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Upright Stratification of Vascular Epiphytes in Chapramari Wildlife Sanctuary, Eastern Himalaya

ROSHNI CHOWDHURY AND MONORANJAN CHOWDHURY*
Taxonomy of Angiosperm and Biosystematics Laboratory, Department of Botany, University of North Bengal, Darjeeling, West Bengal, India
E-mail: rchowdhury268@gmail.com, mono_malda@yahoo.co.in
ORCID ID: 0009-0005-1627-3796 (RC), 0000-0002-7978-1713 (MC)
***Corresponding author**

ABSTRACT
Vascular epiphyte makes a significant contribution to the tropical and sub-tropical diversity. In this study vertical distribution of vascular epiphytes and their significance presence were analysed within the Chapramari Wildlife Sanctuary. Tree species were sampled upon which VEA (Vascular epiphytic assemblage) were studied by using binocular and rope climbing method. A total of 1057 individual epiphytes representing 59 species belonging to 10 families were sampled. Trees were grouped over heights, DBH and Vertical distribution according to zonation pattern confirmed by Detrended Correspondence Analysis (DCA). Orchids and ferns were found dominant species of the study area.

Key words: Natural vegetation, Vascular epiphytes, Vertical zonation, Diversity, Conservation

INTRODUCTION

Eastern Himalayan foothills are home to a variety of species-rich forest formations that are a component of the Himalaya biodiversity hotspot (Myers et al. 2000). As compared to the northwest Himalaya, the eastern Himalayan forests contain a substantially larger number of species (Purohit and Dhar 1997). The majority of researchers have used comparable sampling procedures to estimate tree species richness, with little attention paid to standardising the sample area, despite the significant difference in tree diversity across the Himalayan region (Bhuyan et al. 2003, Singh et al. 2016, Gautam et al. 2016). On tree trunk, the vertical distribution of vascular epiphytes is not random and perhaps influenced by branch properties, humidity, and photon-flux densities. Vascular epiphytes present upon this stretched fertile area are a conspicuous and highly diverse group in nature and also a significant component of tropical and subtropical forests, not just because of its diverse species, but also for its huge biomass accumulation (Gentry and Dodson 1987, Benzing 1987, 1990, Nadkarni 1994, Isaza et al. 2004). Many authors presented different definitions for vascular epiphyte during the course of time. The oldest known definition of epiphyte is 'Plants which germinate on other plants without taking their nourishment' (Brisseau-Mirbel, 1815). These are plants which germinate with roots non-parasitically on other plants without harming the host tree (Benzing 1987, 1990). These are characterized by using a mechanical host only for support and to reach areas with higher levels of light availability (Quaresema et al., 2017). The Chapramari wildlife sanctuary is situated in the foothills of eastern Himalaya region and is surrounded by Gorumara National Park and Neora valley National Park. Many studies reported the rich diversity of the lowland forests of eastern Himalayas (Shankar 2001, Das et al. 2010, Sarkar et al. 2017, Kumar et al. 2017, Mallick 2021, 2022). This study aims to assess the epiphytic communities of a Chapramari Wildlife Sanctuary which missing in most of these studies. Vertical distribution of vascular epiphytes on phorophytes and abundance is studied following zonation method (Mojiol et al. 2009).

MATERIAL AND METHODS

Study area

The Chapramari Wildlife Sanctuary (Fig. 1) covering 9.6 km^2 (http://wiienvis.nic.in/) area (26.8746° N, 88.8551° E) is located at the District Jalpaiguri (Dooars) region of North Bengal bounded by Murti river on its west and Jaldhaka river on east. The

