tea productivity under favourable environmental conditions by conserving soil from erosion during heavy rainfall (Rahman et al. 2020). The tree also enriches soil fertility and organic matter content through leaf litter and supports diverse flora and fauna (Visser 1961; Hadfield 1974, Mohotti 2004). A total of 45 species of preferred shade trees representing 34 genera of 15 families were recorded from the tea gardens of Terai and Dooars out of which Fabaceae shows the highest number of preferred shade trees (Chowdhury et al. 2016). The major shade trees of this region are *Albizia odoratissima* (L.f.) Benth., *Albizia chinensis* (Osbeck) Merr., *Albizia lebbeck* (L.) Benth., *Albizia procera* (Roxb.) Benth., *Dalbergia sissoo* Roxb. ex DC., *Erythrina variegata* L., and *Melia azedarach* L. (Barua 2007). Therefore, the present study attempts to analyse and record the vascular epiphytic diversity in the tea gardens of the study area to understand the present ecosystem for future conservation.

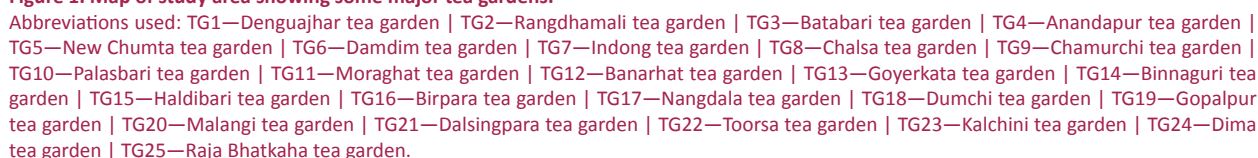
MATERIAL AND METHODS

Study area

The present study was conducted in the tea gardens of Terai & Dooars of West Bengal, which are spreading through the districts of Jalpaiguri, Alipurduar, some parts of Coochbehar, and the plains of Darjeeling (Figure 1). The study area is located at 25.944–26.606 °N and 89.899–88.786 °E (Terai) 26.278–26.999 °N and 88.066–89.880 °E (Dooars) with the altitude range varying 80–150 m (Chowdhury 2015). The entire area has many rivers and rivulets like Teesta, Torsa, Jarda, Raidak, Jaldhaka, and Sankosh, coming from the Darjeeling, Sikkim Himalaya, Nepal and Bhutan. The protected areas of this region is predominated by tropical evergreen forests, namely: Chapramari Wildlife Sanctuary, Gorumara National Park, Neora Valley National Park, Jaldapara National Park, and Mahananda Wildlife Sanctuary. Moreover, the average rainfall of this region is 120–350 mm with a relative humidity of 99.4%, and temperature ranges from 6.5–35 °C as provided by CTRI, Dinhata. The major tea gardens of this region are the Matigara Tea Garden, Gaya Ganga Tea Garden, Hansqua Tea Garden, Dagapur Tea Garden, Gulma Tea Garden, Denguajhar Tea Garden, Damdim Tea Garden, Bagrakot Tea Garden, Batabari Tea Garden, Dyna Tea Garden, and Dalgaon Tea Garden (Table 1).

Data collection

Extensive taxonomical explorations in different tea gardens of this region were done from March 2018 to September 2022 at proper intervals of time in pre-monsoon (March–May), monsoon (July–September), and post-monsoon (November–January) seasons. A vegetation survey was done by random sampling method, where host species were chosen randomly with exclusive characters like DBH (Freiberg 2000; Nieder et al. 2001) to make a checklist of the vascular epiphytes of the tea gardens. The collected specimens were identified in the field, and the unidentified specimens were preserved following standard Herbarium techniques (Paul et. al 2020). Plants were identified using relevant identification keys (Prain 1903; Noltie 2000; Singh et al. 2005) and digital repositories (POWO). All the identified voucher specimens were deposited at the North Bengal University herbarium (NBU). During the survey, binoculars (Nikon ACULON A211 10x50) were used for the highly developed canopies and in some areas ladders (Image 1) or indigenous tree climbers were used (Tafa 2010). The vertical distribution of the epiphytes was recorded in five vertical tree zones following a zonation


$$Y = a + bX$$

Accordingly, the zonation pattern on the (Figure 2) host is categorised into three zones: i) Basal zone (ZN1), from the ground to tree breast height; ii) Trunk (ZN2), to the first fork; and iii) Canopy, first branching/fork to the ultimate tip (ZN3; ZN4; ZN5). The vertical stratification method of Johansson (1974) was slightly modified by taking the entire trunk of the tree as Zone 1. The species were then classified based on their occurrence on host trees and their zone upon host for preference for proliferation (Mojjoli et al. 2009). All the recorded species are summarised in Table 2 regarding their life forms (holoepiphytes: true epiphytes growing on host trees; hemi epiphytes: first grow as terrestrial plant later on adapt epiphytic life form; facultative: not true epiphyte can grow as terrestrial or as epiphyte, and accidental: true terrestrial plants accidentally grow upon host tree), status, zone preference, host preference, and distribution.

$$H = -\sum p_i (\ln p_i)$$

To predict the correlation between the two variables linear regression equation was used depending on

RESULTS

The present study recorded a total of 6,704 individuals that belonged to 74 species representing 45 genera of 20 families of vascular epiphytes. Among the collected species 46 species were holoeiphyte (62.16%), 15 species were hemieiphyte (20.27%), 10 species were accidental epiphytes (13.51%), and two species were facultative epiphytes (2.7%). Orchidaceae was the most dominant family with 21 species (28%) belonging to 12 genera, while Araceae was the second dominant family with 11 species (15%) representing seven genera followed by Polypodiaceae with nine species (12.1%) representing nine genera, Apocyanaceae with six species (8.1%) representing two genera, Pteridaceae, Lycopodiaceae, Moraceae, Piperaceae with three species (4.05%), Smilacaceae, Dioscoreaceae, and Aspleniaceae with two species (2.7%). The remaining nine families had one species (1.35%) each. The species diversity of the vascular epiphytes for the study area is calculated to be $H' = 3.88$.

Vascular epiphytic assemblages on host trees

The dominant shade tree species recorded with vascular epiphytes were *Samanea saman* (Jacq.) Merr, *Albizia odoratissima* (L.f.) Benth., *A. lebbeck* (L.) Benth., *Ficus religiosa* L., *Alstonia scholaris* (L.) R.Br., *Artocarpus chama* Buch.-Ham., *Artocarpus heterophyllus* Lam., and *Mangifera indica* L. Whereas, other shade trees like *Bombax ceiba* L., *Baccaurea motleyana* (Müll.Arg.) Müll.Arg. and *Populus ciliata* Wall. ex Royle does not have vascular epiphytes. To explore host specificity, 10 dominant tree species from the study area were selected. The vascular epiphytic assemblages (VEA) on them were recorded. *Albizia lebbeck* (L.) Benth. (H2) with VEA of 737, *Albizia odoratissima* (L.f.) Benth. (H6) with 627 VEAs, *Ficus benghalensis* L. (H4) with 554 VEAs, *Artocarpus chama* Buch.-Ham. (H7) with 546 VEAs, *Dillenia pentagyna* Roxb. (H9) with 531 VEAs, *Alstonia scholaris* (L.) R.Br. (H5) with 489 VEAs, *Mangifera indica* L. (H1) with 486 VEAs, *Litsea glutinosa* (Lour.) C.B.Rob. (H10) with 465 with VEAs, *Swietenia mahagoni* (L.) Jacq. (H8) with 452 VEAs, *Gmelina arborea* Roxb. ex Sm. (H3) with 450 VEAs. Vascular epiphytic species richness, abundance, and composition were preferably high on these shade trees therefore, to assess whether differences in the number are affected by the different hosts calculated using interpolation and extrapolation analyses (Chao et al. 2014), which evaluate sample preference based on the dominant tree using iNEXT function in the iNEXT package (Hsieh et al. 2016). H1, H2, H5, H6, H7, H8, H9 & H10 had more than 50% sample coverage area of VEA.

