



A review on terrestrial and lithophytic orchid diversity in the north eastern state of Assam

Rakesh Kalita¹, Mustafizur Rahman²

¹Department of Botany, Plant Ecology, Gauhati University, Assam, India

²Department of Botany, Plant Taxonomy, Royal Global University, Assam, India

Abstract

Orchidaceae resembles a unique group of epiphytic, saprophytic, terrestrial or lithophytic herbal flora that have reached a highest position of complex morphological adaptations among angiosperms to bring about successful cross pollination by various motile agents. Comprising about 10% of total flowering plants it accounts for about 25,000 to 35,000 species. Assam being a part of the greater bio-diverse seven sister states houses for about 400 species of orchids, with many yet to be explored. Although a greater mass is attracted towards epiphytic orchids due to their captivating floral appearances but an equal amount of terrestrial and lithophytic orchids are also found in abundance in the mighty forests of Assam. This study gives an overall idea on distribution of members of Orchidaceae from global to national perspectives, narrowing down to their abundance in Assam. This review additionally emphasizes on the species diversity of terrestrial and lithophytic orchids of the state Assam. There are about 120 documented species of terrestrial orchids in Assam, representing at least 50 different terrestrial genera. Of all the terrestrial orchid species that have been described from Assam, the genus *Zeuxine* and *Calanthe* has shown the maximum species diversity followed by *Eulophia* and *Habenaria*. With regard to orchids that are growing as lithophytes, there are at least 59 distinct species of them belonging to 27 different genera are described in the state. Maximum species found in lithophytic habitats were from the genera of *Dendrobium*, followed by *Coelogyne* and *Cymbidium*. But lithophytic orchid species do not always grow exclusively on rocks instead the same species may have diverse habitat forms which are also further explored in this review. Using an illustration of the species diversity within different ground orchid genera, this review seeks to shed light on the terrestrial orchids' numerical strength in Assam.

Keywords: Orchid diversity, terrestrial orchids, lithophytic orchids, ground orchids of Assam, orchid diversity of North East, Assam

Introduction

The family Orchidaceae representing one of the largest families of the anthophytes comprises unique assemblage of highly advanced monocotyledonous plants. Some of the distinctive characters that differs the family Orchidaceae from other Angiospermic families are – lower lip modified to form the labellum, ovary is inferior, resupination of the ovary; style, stigma and the androecium are united to form the gynandrium, the pollen usually aggregated into several masses to form the pollinia that have a sticky portion for the attachment of the pollinators. Literature suggests that there lies about 25,000 – 35,000 orchid species under 800 – 1,000 genera diversified throughout the world. The family Orchidaceae comprises about 10% of all angiospermic plants with an estimation of 25,000 species distributed throughout the world (Cribb *et al.*, 2003) [15]. Another estimation suggests that approximately 24,500 orchid species under 788 genera are distributed in the world as per Dressler, 2006. But about the estimation of terrestrial orchid diversity a little is explored compared to the diversified study on epiphytic orchids. Such condition is probably due to the scarce abundance and lack of proper study of the former compared to the later. So, this review aims to provide an overview of the species diversity within the terrestrial orchid genera in Assam, as well as the numerical strength of these genera. This review also examines the orchid genera that exhibit lithophytic adaptation in addition to shedding light on the diversity of ground orchids.

Importance of this review

Assam has many terrestrial orchids that are described and discovered from different locations, but there haven't been any review studies that provide a comprehensive overview of the state's total terrestrial orchid diversity as of yet. This review aims to provide an overview of the species diversity within the terrestrial orchid genera in Assam, as well as the numerical strength of these genera. In addition to shedding light on the diversity of ground orchids, this review investigates the orchid genera that exhibit lithophytic adaptation. Since there is a dearth of literature on the diversity of lithophytic orchids in the state, this review attempts to examine the diversity of lithophytic orchid species and their genera in terms of numbers.