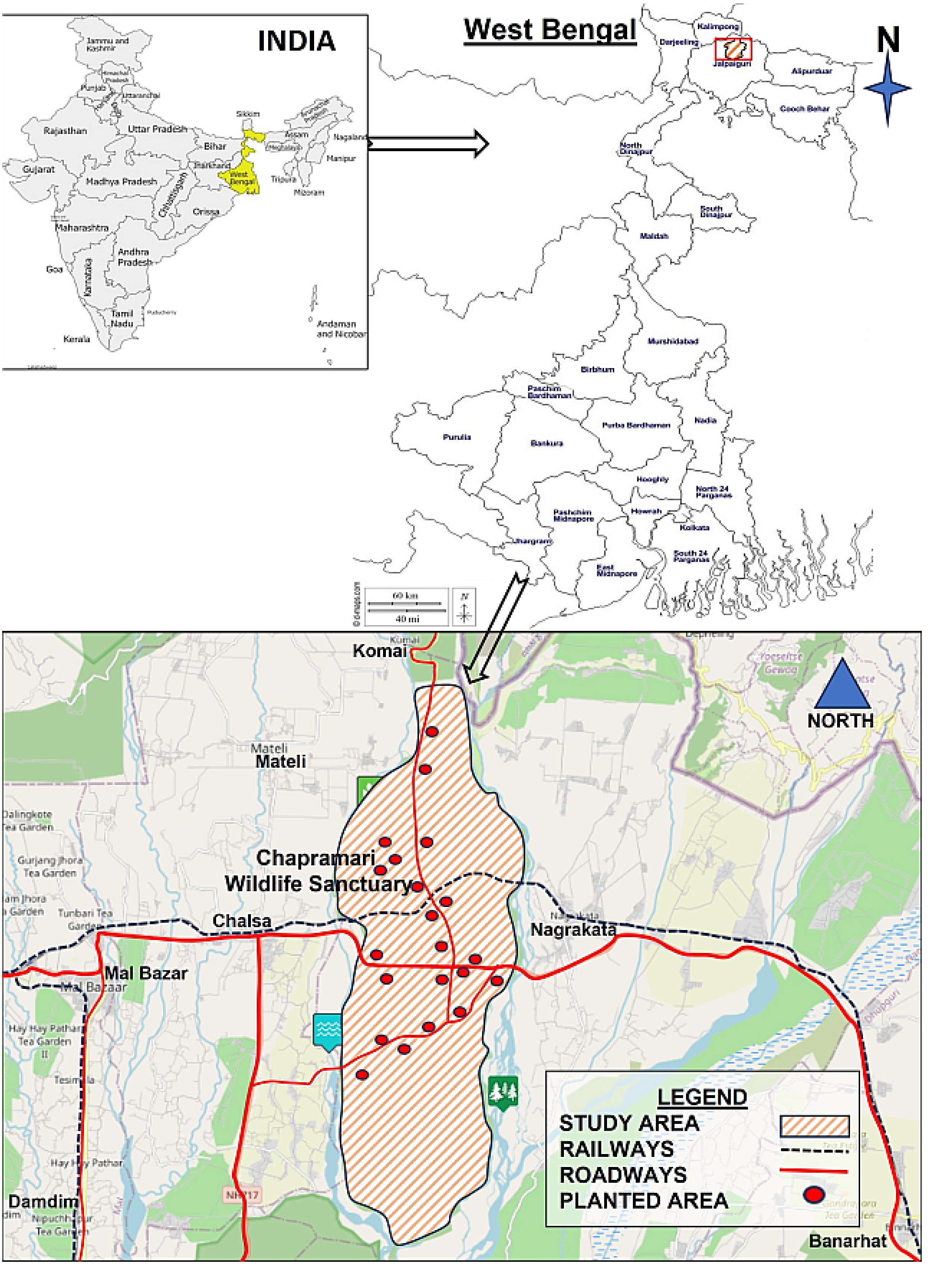

Figure 1. Map of the study area with adjacent forests and local habitats

temperature of the area in pre-monsoon is 24-32°C, monsoon is 27-37°C and post-monsoon is 10-22°C. The relative humidity varies between 75-95%. The annual rainfall is 370-385 cm with different forest types like Terai grassland, Dry mixed forests, Wet mixed forests and Sal forests (Champion and Seth 1968). This sanctuary is fragmented in some areas by human habitations and cultivated lands although connected by few corridors.

