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

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ARTICLE

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

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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.

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Competing interests: The authors declare no competing interests.

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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

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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

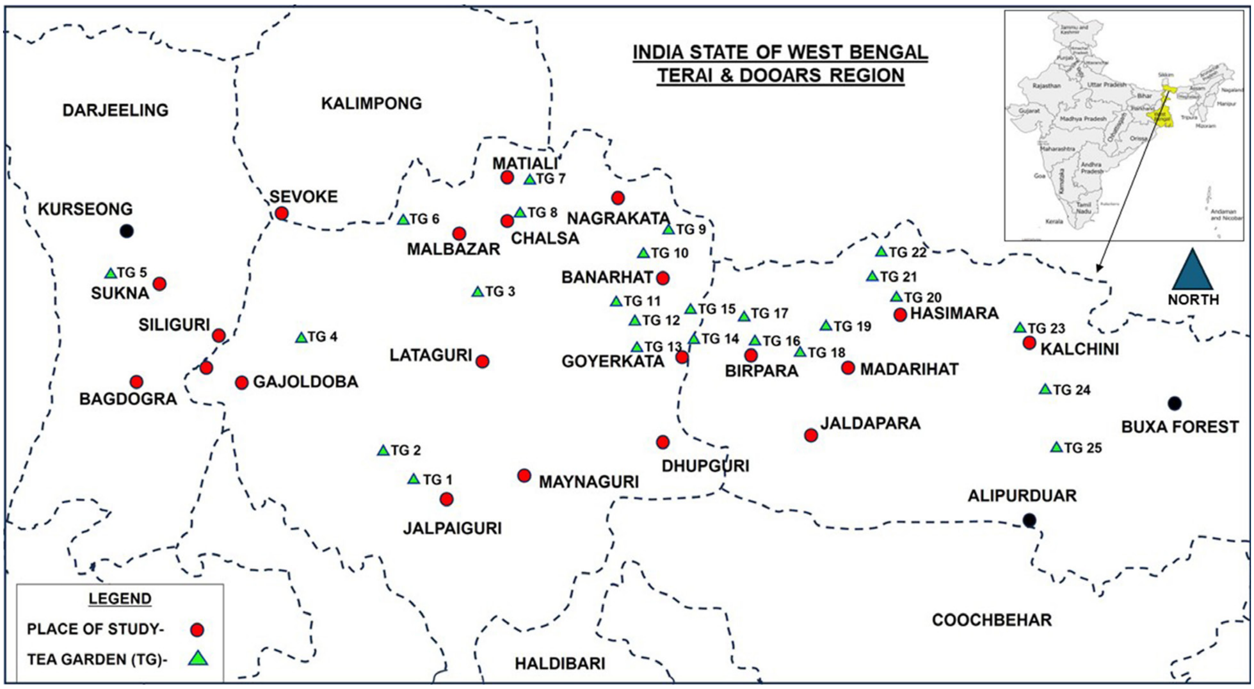

Figure 1. Map of study area showing some major tea gardens.
Abbreviations used: TG1—Denguajhar tea garden | TG2—Rangdhamali tea garden | TG3—Batabari tea garden | TG4—Anandapur tea garden | TG5—New Chumta tea garden | TG6—Damdim tea garden | TG7—Indong tea garden | TG8—Chalsa tea garden | TG9—Chamurchi tea garden | TG10—Palasbari tea garden | TG11—Moraghat tea garden | TG12—Banarhat tea garden | TG13—Goyerkata tea garden | TG14—Binnaguri tea garden | TG15—Haldibari tea garden | TG16—Birpara tea garden | TG17—Nangdala tea garden | TG18—Dumchi tea garden | TG19—Gopalpur tea garden | TG20—Malangi tea garden | TG21—Dalsingpara tea garden | TG22—Toorsa tea garden | TG23—Kalchini tea garden | TG24—Dima tea garden | TG25—Raja Bhatkaha tea garden.

scheme slightly modified after Johansson (1974). For photography, Nikon D5500 and Sigma 150–600 mm F5–6.3 DG OS HSM and Nikon D5600 18–45 mm, 300 mm were used.

Data analysis

The vertical distribution (Johansson 1974; Nadkarni 1994) of vascular epiphytes on phorophytes was studied by observing DBH (Diameter breast height) of the host trees ranging 1–7 m diameter of the tree trunk and VEA (Vascular epiphyte assemblages) on them were counted (Images 2a&b, 3).