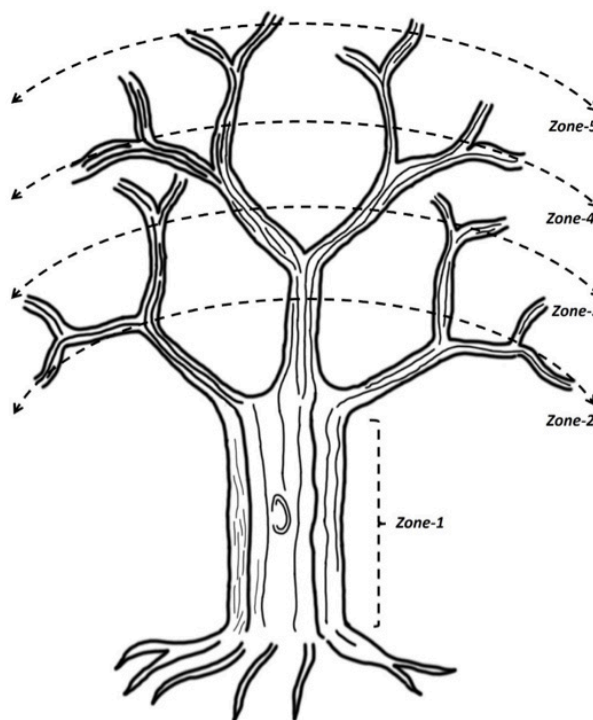


Figure 2. Diagrammatic representations of zones of distribution on the host tree (modification of Johansson ,1974).

Table 1. Major tea gardens with location and area of spreading on Terai & Doars.

Tea gardens	Co-ordinates		Area (ha)
	Latitude (°N)	Longitude (°E)	
Kalchini tea garden	26.707	89.440	742.15
Matigara tea garden	26.711	88.386	142.09
Denguajhar tea garden	26.558	88.694	660.57
Batabari tea garden	26.840	88.796	299.59
Dyna tea garden	26.848	89.026	418.3
Kurti tea garden	26.926	88.935	417.93
Banarhat tea garden	26.798	89.043	634.21
Dalgaon tea garden	26.703	89.148	656.02
Bagdogra tea garden	26.690	88.307	262.28
Damdin tea garden	26.822	88.674	738.02
Chalsa tea garden	26.930	88.833	442.6
Chamurchi tea garden	26.850	89.061	493.22
Gayerkata tea garden	26.683	89.026	710.63
Moraghat tea garden	26.774	89.011	513.47
Haldibari tea garden	26.746	89.015	851.24
Red bank tea garden	26.849	89.046	361.63
Anandapur tea garden	26.756	88.664	402.25
Bagrakote tea garden	26.865	88.854	488.89
Matelli tea garden	26.949	88.815	730.08
Odlabari tea garden	26.828	88.617	484.18
Binnaguri tea garden	26.763	89.056	602.56



Image 1. Field studies with ladder climbing technique.

In comparison, H4 and H3 had 17% or less than sample coverage (Figure 3).

Vertical stratification

The vertical stratification studies from basal/trunk to top most dense canopies showed variation. The epiphytic species were higher in number in the middle canopy (ZN2, ZN3, and ZN4) and then declined toward the top canopies (ZN4 and ZN5). In the study, ZN5 had the least vascular epiphytes with one species of hemiepiphyte, and two species of holoepiphytes followed by ZN1 which was reported to contain one species of accidental epiphyte, one species of facultative epiphytes, two species of hemiepiphytes, and 32 species of holoepiphyte. ZN2 had the maximum number of epiphytes with one species of facultative epiphytes, nine species of accidental epiphytes, 13 species of hemiepiphytes, and 44 species of holoepiphytes. ZN3 was reported to have one species of facultative epiphyte, five species of accidental epiphytes, 11 species of hemiepiphytes, and 34 species of holoepiphytes. Whereas, ZN4 had two species of accidental epiphytes, seven species of hemiepiphytes, and



Image 2. Study habitat: A—epiphytic flora of the tea gardens | B—vascular epiphytic assemblages on the host tree.

16 species of holoepiphytes (Figure 4). Stratification with diameter studies showed that at DBH 1–2m the epiphytic assemblage was less than 20.2%, at 3–5m DBH epiphytic assemblage was increased and highest with 59.4%, but as the DBH attained 6–7m the VEA decreased by 43.2% and attained saturation. Variable regression plotting (Figure 5) using IBM SPSS version 64-bit window version is done which shows a positive correlation between DBH and VEA.