Data collection

A floristic exploration was conducted from September 2022 to June 2023 and 10 dominant trees (Nieder et al. 2000, Freiberg 2000) were selected in Chapramari Wildlife Sanctuary for sampling of vascular epiphytes.The selection of the trees was based on its uniformity over the area, specificity toward epiphytes, bark texture and most importantly tree should attain certain height for zonation demarcation on random basis. The younger trees with ≤ 2 m DBH were omitted due to presence of less epiphytic assemblage. For up to 25 m collection over the tree ≥ 2 m DBH self-designed assemblage stick was used with hook at the tip. For top dense canopies binocular method was used (Perry 1978). Trees were divided into four height zones for accurate studies on vascular epiphytes upon them and it also allows uniformity to application on trees (Gradstein 2003). The vertical distribution of vascular epiphytes on phorophytes was studied following noting DBH (Diameter at breast height) of host trees from 1 to 7 m and in respect of that VEA (Vascular epiphyte assemblages) counted Accordingly, i) basal zone (ZN1), ii) lower trunk (ZN 2), iii) upper trunk (ZN3), iv) lower canopy (ZN4), v) middle canopy (ZN5), vi) outer canopy (ZN6) and vii) ultimate crown tip (ZN7). Each zone is considered as plots (Pos and Sleegers 2010). In ZN1- ZN3 plots samples were studied and collected by hand; ZN4-ZN5 adjustable stick were used and ZN6-ZN7 binocular method was used (Nikon ACULON A211 10x50). Collected specimens were identified with the help of available local floras (Prain 1903, Bose and Bhattacharjee 1999, Ranjan et al. 2016), reliable herbaria and e-resources (Anonymous nd., 2024). Collected specimens were processed as per conventional herbarium techniques (Paul et al. 2020) and deposited to Herbarium of University of North Bengal (NBU) for future reference. All the recorded species were summarised in Table 1 with reference to their zone of preference.

Statistical analysis

To investigate the diversity of the vascular epiphytes extracted by vertical zonation pattern by Detrended Correspondence Analysis [PAST 4.3]. DCA is used to get over the alterations done by flattening the arch and rescaling the variables along an axis due to correspondence analysis ordination (Hill et. al 1980), in particular the tendency for one-dimensional gradients to be distorted into an arch on the second ordination axis.

$$\sum_{i=1}^{n} a_i + x_1 = 0$$

$$\sum_{i=1}^{n} a_i + x_i^2 = 1$$

Where, $x_{i\,=}$ arbitrarily chosen score, $a_{i\,=}$ abundance of a taxon, n = number of rows on a matrix.

Sample score of a matrix was standardised of mean one and variance zero (Holland 2008). For more precise data interpretation with different variables box-whisker plots were constructed using IBM SPSS windows 10 version. The plot graph has a line at the median of the data set this value in the set divides it evenly in half, with an equal number of points smaller and larger. The median (Q1) is halfway between the two central point's known as quartile (Q2 and Q3). Anything ranging outside the plot ranging between 1.5 × IQR below Q1 and 1.5 × IQR above Q3 is known as outliers.

RESULTS

Vertical stratification

The highest number of species recorded from Zone 2 (51 species; 28% of all species) and Zone 3 (42 species; 24% of all), then Zone 1 which comprises of 37 species; 19.6% of total species recorded. Nevertheless, Zone 4 (23 species; 12%) and Zone 5 (15 species; 11% of all) holds same number of vascular epiphytes. The number count decreases from Zone 6 (14 species; 3.6%) to ultimately lowest

Table 1. Number of individuals (N) per species of epiphytes. All species against the specific height zones of host are sorted according to their zone of occurrence