Those epiphytes occurring in dense stands were counted as one individual (Johansson 1974; Barthlott et al. 2001). To understand the proper plant diversity of vascular epiphytic species, the Shannon-Weiner index (1948) was followed.

$$H = -\Sigma\, p_i(\ln p_i)$$

Where p is the proportion (n/N) of individuals of one particular species found (n) divided by the total number of individuals found (N), ln is the natural log, Σ is the sum of the calculations.

To predict the correlation between the two variables linear regression equation was used depending on which graph is extracted using IBM-SPSS 2022. A linear regression line has an equation of the form

$$Y = a + bX$$

where *X* is the explanatory variable and *Y* is the dependent variable. The slope of the line is *b*, and *a* is the intercept (the value of *y* when *x* = 0).

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 (Mojiol 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.

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 holoepiphyte (62.16%), 15 species were hemiepiphyte (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.

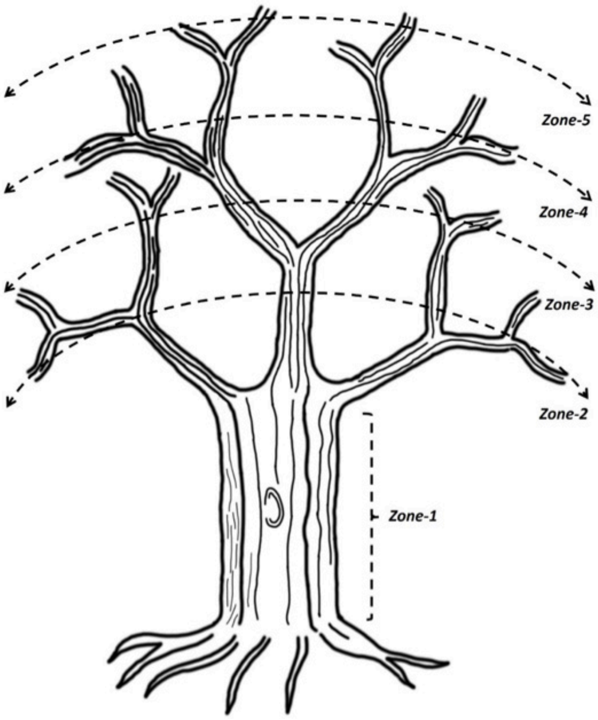

Figure 2. Diagrammatic representations of zones of distribution on the host tree (modification of Johansson ,1974).

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

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
Damdim 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.

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

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 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.