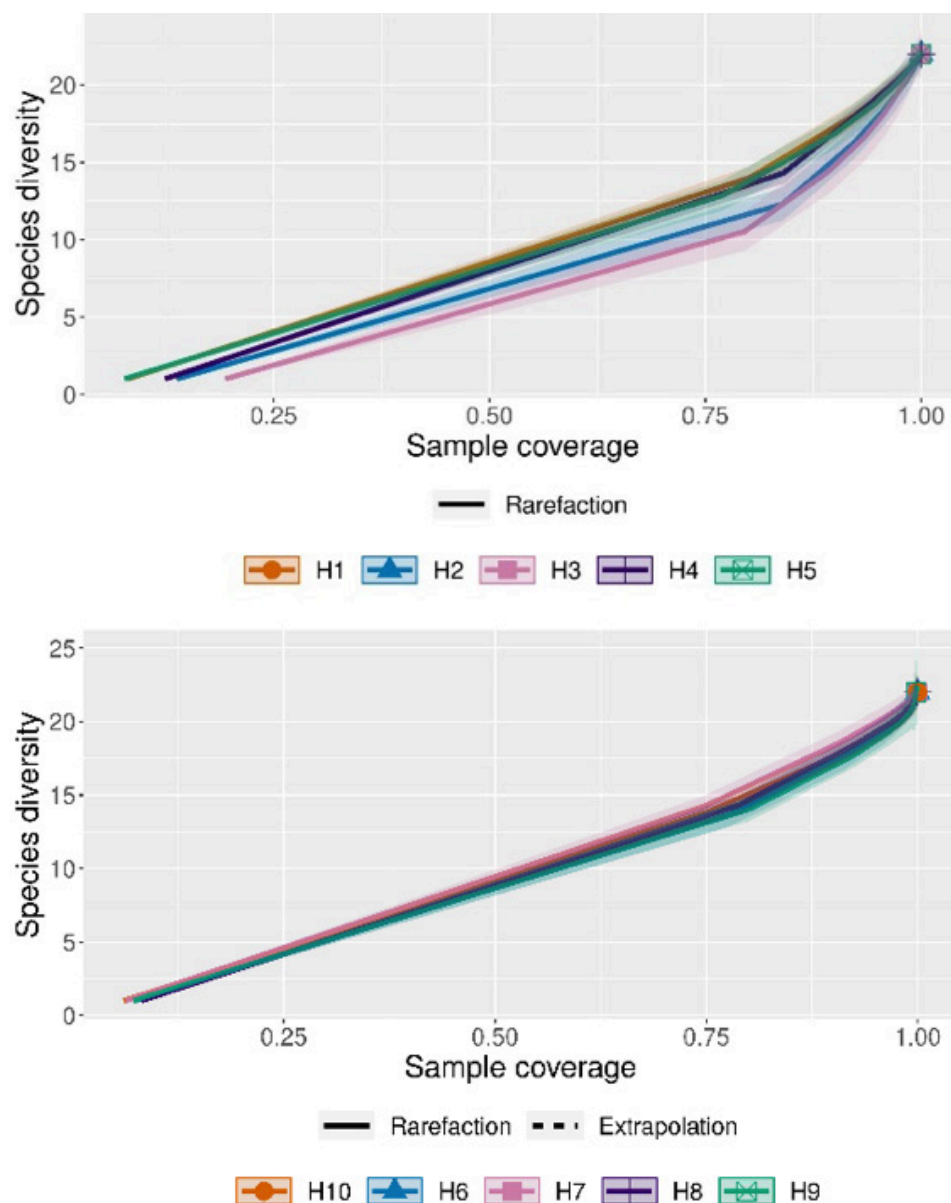


Figure 3. Inter and extrapolation analysis (iNEXT) of epiphyte diversity according sample coverage: H1—*Mangifera indica* L. | H2—*Albizia lebbbeck* (L.) Benth. | H3—*Gmelina arborea* Roxb. ex Sm. | H4—*Ficus benghalensis* L. | H5—*Alstonia scholaris* (L.) R.Br. | H6—*Albizia odoratissima* (L.f.) Benth. | H7—*Artocarpus chama* Buch.-Ham. | H8—*Swietenia mahagoni* (L.) Jacq. | H9—*Dillenia pentagyna* Roxb. | H10—*Litsea glutinosa* (Lour.) C.B.Rob. The interpolated (observed) species richness of vascular epiphytes was obtained by merging the number of individual vascular epiphyte assemblages and obtaining an average of individual species. Extrapolated (expected) species richness for each host tree was based on the maximum sample coverage.

DISCUSSION

The study shows that the tea gardens of Terai and Dooars have a good number of vascular epiphytes, characterising them as important vegetation hotspots. Vascular epiphyte assemblage was found to be high on those host shade trees that have rough bark texture with ridges and stripes supporting the proliferation of epiphytes. The finding agrees with the prior works on the Yayu Forest and Gera

Forest in Ethiopia (Tafesse et. al. 2015). Whereas, some host trees have no or less vascular epiphytes like *Litsea glutinosa* (Lour.) C.B.Rob. has 465 VEAs and *Gmelina arborea* Roxb. has 450 vascular epiphytic coverage which may be due to the smooth texture of the bark which decreases the water and soil retention (deposited by ants or other insects, old leaf debris) capacity of the host which in turn leads to inhibition of epiphytic growth as discussed by Benzing (1990) working on neotropical forest

Table 2. List of vascular epiphytes recorded from tea gardens of Terai & Dooars, West Bengal.

Scientific name	Family	Life form	Status	Zone preference	Geographical distribution
<i>Selenicereus undatus</i> (Haw.) D.R.Hunt *	Cactaceae	Facultative	Common	ZN2 ZN3	NAG, CHA
<i>Smilax ovalifolia</i> Roxb. ex D.Don	Smilacaceae	Hemiepiphyte	Common	ZN2 ZN3 ZN4	MAI, JPG
<i>Smilax perfoliata</i> Lour.	Smilacaceae	Hemiepiphyte	Common	ZN2 ZN3 ZN4	CHA, JPG, RAJ
<i>Pothos scandens</i> L.	Araceae	Hemiepiphyte	Common	ZN1 ZN2 ZN3	JPG, NAG, CHA, BAN
<i>Pothos chinensis</i> (Raf.) Merr.	Araceae	Hemiepiphyte	Less common	ZN1 ZN2 ZN3	JPG, MAT, CHA
<i>Scindapsus officinalis</i> (Roxb.) Schott	Araceae	Hemiepiphyte	Abundant	ZN2 ZN3	JPG, NAG, CHA, BAN
<i>Philodendron hastatum</i> K.Koch & Sello	Araceae	Holoepiphyte	Abundant	ZN2 ZN3	JPG, NAG, CHA, BAN
<i>Philodendron herbaceum</i> Croat & Grayum	Araceae	Hemiepiphyte	Abundant	ZN2 ZN3 ZN4	JPG, CHA, MAT
<i>Epipremnum aureum</i> (Linden & André) G.S.Bunting	Araceae	Hemiepiphyte	Abundant, common	ZN2 ZN3 ZN4	JPG, NAG, CHA, BAN
<i>Syngonium podophyllum</i> Schott	Araceae	Hemiepiphyte	Common	ZN3 ZN4	JPG, MAI, PHAN
<i>Colocasia affinis</i> Schott	Araceae	Accidental	Common	ZN2 ZN3	JPG, NAG, CHA, BAN
<i>Colocasia esculenta</i> (L.) Schott	Araceae	Accidental	Abundant	ZN2 ZN3	JPG, NAG, CHA, BAN
<i>Rhaphidophora decursiva</i> (Roxb.) Schott	Araceae	Hemiepiphyte	Less common	ZN2 ZN3 ZN4	JPG, CHA, MAT
<i>Rhaphidophora glauca</i> (Wall.) Schott	Araceae	Hemiepiphyte	Common	ZN2 ZN3	JPG, CHA, MAT
<i>Dioscorea bulbifera</i> L.	Dioscoreaceae	Accidental	Common	ZN2 ZN3 ZN4	JPG, MAL, BAN, MAI
<i>Dioscorea belophylla</i> (Prain) Voigt ex Haine	Dioscoreaceae	Accidental	Less common	ZN2 ZN3 ZN4	CHA, JPG, RAJ
<i>Hellenia speciosa</i> (J.Koenig) S.R.Dutta	Costaceae	Accidental	Common	ZN2 ZN3	JPG
<i>Streblus asper</i> Lour.	Moraceae	Accidental	Common	ZN2	JPG, MAI, NAG
<i>Ficus religiosa</i> L.	Moraceae	Accidental	Abundant	ZN2 ZN3	JPG, MAL, BAN, MAI
<i>Ficus benamina</i> L.	Moraceae	Hemiepiphyte	Rare	ZN2	CHA, JPG
<i>Premna scandens</i> Roxb.	Lamiaceae	Hemiepiphyte	Common	ZN1 ZN2	CHA, JPG, MAI
<i>Dischidia chinensis</i> Champ. ex Benth	Apocyanaceae	Holoepiphyte	Common	ZN1 ZN2	JPG, CHA, MAT, NAG
<i>Dischidia bengalensis</i> Colebr.	Apocyanaceae	Holoepiphyte	Common	ZN1 ZN2 ZN3 ZN5	JPG, CHA, MAT, NAG
<i>Hoya arnottiana</i> Wight	Apocyanaceae	Holoepiphyte	Less common	ZN2 ZN3	CHA, MAT, PHAN
<i>Hoya bella</i> Hook.	Apocyanaceae	Holoepiphyte	Rare	ZN1 ZN2	MAT
<i>Hoya verticillata</i> var. <i>verticillata</i> Wall. ex Traill	Apocyanaceae	Holoepiphyte	Abundant	ZN1 ZN2 ZN3	JPG, CHA, MAT, NAG
<i>Hoya latifolia</i> G.Don	Apocyanaceae	Holoepiphyte	Abundant	ZN2 ZN3 ZN5	MAI
<i>Piper longum</i> L.	Piperaceae	Hemiepiphyte	Abundant	ZN2 ZN3 ZN4	JPG, CHA, MAT
<i>Piper nigrum</i> L.	Piperaceae	Hemiepiphyte	Abundant	ZN2 ZN3 ZN4	JPG, CHA, MAT, NAG
<i>Peperomia pellucida</i> (L.) Kunth	Piperaceae	Facultative	Abundant	ZN1	JPG, NAG, MAI, CHA
<i>Aeschynanthus acuminatus</i> Wall. ex A.DC.	Gesneriaceae	Holoepiphyte	Abundant	ZN2 ZN3 ZN4	JPG, MAL, BAN, MAI
<i>Ehretia aspera</i> Willd.	Boraginaceae	Hemiepiphyte	Less common	ZN2	JPG
<i>Heptapleurum arboricola</i> Hayata	Araliaceae	Accidental	Less common	ZN2 ZN3	JPG, NAG
<i>Commelina benghalensis</i> L.	Commelinaceae	Accidental	Abundant	ZN1 ZN2	JPG, NAG, MAI, CHA
<i>Pilea microphylla</i> (L.) Liebm.	Urticaceae	Accidental	Abundant	ZN1 ZN2	JPG, NAG, MAI, CHA
<i>Huperzia phlegmaria</i> (L.) Rothm.	Lycopodiaceae	Holoepiphyte	Common	ZN1 ZN2 ZN3	CHA, MAT
<i>Huperzia squarrosa</i> (G.Forst.) Trevis.	Lycopodiaceae	Holoepiphyte	Abundant	ZN1 ZN2	JPG, CHA, MAT
<i>Huperzia hamiltonii</i> (Spreng.) Trevis.	Lycopodiaceae	Holoepiphyte	Abundant	ZN2 ZN3	JPG, NAG, MAI, CHA
<i>Nephrolepis cordifolia</i> (L.) C.Presl	Polypodiaceae	Holoepiphyte	Common	ZN1 ZN2 ZN3 ZN4	JPG, MAL, BAN, MAI
<i>Drynaria quadrifolia</i> (L.) J.Sm.	Polypodiaceae	Holoepiphyte	Abundant	ZN1 ZN2 ZN3 ZN4	JPG, CHA, MAT, NAG, BAN
<i>Microsorium punctatum</i> (L.) Copel.	Polypodiaceae	Holoepiphyte	Abundant	ZN1 ZN2 ZN3 ZN4 ZN5	JPG, CHA, MAT, NAG, BAN