1. International status

The family Orchidaceae is one of the most diversified and widespread families of the anthophytes. Although history suggests that, orchids originate in the Earth back from 120 million years ago, many literatures suggests that the history of orchids started in Japan or China about 3000 – 4000 years ago. In the discovery of the new world, various epiphytic orchids which was completely unknown before, became a part of European orchid literature. A Swedish botanist, named Carl Von Line established the first coherent identification of plants and used the term "Orchidaceae" (from Orkhis) to resemble the orchid family in his study "Genera Plantarum" in the year 1735. Pioneer studies done by Linnaeus, also known as "Father of Taxonomy" recorded 62 European species in his book "Species Plantarum" in the

year 1753. John Lindley, also known as “Father of Orchid Cultivation” was the first to classify orchids in his book “The Genus and the Species of Orchidaceae plants” in the year 1830. George Bentham in the year 1883 [6] published the final volume of “Genera Plantarum” where he mentioned the subtribes for the first time which was a very important step for the classification of plants. From 1999 to 2014, “Genera Orchidacearum” was published in 6 volumes that covers all known orchid species including the description of each genus. Dressler in the year 2006 recorded 24,500 species of orchids under 788 genera that is diversified throughout the world. Chase in 2015 in his new report merged various previously recorded genera, reducing the total number of genera to 736.

2. National status

In India, the family Orchidaceae comprises of 158 genera with 1,331 species with the estimated growth elevation of 5,000m (De L.C. and Medhi, 2015). The epiphytic orchids resembles about 60% of the total population of orchids in India and the rest resembles the terrestrial orchids (Pal and Nagrare, 2006) [42]. The epiphytic orchids are common in the Northeastern part of India that reaches upto an elevation of about 2,000m above the sea level. The terrestrial orchids are common in the humus rich moist area under shaded trees in the Northwestern part of India. Various small flowered orchids are commonly found in the Western ghats of India. An estimation suggests that, a good number of orchid species are distributed in the Himalayan region, especially in the North Eastern Himalayas of India. A report estimates that, 875 species from 151 genera of orchid species are distributed in the Himalayan region of India representing about 70% of the total orchid species of India (Medhi et al., 2009) [40]. John Dalton Hooker (1890) had given a taxonomic account of orchids from the sub-continent of India and his later works (1885 – 1890) he reported about 1250 species under 117 genera from the family Orchidaceae in the books “Flora of British India”, (vol V and vol VI). Generally, epiphytic orchids are commonly distributed in Northeastern India and the terrestrial orchids are diversified in humus rich moist soil under shaded trees in Northwestern part of India. Hazra and De in the year 2010 reported the status of distribution of orchids in the various parts of India which are as follows:

1. Eastern Himalayas and Northeast Indian region (Including Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura):- with 159 genera including 870 species
2. North Western Himalayan region (including Jammu & Kashmir, Himachal Pradesh, Uttarakhand): - with 75 genera including 288 species
3. Peninsular Indian region (including Madhya Pradesh, Orissa, Andhra Pradesh, Gujarat, Central India, Eastern and Western Ghats): - with 89 genera including 379 species
4. Andaman and Nicobar Islands region (including 319 islands and islets in Bay of Bengal): with 53 genera including 115 species

Recently several works has been done in the field of taxonomic study of orchids throughout India. Botanical Survey of India in the year 2019 published “Orchids of India, A Pictorial Guide” where they listed 1256 taxa under 155 genera from India. In the Uttarakhand state, 73 genera

with 240 species of orchids were recorded out of which 130 are terrestrial orchids, 11 are saprophytic and 99 are epiphytic orchids (Jalal, 2012) [36, 37]. In Maharashtra, 32 genera with 106 species of orchid species were recorded out of which 53 are terrestrial and 53 are epiphytic (Jalal and Jayanthi, 2018). From the Darjeeling Himalayas of West Bengal, 85 genera with 311 species of orchid species was reported out of which 77 are terrestrial, 17 are saprophytic and 217 species are epiphytic orchids (Yonzone *et al.* 2012) [49]. From Andhra Pradesh, 36 genera with 77 species were reported out of which 37 are terrestrial orchids and 40 are epiphytic orchids (Vatsavaya *et al.*, 2008).