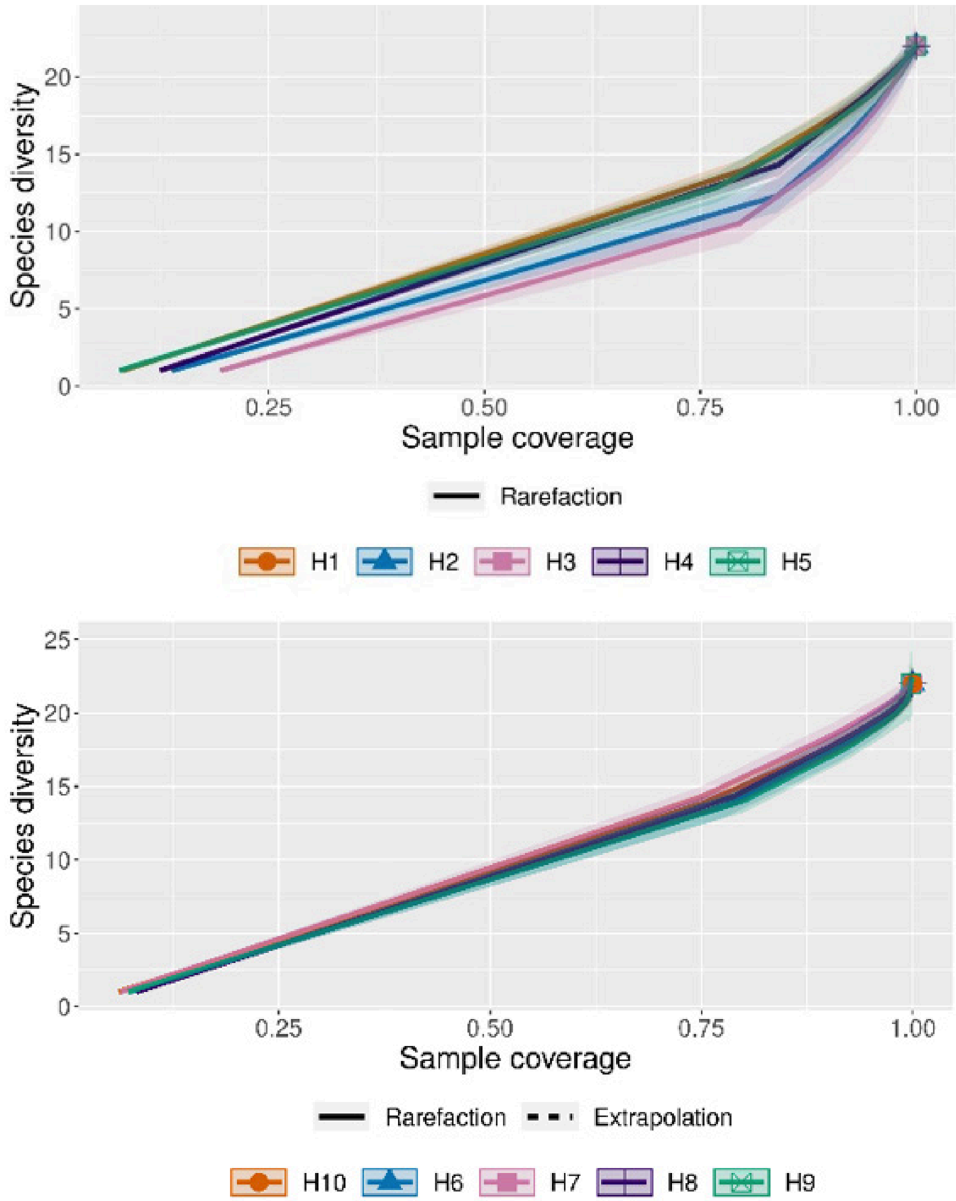

Figure 3. Inter and extrapolation analysis (iNEXT) of epiphyte diversity according sample coverage: H1—*Mangifera indica* L. | H2—*Albizia lebbeck* (L.) Benth. | H3—*Gmelina arborea* Roxb. ex Sm. | H4—*Ficus benghalensis* L. | H5—*Alstonia scholaris* (L.) R.Br. | H6—*Albizia odoratissima* (L.f.) Benth. | 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
Selenicereus undatus (Haw.) D.R.Hunt *	Cactaceae	Facultative	Common	ZN2 | ZN3	NAG, CHA
Smilax ovalifolia Roxb. ex D.Don	Smilacaceae	Hemiepiphyte	Common	ZN2 | ZN3 | ZN4	MAI, JPG
Smilax perfoliata Lour.	Smilacaceae	Hemiepiphyte	Common	ZN2 | ZN3 | ZN4	CHA, JPG, RAJ
Pothos scandens L.	Araceae	Hemiepiphyte	Common	ZN1 | ZN2 | ZN3	JPG, NAG, CHA, BAN
Pothos chinensis (Raf.) Merr.	Araceae	Hemiepiphyte	Less common	ZN1 | ZN2 | ZN3	JPG, MAT, CHA
Scindapsus officinalis (Roxb.) Schott	Araceae	Hemiepiphyte	Abundant	ZN2 | ZN3	JPG, NAG, CHA, BAN
Philodendron hastatum K.Koch & Sello	Araceae	Holoepiphyte	Abundant	ZN2 | ZN3	JPG, NAG, CHA, BAN
Philodendron herbaceum Croat & Grayum	Araceae	Hemiepiphyte	Abundant	ZN2 | ZN3 | ZN4	JPG, CHA, MAT
Epipremnum aureum (Linden & André) G.S.Bunting	Araceae	Hemiepiphyte	Abundant, common	ZN2 | ZN3 | ZN4	JPG, NAG, CHA, BAN
Syngonium podophyllum Schott	Araceae	Hemiepiphyte	Common	ZN3 | ZN4	JPG, MAI, PHAN
Colocasia affinis Schott	Araceae	Accidental	Common	ZN2 | ZN3	JPG, NAG, CHA, BAN
Colocasia esculenta (L.) Schott	Araceae	Accidental	Abundant	ZN2 | ZN3	JPG, NAG, CHA, BAN
Rhaphidophora decursiva (Roxb.) Schott	Araceae	Hemiepiphyte	Less common	ZN2 | ZN3 | ZN4	JPG, CHA, MAT
Rhaphidophora glauca (Wall.) Schott	Araceae	Hemiepiphyte	Common	ZN2 | ZN3	JPG, CHA, MAT
Dioscorea bulbifera L.	Dioscoreaceae	Accidental	Common	ZN2 | ZN3 | ZN4	JPG, MAL, BAN, MAI
Dioscorea belophylla (Prain) Voigt ex Haine	Dioscoreaceae	Accidental	Less common	ZN2 | ZN3 | ZN4	CHA, JPG, RAJ
Hellenia speciosa (J.Koenig) S.R.Dutta	Costaceae	Accidental	Common	ZN2 | ZN3	JPG
Streblus asper Lour.	Moraceae	Accidental	Common	ZN2	JPG, MAI, NAG
Ficus religiosa L.	Moraceae	Accidental	Abundant	ZN2 | ZN3	JPG, MAL, BAN, MAI
Ficus benjamina L.	Moraceae	Hemiepiphyte	Rare	ZN2	CHA, JPG
Premna scandens Roxb.	Lamiaceae	Hemiepiphyte	Common	ZN1 | ZN2	CHA, JPG, MAI
Dischidia chinensis Champ. ex Benth	Apocyanaceae	Holoepiphyte	Common	ZN1 | ZN2	JPG, CHA, MAT, NAG
Dischidia bengalensis Colebr.	Apocyanaceae	Holoepiphyte	Common	ZN1 | ZN2 | ZN3 | ZN5	JPG, CHA, MAT, NAG