Scientific name	Family	Life form	Status	Zone preference	Geographical distribution
<i>Microsorium diversifolium</i> Copel.	Polypodiaceae	Holoepiphyte	Common	ZN1 ZN2	JPG, CHA, MAT, NAG
<i>Pyrrosia lanceolata</i> (L.) Farw.	Polypodiaceae	Holoepiphyte	Abundant	ZN1 ZN2 ZN3 ZN4	JPG, CHA, MAT, NAG, BAN
<i>Pyrrosia adnascens</i> (Sw.) Ching	Polypodiaceae	Holoepiphyte	Abundant	ZN1 ZN2 ZN3 ZN4	JPG, CHA, MAT, NAG, BAN
<i>Pyrrosia costata</i> (Wall. ex C.Presl). Tagawa et al.	Polypodiaceae	Holoepiphyte	Common	ZN1 ZN2	JPG, CHA, MAT
<i>Lepisorus nudus</i> (Hook.) Ching	Polypodiaceae	Holoepiphyte	Common	ZN1 ZN2 ZN3	MAT, NAG, BAN
<i>Davallia trichomanoides</i> Blume	Polypodiaceae	Holoepiphyte	Common	ZN2 ZN3 ZN4	JPG, CHA, MAT, NAG, BAN
<i>Haplopteris elongate</i> (Sw.) E.H.Crane	Pteridaceae	Holoepiphyte	Common	ZN1 ZN2 ZN3	JPG, CHA, MAT
<i>Haplopteris flexuosa</i> (Fée) E.H.Crane	Pteridaceae	Holoepiphyte	Common	ZN1 ZN2 ZN3	JPG, CHA, MAT, NAG, BAN
<i>Pteris vittata</i> L	Pteridaceae	Holoepiphyte	Common	ZN1 ZN2 ZN3 ZN4	JPG, MAL, MAI, NAG
<i>Asplenium crinicaule</i> Hance	Aspleniaceae	Holoepiphyte	Common	ZN1 ZN2 ZN3	MAL, JPG, BAN
<i>Asplenium nidus</i> L.	Aspleniaceae	Holoepiphyte	Abundant	ZN2 ZN3 ZN4	MAL, BAN, CHAL
<i>Psilotum nudum</i> (L.) P.Beauv.	Psilotaceae	Holoepiphyte	Common	ZN2 ZN3	JPG, CHA, BAN
<i>Aerides odorata</i> Lour.	Orchidaceae	Holoepiphyte	Abundant	ZN1 ZN2 ZN3	MAL, JPG, BAN
<i>Aerides multiflora</i> Roxb.	Orchidaceae	Holoepiphyte	Abundant	ZN1 ZN2 ZN3	MAL, JPG, BAN
<i>Rhynchostylis retusa</i> Blume	Orchidaceae	Holoepiphyte	Abundant	ZN1 ZN2 ZN3 ZN4	MAL, JPG, BAN, NAG, RAJ
<i>Coelogyne corymbosa</i> Lindl.	Orchidaceae	Holoepiphyte	Common	ZN2 ZN3 ZN4	MAL, BAN, CHAL
<i>Coelogyne cristata</i> Lindl.	Orchidaceae	Holoepiphyte	Common	ZN2 ZN3 ZN4	MAL, BAN, CHAL
<i>Dendrobium aphyllum</i> (Roxb.) C.E.C.Fisch	Orchidaceae	Holoepiphyte	Abundant	ZN2 ZN3	JPG, CHA, BAN
<i>Dendrobium anceps</i> Sw.	Orchidaceae	Holoepiphyte	Abundant	ZN1 ZN2	JPG, MAL, MAI, NAG
<i>Dendrobium crepidatum</i> Lindl. & Paxton	Orchidaceae	Holoepiphyte	Less common	ZN2 ZN3 ZN4	JPG, CHA, BAN
<i>Dendrobium moschatum</i> Wall. ex D.Don	Orchidaceae	Holoepiphyte	Abundant	ZN1 ZN2	JPG, MAL, MAI, NAG
<i>Dendrobium nobile</i> Lindl.	Orchidaceae	Holoepiphyte	Common	ZN1 ZN2	JPG, MAL, NAG
<i>Dendrolirium lasiopetalum</i> (Willd.) S.C.Chen & J.J.Wood	Orchidaceae	Holoepiphyte	Abundant	ZN1 ZN2	JPG, MAL, MAI, NAG
<i>Luisia zeylanica</i> Lindl.	Orchidaceae	Holoepiphyte	Rare	ZN1	NAG
<i>Panisea uniflora</i> (Lindl.) Lindl.	Orchidaceae	Holoepiphyte	Common	ZN2 ZN3	JPG, CHA, NAG
<i>Gastrochilus dasypogon</i> (Sm.) Kuntze	Orchidaceae	Holoepiphyte	Rare	ZN2 ZN3	NAG, MAT
<i>Bulbophyllum crassipes</i> Hook.f.	Orchidaceae	Holoepiphyte	Less common	ZN1 ZN2 ZN3 ZN4	JPG, MAL, BAN
<i>Bulbophyllum hirtum</i> Hook.f.	Orchidaceae	Holoepiphyte	Less common	ZN1 ZN2 ZN3	JPG, MAL, BAN, MAI
<i>Bulbophyllum reptans</i> (Lindl.) Lindl. ex Wall.	Orchidaceae	Holoepiphyte	Common	ZN1 ZN2 ZN3 ZN4	JPG, MAL, NAG
<i>Cymbidium bicolor</i> Lindl.	Orchidaceae	Holoepiphyte	Abundant	ZN2 ZN3 ZN4	JPG, MAL, NAG
<i>Cymbidium aloifolium</i> (L.) Sw.	Orchidaceae	Holoepiphyte	Abundant	ZN2 ZN3	JPG, MAL, CHAL
<i>Papilionanthe teres</i> Schltr.	Orchidaceae	Holoepiphyte	Abundant	ZN1 ZN2 ZN3 ZN4	JPG, MAL, MAI, NAG
<i>Thunia alba</i> (Lindl.) Rchb.f.	Orchidaceae	Holoepiphyte	Less common	ZN1	MAL, MAT

ZN—Zone preference on host | Blocks of District: JPG—Jalpaiguri | MAL—Malbazar | NAG—Nagrakata | CHAL—Chalsa | MAI—Maitali | MAT—Matigara | BAN—Banarhat | PHAN—Phansidewa. *—non native.