Scientific names	Family	N	ZN1	ZN2	ZN3	ZN4	ZN5	ZN6	ZN7
Pothos scandens L.	Araceae	4	1	1	2	-	-	-	-
P. chinensis (Raf.) Merr.	Araceae	2	1	-	1	-	-	-	-
Scindapsus officinalis (Roxb.) Schott	Araceae	4	1	1	-	2	-	-	-
Philodendron hastatum K.Koch & Sello	Araceae	5	1	2	2	-	-	-	-
P. herbaceum Croat & Grayum	Araceae	2	1	-	1	-	-	-	-
Syngonium podophyllum Schott	Araceae	3	1	1	1	-	-	-	-
Rhaphidophora decursiva (Roxb.) Schott	Araceae	4	1	2	1	-	-	-	-
R. glauca (Wall.) Schott	Araceae	2	1	-	1	-	-	-	-
Monstera deliciosa Liebm.	Araceae	7	3	4	-	-	-	-	-
Dischidia chinensis Champ. ex Benth.	Apocyanaceae	13	5	2	3	-	1	1	1
D. bengalensis Colebr.	Apocyanaceae	8	3	2	-	2	-	1	-
Hoya verticillata var. verticillata	Apocyanaceae	7	2	2	1	-	1	1	-
Piper longum L.	Piperaceae	4	1	1	1	1	-	-	-
Aeschynanthus acuminatus Wall. ex A.DC.	Gesneriaceae	4	1	2	1	-	-	-	-
Huperzia phlegmaria (L.) Rothm.	Lycopodiaceae	2	-	1	-	1	-	-	-
H. squarrosa (G.Forst.) Trevis.	Lycopodiaceae	1	-	-	1	-	-	-	-
Nephrolepis cordifolia (L.) C. Presl	Polypodiaceae	17	3	7	2	-	2	3	-
Drynaria quercifolia (L.) J.Sm.	Polypodiaceae	116	7	14	42	21	17	10	5
Microsorum punctatum (L.) Copel.	Polypodiaceae	54	5	16	21	8	4	-	-
Pyrrosia lanceolata (L.) Farw.	Polypodiaceae	112	20	32	10	21	29	-	-
P. costata (Wall. ex C.Presl) Tagawa & K.Iwats.	Polypodiaceae	12	3	4	2	-	2	1	-
P. adnascens (Sw.) Ching	Polypodiaceae	49	6	7	15	21	-	-	-
Lepisorus nudus (Hook.) Ching	Polypodiaceae	88	14	32	14	-	28	-	-
Davallia trichomanoides Blume	Polypodiaceae	14	7	3	-	4	-	-	-
Haplopteris elongata (Sw.) E.H.Crane	Pteridaceae	26	-	12	14	-	-	-	-
Pteris vittata L.	Pteridaceae	48	-	21	12	3	12	-	-
Asplenium crinicaule Hance	Pteridaceae	17	5	7	3	-	2	-	-
A. nidus L.	Pteridaceae	12	-	-	12	-	-	-	-
Psilotum nudum (L.) P.Beauv.	Psilotaceae	4	-	2	2	-	-	-	-
Adiantum caudatum L.	Pteridaceae	3	-	1	-	1	-	1	-
Aerides odorata Lour.	Orchidaceae	50	22	12	5	11	-	-	-
A. multiflora Roxb.	Orchidaceae	15	-	3	7	-	3	1	1
Rhynchostylis retusa (L.) Blume	Orchidaceae	7	1	3	2	1	-	-	-
Coelogyne corymbosa Lindl.	Orchidaceae	7	-	3	4	-	-	-	-
C. cristata Lindl.	Orchidaceae	4	-	3	-	1	-	-	-
Dendrobium aphyllum (Roxb.) C.E.C.Fisch.	Orchidaceae	4	-	1	2	1	-	-	-
D. anceps Sw.	Orchidaceae	2	1	1	-	-	-	-	-
D. crepidatum Lindl. & Paxton	Orchidaceae	3	-	-	3	-	-	-	-
D. moschatum (Banks) Sw.	Orchidaceae	2	-	1	1	-	-	-	-
D. nobile Lindl.	Orchidaceae	1	1	-	-	-	-	-	-
D. macraei Lindl.	Orchidaceae	12	-	7	5	-	-	-	-
Dendrolirium lasiopetalum (Willd.) S.C.Chen & J.J.Wood	Orchidaceae	5	-	2	3	-	-	-	-
Luisia zeylanica Lindl.	Orchidaceae	5	1	2	1	-	1	-	-
Coelogyne uniflora Lindl.	Orchidaceae	60	26	15	7	12	-	-	-
Gastrochilus dasypogon (Sm.) Kuntze	Orchidaceae	4	1	2	-	1	-	1	-

Scientific names	Family	N	ZN1	ZN2	ZN3	ZN4	ZN5	ZN6	ZN7
Bulbophyllum crassipes Hook.f.	Orchidaceae	29	16	7	-	6	-	-	-
B. hirtum (Sm.) Lindl. ex Wall.	Orchidaceae	45	7	12	13	-	-	6	7
B. reptans (Lindl.) Lindl. ex Wall.	Orchidaceae	35	-	11	17	-	7	-	-
Cymbidium bicolor Lindl.	Orchidaceae	3	-	1	1	-	-	1	-
C. aloifolium (L.) Sw.	Orchidaceae	4	-	1	1	1	-	1	-
Coelogyne fusca (Lindl.) Rchb.f.	Orchidaceae	5	2	1	2	-	-	-	-
C. imbricata (Hook.) Rchb.f.	Orchidaceae	57	30	12	15	-	-	-	-
Acampe praemorsa var. longepedunculata (Trimen) Govaerts	Orchidaceae	6	-	2	1	2	1	-	-
A. praemorsa (Roxb.) Blatt. & McCann	Orchidaceae	5	1	2	-	2	-	-	-
Papilionanthe teres (Roxb.) Schltr.	Orchidaceae	31	-	6	5	6	4	10	-
Oberonia mucronata (D.Don) Ormerod & Seidenf.	Orchidaceae	3	-	1	-	1	-	1	-
Smitinandia micrantha (Lindl.) Holttum	Orchidaceae	5	3	-	2	-	-	-	-
Heptapleurum arboricola Hayata	Araliaceae	1	-	1	-	-	-	-	-
Ficus pumila L.	Moraceae	2	1	1	-	-	-	-	-