Hoya arnottiana Wight	Apocyanaceae	Holoepiphyte	Less common	ZN2 | ZN3	CHA, MAT, PHAN
Hoya bella Hook.	Apocyanaceae	Holoepiphyte	Rare	ZN1 | ZN2	MAT
Hoya verticillata var. verticillata Wall. ex Traill	Apocyanaceae	Holoepiphyte	Abundant	ZN1 | ZN2 | ZN3	JPG, CHA, MAT, NAG
Hoya latifolia G.Don	Apocyanaceae	Holoepiphyte	Abundant	ZN2 | ZN3 | ZN5	MAI
Piper longum L.	Piperaceae	Hemiepiphyte	Abundant	ZN2 | ZN3 | ZN4	JPG, CHA, MAT
Piper nigrum L.	Piperaceae	Hemiepiphyte	Abundant	ZN2 | ZN3 | ZN4	JPG, CHA, MAT, NAG
Peperomia pellucida (L.) Kunth	Piperaceae	Facultative	Abundant	ZN1	JPG, NAG, MAI, CHA
Aeschynanthus acuminatus Wall. ex A.DC.	Gesneriaceae	Holoepiphyte	Abundant	ZN2 | ZN3 | ZN4	JPG, MAL, BAN, MAI
Ehretia aspera Willd.	Boraginaceae	Hemiepiphyte	Less common	ZN2	JPG
Heptapleurum arboricola Hayata	Araliaceae	Accidental	Less common	ZN2 | ZN3	JPG, NAG
Commelina benghalensis L.	Commelinaceae	Accidental	Abundant	ZN1 | ZN2	JPG, NAG, MAI, CHA
Pilea microphylla (L.) Liebm.	Urticaceae	Accidental	Abundant	ZN1 | ZN2	JPG, NAG, MAI, CHA
Huperzia phlegmaria (L.) Rothm.	Lycopodiaceae	Holoepiphyte	Common	ZN1 | ZN2 | ZN3	CHA, MAT
Huperzia squarossa (G.Forst.) Trevis.	Lycopodiaceae	Holoepiphyte	Abundant	ZN1 | ZN2	JPG, CHA, MAT
Huperzia hamiltonii (Spreng.) Trevis.	Lycopodiaceae	Holoepiphyte	Abundant	ZN2 | ZN3	JPG, NAG, MAI, CHA
Nephrolepis cordifolia (L.) C.Presl	Polypodiaceae	Holoepiphyte	Common	ZN1 | ZN2 | ZN3 | ZN4	JPG, MAL, BAN, MAI
Drynaria quadrifolia (L.) J.Sm.	Polypodiaceae	Holoepiphyte	Abundant	ZN1 | ZN2 | ZN3 | ZN4	JPG, CHA, MAT, NAG, BAN
Microsorum punctatum (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
Microsorum diversifolium Copel.	Polypodiaceae	Holoepiphyte	Common	ZN1 | ZN2	JPG, CHA, MAT, NAG
Pyrrossia lanceolata (L.) Farw.	Polypodiaceae	Holoepiphyte	Abundant	ZN1 | ZN2 | ZN3 | ZN4	JPG, CHA, MAT, NAG, BAN
Pyrrosia adnascens (Sw.) Ching	Polypodiaceae	Holoepiphyte	Abundant	ZN1 | ZN2 | ZN3 | ZN4	JPG, CHA, MAT, NAG, BAN
Pyrrosia costata (Wall. ex C.Presl). Tagawa et al.	Polypodiaceae	Holoepiphyte	Common	ZN1 | ZN2	JPG, CHA, MAT
Lepisorus nudus (Hook.) Ching	Polypodiaceae	Holoepiphyte	Common	ZN1 | ZN2 | ZN3	MAT, NAG, BAN
Davallia trichomanoides Blume	Polypodiaceae	Holoepiphyte	Common	ZN2 | ZN3 | ZN4	JPG, CHA, MAT, NAG, BAN
Haplopteris elongate (Sw.) E.H.Crane	Pteridaceae	Holoepiphyte	Common	ZN1 | ZN2 | ZN3	JPG, CHA, MAT