vegetation working on neotropical forest vegetation. The study on the vertical distribution of vascular epiphytes on shade trees has a difference in species presence from the basal part to the topmost crown. The middle strata of the host have recorded the greatest number of species this may be due to microclimate changes and exposure to sunlight of the host plants in the different zones. This

same finding was supported in the works of Bogh (1992), Freiberg (1996), Arévalo & Betancur (2006) with high epiphytic abundance in the center of host crowns due to microclimate differences. From data analysis, it was found that ferns and orchids were major epiphytes of the study area. In total 17 species of epiphytic ferns were recorded from the study sites, which was in accordance with the

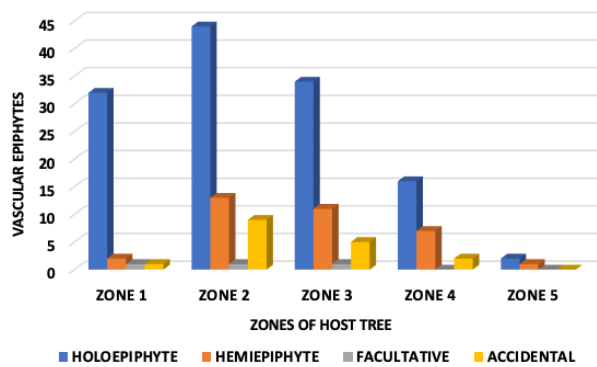


Figure 4. Types of vascular epiphytes distributed on different zones of host trees.



Image 3. Shade tree plantation in the tea garden.

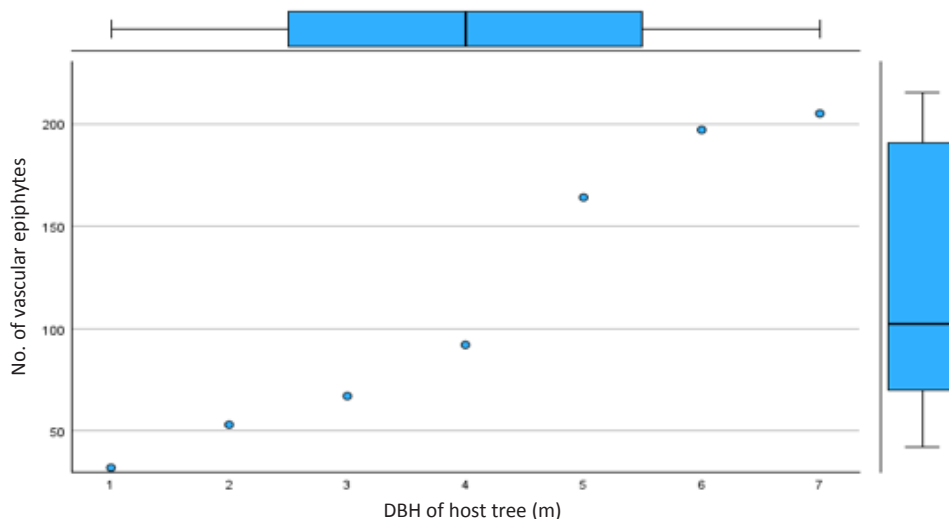


Figure 5. Variable regression plotting using IBM SPSS version 64-bit window version is done which shows a positive correlation between DBH and vascular epiphytes assemblage.

study on Dooars tea gardens with a total of 44 species of pteridophytes including only seven species of epiphytic ferns (Chowdhury et al. 2016). The family Orchidaceae has the maximum number of species recorded which is 12 genera with 21 species. The high number of orchids in this sub-Himalayan region has also been recorded by other authors from different protected areas, for example, from the eastern Himalaya region of India reported 545 species of orchids (Pangtey et al. 1991) and from West Bengal 110 genera with 466 species have been reported (Mitra et al. 2020; Mitra 2021). The overall Shannon diversity index ($H' = 3.88$) of vascular epiphytes of tea gardens is very high. The diversity index value agrees with the previous works done on the tree diversity of Chapramari Wildlife Sanctuary, eastern Himalaya (Rana et al. 2017). These pragmatic findings suggest that the tea garden of this

region harbours a virtuous amount of vascular epiphytic diversity other than forest.

CONCLUSION

The present study is a unique attempt to document the vascular epiphytes vegetation, their assemblage pattern on various zones of tree trunks, and ecology in the tea gardens of sub-Himalayan West Bengal. The rich and diverse assemblage of orchids and fern flora was identified as the most dominant group. The unique climatic factors influencing the diversity and abundance of vascular epiphytes and density towards vertical stratification on host plants. Large DBH and moist bark of host trees provide microclimatic conditions that

allow greater numbers of individuals of various species. Vascular epiphytes and host trees make a very healthy ecosystem in this region and also provide shelter to various wild creatures. The fast decline of epiphytic assemblage was also observed may be a result of either improper restoration of vascular epiphytes or the regular use of sticky traps to check insects on tree trunks, which hinder the pollination process of epiphytes. Therefore, there is an urgent need for the conservation of these huge diverse vascular epiphytic floras along with their host in this region to maintain the stable and climax ecosystem.