number of species was found on the Zone 7, the canopy tips which holds 4 species and 1.3% (Table 1). The major number of vascular epiphytes are restricted to middle canopy region maybe they are specialist in nature. To reveal patterns in the distribution of species analysis was done on specific height zones and DBH. The minimum height taken for study is 10m to highest 40 m. Same for DBH minimum 1 and maximum 7 score was fixed. Finally, DCA was performed considering all plots as separate sampling units. Considering each zone as plot separately, the number of used detrending segments were set on 26. Grouping all plots according to zonation, however, gave a pattern. DCA axis 1 scores (zone 1 = 0, zone 2 = 141, zone 3 = 227, zone 4 = 100, zone 5 = 218, zone 6 = 345 and zone 7 =356). Furthermore, DCA showed that zones 3 and 5, zones 2 and 4 and zone 6 and 7 have very significant similarity. For confirming the results, variable is weighted against PCA by extracting scree plot of zones by vascular epiphytes as component of analysis (Fig. 2). For heights to vascular epiphytic relationship variable on boxplot are plotted, the median (M) for height up to 10 m is 7, Q1= 5, Q3= 12, maximum range (MR) 15 and minimum range (MiR) 3; 20 m height M= 22, Q1= 11, Q3= 26, MR= 28 and MiR= 5; 30 m height M= 22, Q1= 16, Q3= 23, MR= 28 and MiR= 12 and 40 m height M= 33, Q1= 31, Q3= 38, MR= 43 and MiR= 0. No outliers were present (Fig. 3a). The DBH of host plant vs number of vascular epiphytes shows host plants with DBH 5 and 6 m is the most diverse. In 5 m DBH; M= 42, Q1= 37, Q3= 46, MR= 62 and MiR= 27 and 6 m DBH; M= 42, Q1= 50, Q3= 37, MR= 45 and MiR= 18. Lowest diversity in DBH with 1 m (Fig. 3b). No outliers were present. The vertical distribution of vascular epiphytes according to zones (Fig. 3c) is maximum in zone 2 (M= 5, Q1= 3, Q3= 10, MR= 22 and MiR= 2), zone 3 (M= 5, Q1= 2, Q3= 10, MR= 22 and MiR= 2) and zone 4 (M= 5, Q1= 3, Q3= 12, MR= 22 and MiR= 3). Zone 1, zone 2, zone 3 and zone 5 has outliers.

Floristic outcome

The ten sampled trees of average canopy height yielded a total number of 1057 individuals belonging to 59 species of vascular epiphytes distributed over 19 families. In total, 26 species of Orchidaceae, 9 species of Araceae, 8 species of polypodiaceae, 6 species from Pteridaceae, 4 species of Apocyanaceae, 2 species from Lycopodiaceae and Gesneriaceae, whereas, Araliaceae, Moraceae, and Piperaceae had 1 species showing low diversity. Mean number of species was 7 with standard deviation of 2. The maximum species of vascular epiphytic assemblage were 15 species per tree and minimum of 2 species per tree.

DISCUSSION

The species richness of the study area is comparably high due to its virginity in aspect of vascular