Haplopteris flexuosa (Fée) E.H.Crane	Pteridaceae	Holoepiphyte	Common	ZN1 | ZN2 | ZN3	JPG, CHA, MAT, NAG, BAN
Pteris vittata L	Pteridaceae	Holoepiphyte	Common	ZN1 | ZN2 | ZN3 | ZN4	JPG, MAL, MAI, NAG
Asplenium crinicaule Hance	Aspleniaceae	Holoepiphyte	Common	ZN1 | ZN2 | ZN3	MAL, JPG, BAN
Asplenium nidus L.	Aspleniaceae	Holoepiphyte	Abundant	ZN2 | ZN3 | ZN4	MAL, BAN, CHAL
Psilotum nudum (L.) P.Beauv.	Psilotaceae	Holoepiphyte	Common	ZN2 | ZN3	JPG, CHA, BAN
Aerides odorata Lour.	Orchidaceae	Holoepiphyte	Abundant	ZN1 | ZN2 | ZN3	MAL, JPG, BAN
Aerides multiflora Roxb.	Orchidaceae	Holoepiphyte	Abundant	ZN1 | ZN2 | ZN3	MAL, JPG, BAN
Rhynchostylis retusa Blume	Orchidaceae	Holoepiphyte	Abundant	ZN1 | ZN2 | ZN3 | ZN4	MAL, JPG, BAN, NAG, RAJ
Coelogyne corymbosa Lindl.	Orchidaceae	Holoepiphyte	Common	ZN2 | ZN3| ZN4	MAL, BAN, CHAL
Coelogyne cristata Lindl.	Orchidaceae	Holoepiphyte	Common	ZN2 | ZN3 | ZN4	MAL, BAN, CHAL
Dendrobium aphyllum (Roxb.) C.E.C.Fisch	Orchidaceae	Holoepiphyte	Abundant	ZN2 | ZN3	JPG, CHA, BAN
Dendrobium anceps Sw.	Orchidaceae	Holoepiphyte	Abundant	ZN1 | ZN2	JPG, MAL, MAI, NAG
Dendrobium crepidatum Lindl. & Paxton	Orchidaceae	Holoepiphyte	Less common	ZN2 | ZN3 | ZN4	JPG, CHA, BAN
Dendrobium moschatum Wall. ex D.Don	Orchidaceae	Holoepiphyte	Abundant	ZN1 | ZN2	JPG, MAL, MAI, NAG
Dendrobium nobile Lindl.	Orchidaceae	Holoepiphyte	Common	ZN1 | ZN2	JPG, MAL, NAG
Dendrolirium lasiopetalum (Willd.) S.C.Chen & J.J.Wood	Orchidaceae	Holoepiphyte	Abundant	ZN1 | ZN2	JPG, MAL, MAI, NAG
Luisia zeylanica Lindl.	Orchidaceae	Holoepiphyte	Rare	ZN1	NAG
Panisea uniflora (Lindl.) Lindl.	Orchidaceae	Holoepiphyte	Common	ZN2 | ZN3	JPG, CHA, NAG
Gastrochilus dasypogon (Sm.) Kuntze	Orchidaceae	Holoepiphyte	Rare	ZN2 | ZN3	NAG, MAT
Bulbophyllum crassipes Hook.f.	Orchidaceae	Holoepiphyte	Less common	ZN1 | ZN2 | ZN3 | ZN4	JPG, MAL, BAN
Bulbophyllum hirtum Hook.f.	Orchidaceae	Holoepiphyte	Less common	ZN1 | ZN2 | ZN3	JPG, MAL, BAN, MAI
Bulbophyllum reptans (Lindl.) Lindl. ex Wall.	Orchidaceae	Holoepiphyte	Common	ZN1 | ZN2 | ZN3 | ZN4	JPG, MAL, NAG
Cymbidium bicolor Lindl.	Orchidaceae	Holoepiphyte	Abundant	ZN2 | ZN3 | ZN4	JPG, MAL, NAG
Cymbidium aloifolium (L.) Sw.	Orchidaceae	Holoepiphyte	Abundant	ZN2 | ZN3	JPG, MAL, CHAL
Papilionanthe teres Schltr.	Orchidaceae	Holoepiphyte	Abundant	ZN1 | ZN2 | ZN3 | ZN4	JPG, MAL, MAI, NAG
Thunia alba (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