REFERENCE

- Arévalo, R. & J. Betancur (2006). Vertical distribution of vascular epiphytes in four forest types of the Serranía de Chiribiquete, Colombian Guayana. *Selbyana* 27: 175–185. <https://journals.flvc.org/selbyana/article/view/121293>
- Barthlott, W., V. Neuberger-Schmidt, J. Nieder & S. Engwald (2001). Diversity and abundance of vascular epiphytes: A comparison of secondary vegetation and primary montane rainforest in the Venezuelan Andes. *Plant Ecology* 152: 145–156. <https://doi.org/10.1023/A:1011483901452>
- Barua, D.N. (2007). *Science and Practice in Tea Culture 1st Edition*. Tea Research Association, Assam, 613 pp.
- Benzing, D.H. (1987). Vascular epiphytism: taxonomic participation and adaptive diversity. *Annals of the Missouri Botanical Garden* 74(2): 183–204. <https://doi.org/10.2307/2399394>
- Benzing, D.H. (1990). *Vascular Epiphytes*. Cambridge University Press, Cambridge, 354 pp. <https://doi.org/10.1017/CBO9780511525438>
- Bogh, A. (1992). Composition and distribution of the vascular epiphyte flora of an Ecuadorian montane rain forest. *Selbyana* 13: 25–34.
- Chao, A., N.J. Gotelli, T.C. Hsieh, E.L. Sander, K.H. Ma, R.K. Colwell & A.M. Ellison (2014). Rarefaction and extrapolation with Hill numbers: A framework for sampling and estimation in species diversity studies. *Ecological Monographs* 84:45–67. <https://doi.org/10.1890/13-0133.1>
- Chowdhury, A. (2015). *Studies on the Diversity and Ethnic uses of Wetland Vascular Plants in Terai and Duars of West Bengal, India*. University of North Bengal, 375pp.
- Chowdhury, A., S. Sarkar & M. Chowdhury (2016). Diversity, ecology and utilization of tea garden Pteridophytes at Duars in West Bengal, India. *International Research Journal of Biological Sciences* 5: 47–53.
- Freiberg, M. (1996). Spatial distribution of vascular epiphytes on three emergent canopy trees in French Guiana. *Biotropica* 28: 345–355. <https://doi.org/10.2307/2389198>
- Freiberg, M. (2000). Epiphyte diversity and biomass in the canopy of lowland and montane forests in Ecuador. *Journal of Tropical Ecology* 16: 673–688. <https://doi.org/10.1017/S0266467400001644>
- Gentry, A.H. & C.H. Dodson (1987). Diversity and biogeography of neotropical vascular epiphytes. *Annals of Missouri Botanical Garden* 74: 205–233. <https://doi.org/10.2307/2399395>
- Hadfield, W. (1974). Shade in north-east Indian tea plantations I. The shade patterns. *Journal of Applied Ecology* 11: 151–178. <https://doi.org/10.2307/2402012>
- Hsieh, T.C., K.H. Ma & A. Chao (2016). iNEXT: An R package for rarefaction and extrapolation of species diversity (Hill numbers). *Methods in Ecology and Evolution* 7(12): 1451–1456. <https://doi.org/10.1111/2041-210X.12613>
- Isaza, C., J. Betancur & J.V. Este'vez-Varo'n (2004). Vertical distribution of bromeliads in a montane forest in the Eastern Cordillera of the Colombian Andes. *Selbyana* 25(1): 126–137. <https://journals.flvc.org/selbyana/article/view/121517>
- Johansson, D. (1974). Ecology of vascular epiphytes in western African forest. *Acta Phytogeographica Suecica* 59: 1–136.
- Madison, M. (1977). Vascular epiphytes: Their systematic occurrence and salient features. *Selbyana* 2(1): 1–13.
- Mitra, S. (2021). Diversity of the orchids flora of West Bengal. *Plant Archives* 21(2): 740–756. <https://doi.org/10.51470/PLANTARCHIVES.2021.v21.no2.115>
- Mitra, S., S. Bandyopadhyay & M.S. Kumar (2020). Taxonomic census of the orchids of West Bengal. *Plant Archives* 20(2): 3951–3980.
- Mohotti, A.J. (2004). Shade in tea: Is it beneficial? *Sri Lanka Journal of Tea Sciences* 69: 27–39.
- Mojiol, A.R., A.M.A. Jitnu, A. Adella, G.M. Ganang & N. Nasly (2009). Vascular epiphytes diversity at Pusat Sejadi, Kawang Forest Reserve, Sabah, Malaysia. *Journal of Sustainable Development* 2(1): 121–127. <https://doi.org/10.5539/jsd.v2n1p121>
- Nadkarni, N.M. (1994). Diversity of species and interactions in the upper tree canopy of forest ecosystems. *American Zoologist* 34: 70–78. <https://doi.org/10.1093/icb/34.1.70>
- Nieder, J., J. Prosperi & G. Michaloud (2001). Epiphytes and their contribution to canopy diversity. *Plant Ecology* 153(1): 51–63. <https://doi.org/10.1023/A:1017517119305>
- Noltie, H.J. (2000) *Flora of Bhutan (Including a record of plants from Sikkim and Darjeeling)*, Vol. 3 Parts 1–2. Royal Botanic Garden, Edinburgh.
- Pangtey, Y.P.S., S.S. Samant & G.S. Rawat (1991). *Orchids of Kumaun Himalaya*. Bishen Singh Mahendra Pal Singh, Dehradun, India, 193 pp.
- Paul, P., S. Dhar, D. Das & M. Chowdhury (2020). *Herbarium Technique: Evolution from Conventional to Digitization*. Orange Books Publication, Chhattisgarh, 132 pp.
- POWO (2024). Plants of the World Online. Royal Botanic Gardens, Kew. Available from <https://powo.science.kew.org/taxon/urn:lsid:ipni.org:names:77171146-1>. Electronic version accessed on 30th July 2024.
- Prain, D. (1903). *Bengal Plants*, Vol. 1–2. First Indian Reprint (1963), Bishen Singh, Mahendra Pal Singh, Dehra Dun.
- Rahman, A., Z.R. Moni, M.A. Rahman & S. Nasreen (2020). Investigation of shade tree species used in tea garden in Bangladesh. *SAARC Journal of Agriculture* 18(1): 219–237. <https://doi.org/10.3329/sja.v18i1.48395>
- Rana, S.K. & G. Singh (2017). Assessment of tree alpha diversity in Chapramari Wildlife Sanctuary, Eastern Himalaya. *Pleione* 11(2): 315–328. <https://doi.org/10.26679/Pleione.11.2.2017.315-328>
- Ranjan, V., P. Lakshminarasimhan, S.S. Dash & H.J. Chowdhury (2016). *Flora of West Bengal Vol. 3*, Botanical Survey of India, 493 pp.
- Shannon, C.E. (1948). A mathematical theory of communication. *The Bell System Technical Journal* 27(3): 379–423. <https://doi.org/10.1002/j.1538-7305.1948.tb01338.x>
- Singh, S. & G. Panigrahi (2005). *Ferns and Fern-Allies of Arunachal Pradesh*. Vols. 1 & 2. Bishen Singh Mahendra Pal Singh, Dehradun, 881 pp.
- Tafa, A. (2010). Diversity of Vascular Epiphytes along Disturbance Gradient in Yayu Forest, Southwest Oromia, Ethiopia. M.Sc. Thesis. Addis Ababa University, Addis Ababa.
- Tafesse, B., T. Bekele & E. Kelbessa (2015). Diversity and ecological analysis of vascular epiphytes in gera wild coffee forest, jimma zone of Oromia regional state, Ethiopia. *Ethiopian Journal of Biological Sciences* 14(2): 147–170.
- Tea Board of India (2024). Dooars–Terai tea gardens. <https://www.teaboard.gov.in/home>. Accessed on 24 January 2024.
- Visser, T. (1961). Interplanting in Tea 1. Effect of shade trees, weeds and bush crops. *Tea Quarterly* 32: 69–82.

Mr. Jatishwor Singh Irungbam, Biology Centre CAS, Branišovská, Czech Republic.
Dr. Ian J. Kitching, Natural History Museum, Cromwell Road, UK
Dr. George Mathew, Kerala Forest Research Institute, Peechi, India
Dr. John Noyes, Natural History Museum, London, UK
Dr. Albert G. Orr, Griffith University, Nathan, Australia
Dr. Sameer Padhye, Katholieke Universiteit Leuven, Belgium
Dr. Nancy van der Poorten, Toronto, Canada
Dr. Kareen Schnabel, NIWA, Wellington, New Zealand
Dr. R.M. Sharma, (Retd.) Scientist, Zoological Survey of India, Pune, India
Dr. Manju Siliwal, WILD, Coimbatore, Tamil Nadu, India
Dr. G.P. Sinha, Botanical Survey of India, Allahabad, India
Dr. K.A. Subramanian, Zoological Survey of India, New Alipore, Kolkata, India
Dr. P.M. Sureshan, Zoological Survey of India, Kozhikode, Kerala, India
Dr. R. Varatharajan, Manipur University, Imphal, Manipur, India
Dr. Eduard Vives, Museu de Ciències Naturals de Barcelona, Terrassa, Spain
Dr. James Young, Hong Kong Lepidopterists' Society, Hong Kong
Dr. R. Sundararaj, Institute of Wood Science & Technology, Bengaluru, India
Dr. M. Nithyanandan, Environmental Department, La Ala Al Kuwait Real Estate. Co. K.S.C., Kuwait
Dr. Himender Bharti, Punjabi University, Punjab, India
Mr. Purnendu Roy, London, UK
Dr. Saito Motoki, The Butterfly Society of Japan, Tokyo, Japan
Dr. Sanjay Sondhi, TITLI TRUST, Kalpavriksh, Dehradun, India
Dr. Nguyen Thi Phuong Lien, Vietnam Academy of Science and Technology, Hanoi, Vietnam
Dr. Nitin Kulkarni, Tropical Research Institute, Jabalpur, India
Dr. Robin Wen Jiang Ngiam, National Parks Board, Singapore
Dr. Lionel Monod, Natural History Museum of Geneva, Genève, Switzerland.
Dr. Asheesh Shivam, Nehru Gram Bharti University, Allahabad, India
Dr. Rosana Moreira da Rocha, Universidade Federal do Paraná, Curitiba, Brasil
Dr. Kurt R. Arnold, North Dakota State University, Saxony, Germany
Dr. James M. Carpenter, American Museum of Natural History, New York, USA
Dr. David M. Claborn, Missouri State University, Springfield, USA
Dr. Kareen Schnabel, Marine Biologist, Wellington, New Zealand
Dr. Amazonas Chagas Júnior, Universidade Federal de Mato Grosso, Cuiabá, Brasil
Mr. Monsoon Jyoti Gogoi, Assam University, Silchar, Assam, India
Dr. Heo Chong Chin, Universiti Teknologi MARA (UiTM), Selangor, Malaysia
Dr. R.J. Shiel, University of Adelaide, SA 5005, Australia
Dr. Siddharth Kulkarni, The George Washington University, Washington, USA
Dr. Priyadarsanan Dharma Rajan, ATREE, Bengaluru, India
Dr. Phil Alderslade, CSIRO Marine And Atmospheric Research, Hobart, Australia
Dr. John E.N. Veron, Coral Reef Research, Townsville, Australia
Dr. Daniel Whitmore, State Museum of Natural History Stuttgart, Rosenstein, Germany.
Dr. Yu-Feng Hsu, National Taiwan Normal University, Taipei City, Taiwan
Dr. Keith V. Wolfe, Antioch, California, USA
Dr. Siddharth Kulkarni, The Hormiga Lab, The George Washington University, Washington, D.C., USA
Dr. Tomas Ditrich, Faculty of Education, University of South Bohemia in Ceske Budejovice, Czech Republic
Dr. Mihaly Foldvari, Natural History Museum, University of Oslo, Norway
Dr. V.P. Uniyal, Wildlife Institute of India, Dehradun, Uttarakhand 248001, India
Dr. John T.D. Caleb, Zoological Survey of India, Kolkata, West Bengal, India
Dr. Priyadarsanan Dharma Rajan, Ashoka Trust for Research in Ecology and the Environment (ATREE), Royal Enclave, Bangalore, Karnataka, India