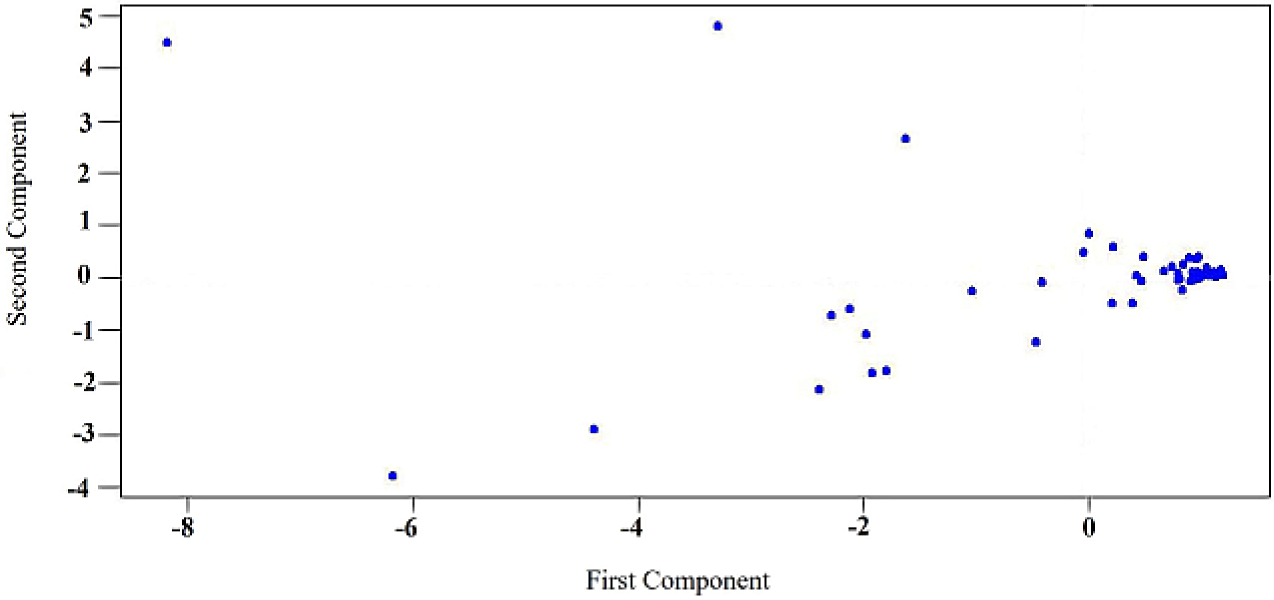

Figure 2. Component score plot of vascular epiphytes to zones by PCA

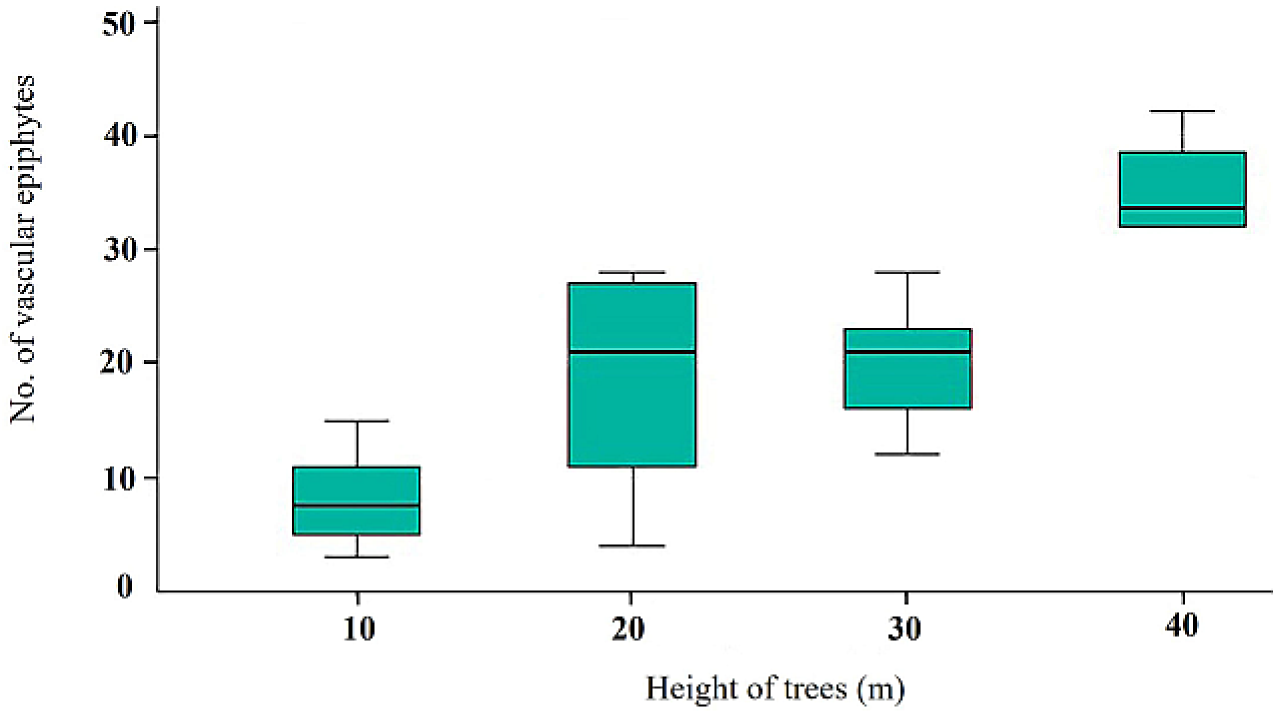

Figure 3a. Box plot analysis of vascular epiphytes distribution in various host plant height class