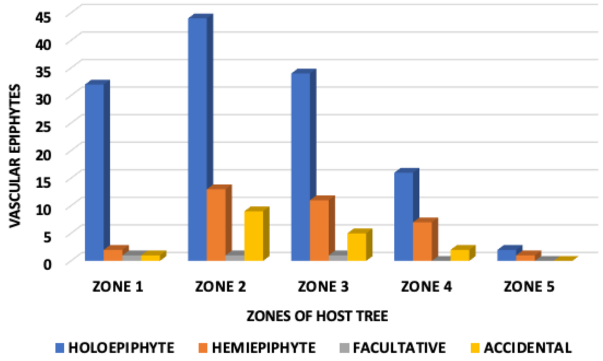

Figure 4. Types of vascular epiphytes distributed on different zones of host trees.

Image 3. Shade tree plantation in the tea garden.

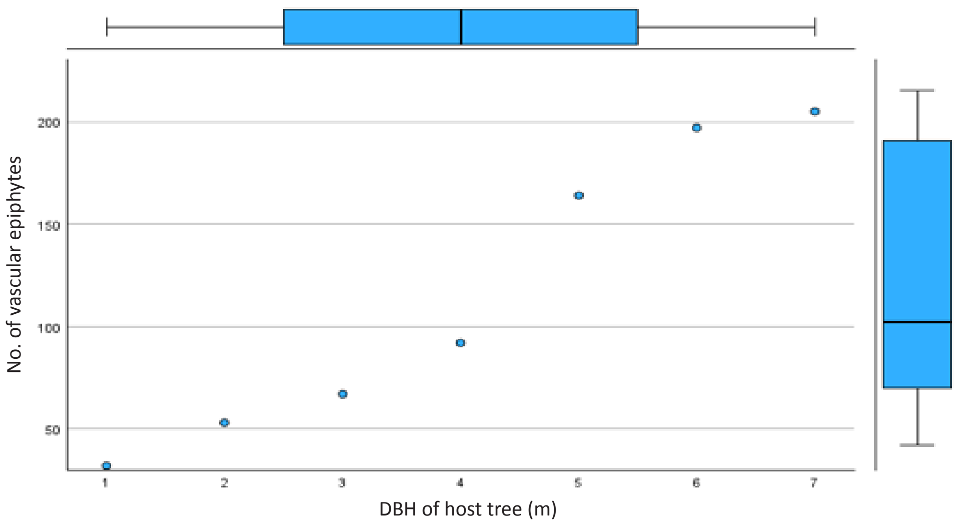

Figure 5. Variable regression plotting using IBM SPSS version 64-bit window version is done which shows a positive correlation between DBH and vascular epiphytes assemblage.

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. Neuerburg–Schdmit, 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 Sci*ences 69: 27– 39.

Mojiol, A.R., A.M.A. Jitinu, 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. Chowdhery (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.

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