Fishes

Dr. Neelesh Dahanukar, IISER, Pune, Maharashtra, India
Dr. Topiltzin Contreras MacBeath, Universidad Autónoma del estado de Morelos, México
Dr. Heok Hee Ng, National University of Singapore, Science Drive, Singapore
Dr. Rajeev Raghavan, St. Albert's College, Kochi, Kerala, India
Dr. Robert D. Sluka, Chiltern Gateway Project, A Rocha UK, Southall, Middlesex, UK
Dr. E. Vivekanandan, Central Marine Fisheries Research Institute, Chennai, India
Dr. Davor Zanella, University of Zagreb, Zagreb, Croatia
Dr. A. Biju Kumar, University of Kerala, Thiruvananthapuram, Kerala, India
Dr. Akhilesh K.V., ICAR-Central Marine Fisheries Research Institute, Mumbai Research Centre, Mumbai, Maharashtra, India
Dr. J.A. Johnson, Wildlife Institute of India, Dehradun, Uttarakhand, India
Dr. R. Ravinesh, Gujarat Institute of Desert Ecology, Gujarat, India

Amphibians

Dr. Sushil K. Dutta, Indian Institute of Science, Bengaluru, Karnataka, India
Dr. Annemarie Ohler, Muséum national d'Histoire naturelle, Paris, France

Reptiles

Dr. Gernot Vogel, Heidelberg, Germany
Dr. Raju Vyas, Vadodara, Gujarat, India
Dr. Pritpal S. Soorae, Environment Agency, Abu Dubai, UAE.
Prof. Dr. Wayne J. Fuller, Near East University, Mersin, Turkey
Prof. Chandrashekhar U. Rivonker, Goa University, Taleigao Plateau, Goa. India
Dr. S.R. Ganesh, Chennai Snake Park, Chennai, Tamil Nadu, India
Dr. Himansu Sekhar Das, Terrestrial & Marine Biodiversity, Abu Dhabi, UAE

Birds

Dr. Hem Sagar Baral, Charles Sturt University, NSW Australia
Mr. H. Byju, Coimbatore, Tamil Nadu, India
Dr. Chris Bowden, Royal Society for the Protection of Birds, Sandy, UK
Dr. Priya Davidar, Pondicherry University, Kalapet, Puducherry, India
Dr. J.W. Duckworth, IUCN SSC, Bath, UK
Dr. Rajah Jayapal, SACON, Coimbatore, Tamil Nadu, India
Dr. Rajiv S. Kalsi, M.L.N. College, Yamuna Nagar, Haryana, India
Dr. V. Santharam, Rishi Valley Education Centre, Chittoor Dt., Andhra Pradesh, India
Dr. S. Balachandran, Bombay Natural History Society, Mumbai, India
Mr. J. Praveen, Bengaluru, India
Dr. C. Srinivasulu, Osmania University, Hyderabad, India
Dr. K.S. Gopi Sundar, International Crane Foundation, Baraboo, USA
Dr. Gombobaatar Sunde, Professor of Ornithology, Ulaanbaatar, Mongolia
Prof. Reuven Yosef, International Birding & Research Centre, Eilat, Israel
Dr. Taej Mundkur, Wetlands International, Wageningen, The Netherlands
Dr. Carol Inskipp, Bishop Auckland Co., Durham, UK
Dr. Tim Inskipp, Bishop Auckland Co., Durham, UK
Dr. V. Gokula, National College, Tiruchirappalli, Tamil Nadu, India
Dr. Arkady Lelej, Russian Academy of Sciences, Vladivostok, Russia
Dr. Simon Dowell, Science Director, Chester Zoo, UK
Dr. Mário Gabriel Santiago dos Santos, Universidade de Trás-os-Montes e Alto Douro, Quinta de Prados, Vila Real, Portugal
Dr. Grant Connette, Smithsonian Institution, Royal, VA, USA
Dr. P.A. Azeez, Coimbatore, Tamil Nadu, India

Mammals

Dr. Giovanni Amori, CNR - Institute of Ecosystem Studies, Rome, Italy
Dr. Anwaruddin Chowdhury, Guwahati, India
Dr. David Mallon, Zoological Society of London, UK
Dr. Shomita Mukherjee, SACON, Coimbatore, Tamil Nadu, India
Dr. Angie Appel, Wild Cat Network, Germany
Dr. P.O. Nameer, Kerala Agricultural University, Thrissur, Kerala, India
Dr. Ian Redmond, UNEP Convention on Migratory Species, Lansdown, UK
Dr. Heidi S. Riddle, Riddle's Elephant and Wildlife Sanctuary, Arkansas, USA
Dr. Karin Schwartz, George Mason University, Fairfax, Virginia.
Dr. Lala A.K. Singh, Bhubaneswar, Orissa, India
Dr. Mewa Singh, Mysore University, Mysore, India
Dr. Paul Racey, University of Exeter, Devon, UK
Dr. Honnavalli N. Kumara, SACON, Anaikatty P.O., Coimbatore, Tamil Nadu, India
Dr. Nishith Dharaia, HNG University, Patan, Gujarat, India
Dr. Spartaco Gippoliti, Socio Onorario Società Italiana per la Storia della Fauna "Giuseppe Altobello", Rome, Italy
Dr. Justus Joshua, Green Future Foundation, Tiruchirappalli, Tamil Nadu, India
Dr. H. Raghuram, The American College, Madurai, Tamil Nadu, India
Dr. Paul Bates, Harison Institute, Kent, UK
Dr. Jim Sanderson, Small Wild Cat Conservation Foundation, Hartford, USA
Dr. Dan Challender, University of Kent, Canterbury, UK
Dr. David Mallon, Manchester Metropolitan University, Derbyshire, UK
Dr. Brian L. Cypher, California State University-Stanislaus, Bakersfield, CA
Dr. S.S. Talmale, Zoological Survey of India, Pune, Maharashtra, India
Prof. Karan Bahadur Shah, Budhanilakantha Municipality, Kathmandu, Nepal
Dr. Susan Cheyne, Borneo Nature Foundation International, Palangkaraja, Indonesia
Dr. Hemanta Kafley, Wildlife Sciences, Tarleton State University, Texas, USA