epiphytic studies. The vertical zonation and diameter are directly proportionate to each other. In this study, the host tree with low DBH ≤ 2 m have least number of epiphytes in zone 1, highest at zone 3, zone 4 and zone 5. Whereas DBH ≥ 2 m have rich epiphytic flora on zone 1, zone 2, zone 3 and zone 4. Interestingly zone 6 and zone 7 is independent of diameter and height of host trees. This finding is in agreement with Flores-Argüelles (2022) in natural and disturbed forest on the northern coast of Jalisco, Mexico. The vertical distribution of vascular epiphytes is depended upon the microclimatic gradients such as temperature, wind velocity, humidity and light intensity (Gentry and Dodson 1987). The outer canopy i.e., zone 6 to 7 have low VEA because of extreme microclimate, due to exposure of high light intensities from direct sunlight. The middle canopy i.e., zone 3, zone 4 and zone 5

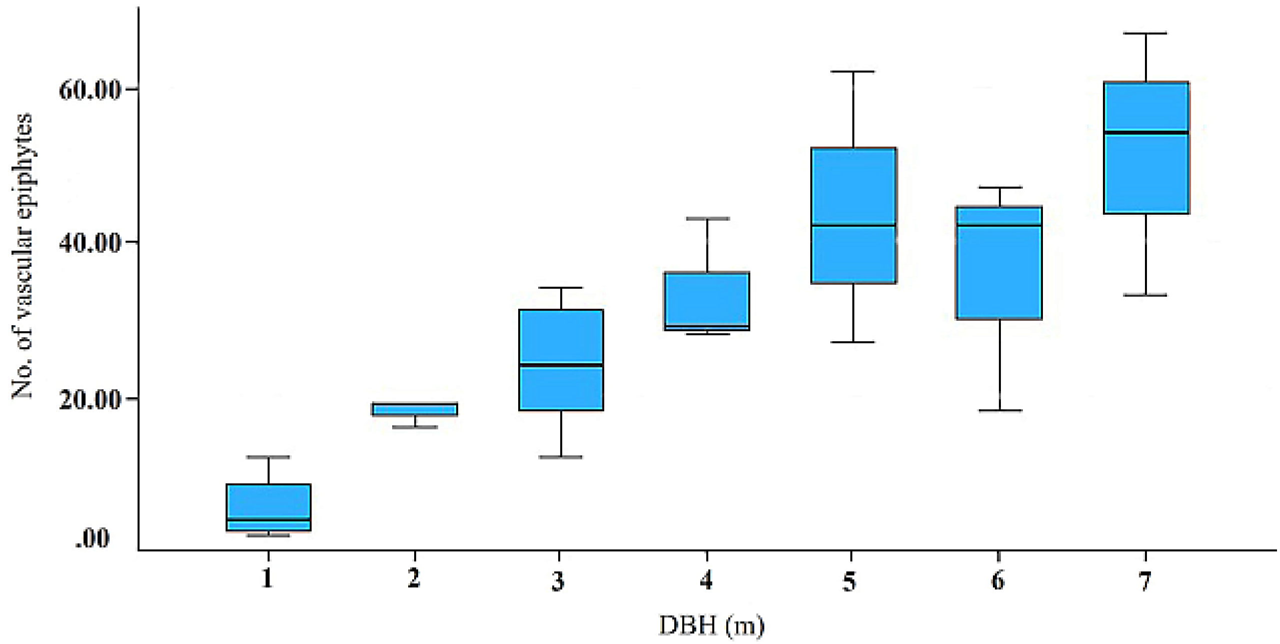

Figure 3b. Distribution of vascular epiphytes in various host plant diameter at breast height class

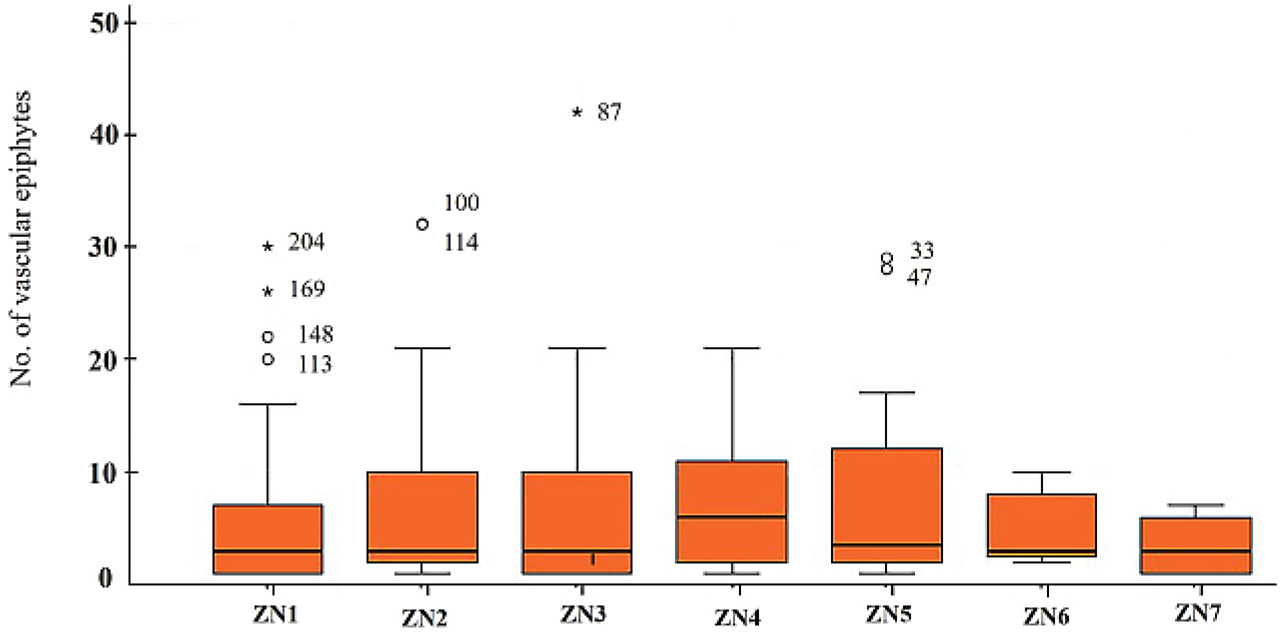

Figure 3c. Distribution of vascular epiphytes in various vertical zones of host trees

benefits by crown shading effect by top epiphytic settlers (Cardelús and Chazdon, 2005). Therefore, middle canopy is the most epiphytic richest part of the host tree. The basal portion of the host is not preoccupied with the microclimate needed for epiphytic invasion due to less sunlight, low water retention capacity, and variation in bark texture supported by other researchers (Bogh 1992, Freiberg 2000 and Adhikari et. al 2021). But, on the other hand, assemblage in this part makes easy biomass accumulation and aids pollination by rapid ant association. During the studies, it was noted that within species they may have also a preference for zones. There can be two types of specificity that might work a) intra specificity within the same genera but different species, b) inter specificity within different genera of vascular epiphytes. During field studies, it has been noted that species of *Dendrobium* prefer specific zones with specific heights (intra-specific). Whereas, *Papilionthes teres* seems to be a generalist species and recorded to grow anywhere irrespective of specific zone therefore coexistence with different genera is high (inter-specific). The present findings of the shift of epiphytic specificity within them were supported by previous scientific research by Štípková et al. (2020). No species of the Bromeliaceae family were recorded despite they are significant epiphyte family.

CONCLUSION

The undisturbed habitats in forests of the eastern Himalayas hold a vast number of epiphytic flora. Vascular epiphytes are inevitable part of flora which is proclaimed to hold an important position for contributing species diversity. As they are also good indicators of environment toxification, can be used for flushing harmful elements. It can replenish degradation of forest output by indicating and ensuring increase in ecological richness. Proper conservation steps may contribute to the increase in the species richness and abundance in forest ecosystem. Alternatively, these vascular epiphytes have potential to be used as an alternative livelihood to the forest tribals. Most of the vascular epiphytes are ornamental and have high demands as indoor plants and extension and awareness programs regarding ornamental, medicinal and ecological use of vascular epiphytes and setting up of small nurseries can benefit and boost survival for both forest dwellers and vascular epiphytes.

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