Other Disciplines

Dr. Aniruddha Belsare, Columbia MO 65203, USA (Veterinary)
Dr. Mandar S. Paingankar, University of Pune, Pune, Maharashtra, India (Molecular)
Dr. Jack Tordoff, Critical Ecosystem Partnership Fund, Arlington, USA (Communities)
Dr. Ulrike Streicher, University of Oregon, Eugene, USA (Veterinary)
Dr. Hari Balasubramanian, EcoAdvisors, Nova Scotia, Canada (Communities)
Dr. Rayanna Hellem Santos Bezerra, Universidade Federal de Sergipe, São Cristóvão, Brazil
Dr. Jamie R. Wood, Landcare Research, Canterbury, New Zealand
Dr. Wendy Collinson-Jonker, Endangered Wildlife Trust, Gauteng, South Africa
Dr. Rajeshkumar G. Jani, Anand Agricultural University, Anand, Gujarat, India
Dr. O.N. Tiwari, Senior Scientist, ICAR-Indian Agricultural Research Institute (IARI), New Delhi, India
Dr. L.D. Singla, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, India
Dr. Rupika S. Rajakaruna, University of Peradeniya, Peradeniya, Sri Lanka
Dr. Bahar Baviskar, Wild-CER, Nagpur, Maharashtra 440013, India

Reviewers 2021–2023

Due to pausity of space, the list of reviewers for 2021–2023 is available online.

The opinions expressed by the authors do not reflect the views of the Journal of Threatened Taxa, Wildlife Information Liaison Development Society, Zoo Outreach Organization, or any of the partners. The journal, the publisher, the host, and the partners are not responsible for the accuracy of the political boundaries shown in the maps by the authors.

Print copies of the Journal are available at cost. Write to:
The Managing Editor, JoTT,
c/o Wildlife Information Liaison Development Society,
43/2 Varadarajulu Nagar, 5th Street West, Ganapathy, Coimbatore,
Tamil Nadu 641006, India
ravi@threatenedtaxa.org

Journal of Threatened Taxa is indexed/abstracted in Bibliography of Systematic Mycology, Biological Abstracts, BIOSIS Previews, CAB Abstracts, EBSCO, Google Scholar, Index Copernicus, Index Fungorum, JournalSeek, National Academy of Agricultural Sciences, NewJour, OCLC WorldCat, SCOPUS, Stanford University Libraries, Virtual Library of Biology, Zoological Records.

NAAS rating (India) 5.64



www.threatenedtaxa.org

OPEN ACCESS



The Journal of Threatened Taxa (JoTT) is dedicated to building evidence for conservation globally by publishing peer-reviewed articles online every month at a reasonably rapid rate at www.threatenedtaxa.org. All articles published in JoTT are registered under [Creative Commons Attribution 4.0 International License](https://creativecommons.org/licenses/by/4.0/) unless otherwise mentioned. JoTT allows unrestricted use, reproduction, and distribution of articles in any medium by providing adequate credit to the author(s) and the source of publication.

ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

August 2024 | Vol. 16 | No. 8 | Pages: 25639–25790

Date of Publication: 26 August 2024 (Online & Print)

DOI: 10.11609/jott.2024.16.8.25639-25790

Articles

The past and current distribution of the lesser-known Indian endemic Madras Hedgehog *Paraechinus nudiventris* (Mammalia: Eulipotyphla: Erinaceidae)

– R. Brawin Kumar & Willam T. Bean, Pp. 25639–25650

Declining trends of over-summering shorebird populations along the southeastern coasts of Tamil Nadu, India

– H. Byju, H. Maitreyi, N. Raveendran & S. Ravichandran, Pp. 25651–25662

Seasonal changes in waterbird assemblages in Chambal River at Mukundra Hills National Park, Rajasthan, India

– Arun George, Megha Sharma, Kavin Duraisamy, P.C. Sreelekha Suresh, Bijo Joy, Govindan Veeraswami Gopi, S.A. Hussain & J.A. Johnson, Pp. 25663–25674

An updated checklist of the skippers (Lepidoptera: Hesperidae) of Bhutan

– Karma Wangdi, Piet van der Poel & K.C. Sajan, Pp. 25675–25688

Conservation imperatives for swallowtail butterflies (Lepidoptera: Papilionidae): a case study in the north bank landscape of river Brahmaputra, Bodoland Territorial Region, India

– Kushal Choudhury, Pp. 25689–25699

The present state of leech fauna (Annelida: Hirudinea) in Dal Lake, Jammu & Kashmir, India

– Niyaz Ali Khan, Zahoor Ahmad Mir & Yahya Bakhtiyar, Pp. 25700–25711

First report of five monogonont rotifers from Jammu, J&K UT, India, with remarks on their distribution

– Nidhi Sharma, Sarbjeet Kour & Aayushi Dogra, Pp. 25712–25719

Diversity of vascular epiphytes on preferred shade trees in tea gardens of sub-Himalayan tracts in West Bengal, India

– Roshni Chowdhury & M. Chowdhury, Pp. 25720–25729

Communications

Identification and chemical composition analysis of salt licks used by Sumatran Elephants *Elephas maximus sumatranus* in Tangkahan, Indonesia

– Kaniwa Berliani, Pindi Patana, Wahdi Azmi, Novita Sari Mastiur Manullang & Cynthia Gozali, Pp. 25730–25736

Occurrence of a female melanistic leopard *Panthera pardus delacouri* (Linnaeus, 1758) (Mammalia: Carnivora: Felidae) in Ulu Sat Permanent Forest Reserve, Machang, Kelantan, Peninsular Malaysia from camera traps reconnaissance survey 2023

– Wan Hafiz Idzni Wan Mohammad Hizam, Muhammad Hamirul Shah Ab Razak, Hazizi Husain, Aainaa Amir & Kamarul Hambali, Pp. 25737–25741

Diversity and distribution of large centipedes (Chilopoda: Scolopendromorpha) in Nui Chua National Park, Vietnam

– Son X. Le, Thinh T. Do, Thuc H. Nguyen & Binh T.T. Tran, Pp. 25742–25747

Diversity of butterfly habitats in and around Udanti-Sitanadi Tiger Reserve, Chhattisgarh, India

– H.N. Tandan, Gulshan Kumar Sahu, Kavita Das, Gulab Chand, Ravi Naidu & Ramanand Agrawal, Pp. 25748–25757

A short-term impact of enriched CO₂ [eCO₂] on select growth performance of *Spodoptera littoralis* (Boisd.) (Lepidoptera: Noctuidae) and its host plant *Gossypium barbadense* L. (Malvaceae)

– A.A. Abu ElEla Shahenda & Wael M. ElSayed, Pp. 25758–25764

Diversity and distribution of springtails (Collembola) from Jharkhand, India

– Koushik Kumar Roy, Guru Pada Mandal & Kusumendra Kumar Suman, Pp. 25765–25773

Short Communications

***Lindernia tamilnadensis* (Linderniaceae) from Indo-Gangetic plains: no more endemic to the Deccan**

– Umama Khan, Revan Yogesh Chaudhari, Bhupendra Singh Adhikari, Syed Ainul Hussain & Ruchi Badola, Pp. 25774–25778

Discovery of a new *Myristica* swamp in the northern Western Ghats of India

– Pravin Desai, Vishal Sadekar & Shital Desai, Pp. 25779–25786

Note

***Ophioglossum jaykrishnae* S.M.Patil et al. (Pteridophyta: Polypodiophyta: Ophioglossaceae): a new distribution record from Kanha National Park, Madhya Pradesh, India**

– Tarun Nayi, Mayur Bhagwat, Sanjay Saini, Soham Haldikar, Ishtayaque Patel, Shivaji Chavan, Nudrat Zawar Sayed & Sunil Kumar Singh, Pp. 25787–25790

Publisher & Host



Threatened Taxa