3. Northeast India

The Northeastern part of India is considered as the biodiversity hotspot comprising of 8 states, namely – Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura located between 87°32 E to 97°52 E latitude and 21°34 N to 29°50 N longitude. This part is also considered as hotspot of orchids due to the accommodation of various suitable conditions i.e. high humidity, low temperature and good rainfall for the growth of the orchid flora. The Northeastern region of India has about 876 species of orchids under 151 genera that contributes approximately 70% of the total orchid species in India. A significant number of various ornamental, rare, endangered and threatened species of orchids are diversified in the wild nature of this region. Medhi and Chakrabarti reported 151 genera with 876 orchid species (Medhi and Chakrabarti, 2009) [40]. The Arunachal Pradesh, also named as “Orchid Paradise” of India contributes 50% of its total orchid species in our country. In recent study, 558 orchid flora was recorded in Arunachal Pradesh belonging to 144 genera and out of which 160 are terrestrial, 377 are epiphytic and 21 are mycotrophic orchid species. (Rao, 2010) [46]. Meghalaya also harbours a significant diversity of orchid flora. 104 genera with 439 taxa of orchids was reported from Khasi, Jaintia and Garo Hills (Kataki, 1986) [38]. Due to geographic diversity, very high rainfall and high humid, Nagaland also harbours a rich and diversified flora of orchids. The state includes 88 genera with 368 orchid species out of which 253 are epiphytic, 116 are terrestrial orchids, 8 are dual habitat type, 6 are saprophytic species (Deb and Jamir, 2003). The forest department of all the 8 Northeastern states of India published their distribution of orchids according to which the numerical strength of genera and species diversity are as follows:- Arunachal Pradesh (126 genus including 550 species), Assam (81 genera including 193 species), Manipur (69 genera including 251 species), Meghalaya (98 genera including 352 species), Mizoram (75 genera including 244 species), Nagaland (63 genera with 241 species), Sikkim (137 genera with 525 species) and Tripura (33 genera with 48 species) (State Forest Dept., 2009). Recently various works have been done in the field of orchids throughout the Northeast India. De L.C and Medhi reported 850 orchid flora out of which 34 are threatened and 85 are endemic (De and Medhi, 2014).

4. Assam

Assam, being the second largest state of Northeast India located in the central most region, comprises a wide variety of orchid species. The area of the state is approximately 78,440 sq.km and bordered by 6 Northeastern states and including West Bengal. This state is generally known to

have a significant amount of rainfall and the climate is typically “tropical monsoon forest” type with high humidity. Khyanjeet Gogoi, also known as the “The Orchid Man of Assam” has mentioned 398 species and 10 intraspecific taxa belonging to 101 genera of orchid species in his book “Wild Orchids of Assam” in the year 2017. It has been reported that 121 species under 48 genera are terrestrial and saprophytic orchids and 277 species under 53 genera are epiphytic orchids. In the Brahmaputra valley that includes 7 districts namely Goalpara, Kamrup, Darrang, Nagaon, Lakhimpur, Dibrugarh and Sibsagar at that time, 50 genera with 115 species with 4 varieties was reported (Baruah, 1978) [3]. The presence of wide diversity of orchid flora in Assam is evident from the fact that the state harbours an endemic species of epiphytic orchid, *Rhynchostyllis retusa* that represents the state flower of Assam. Even from the cultural perspective, one can observe that there exists a strong association between orchid flora and the residents of the state. Various tribes of Assam uses orchids as a ornamentation for their aesthetic beauty, such as - *Rhynchostyllis retusa* (fox tail orchid) commonly known as Kopou phool in Assam are adorned by females on their head as an ornamentation during the Bihu festival of Assam. As a commercially important ornamental flora various cultivators and horticulturist of the state are cultivating the showy and attractive orchid flowers in various nurseries and commercial greenhouses, such as the species of *Dendrobium*, *Bulbophyllum*, *Dendrophylax*, etc. John Dalton Hooker reported 47 genera with 136 species from earlier Assam that includes Naga Hills, Patkaye range, Mishni Hills, Brahmakund of earlier NEFA (North East Frontier Agency) in the book “Flora of British India” in the year 1890. Out of them 121 species under 48 genera are terrestrial orchids and 277 under 53 genera are epiphytic orchids. Gogoi in his recent “Wild Orchid of Tinsukia District” reported 53 genera with 105 orchid species (Gogoi, 2012) [28]. Chaudhury in 2005 reported 31 genera with 293 species of orchid flora of Assam. I.C Baruah in his book “Orchid Flora of Kamrup District, Assam” reported 31 genera with 65 specific and intraspecific taxa (Baruah, 2001) [4].

Terrestrial and lithophytic orchid diversity of Assam

A wide range of habitat diversity and life forms can be observed in orchids expanding from epiphytic nature to terrestrial to lithophytic habits. But certain species, like *Bulbophyllum drymoglossum*, *Sarcanthus scolopendrifolius*, *Lieanthes rupestris*, *Holcoglossum spp.*, *Lepanthes rubipetala*, etc. are found both as lithophytes and epiphytes, particularly in tropical regions (Xing *et al.*, 2015) [48]. Across all continents, terrestrial orchids are renowned for their exceptional species diversity and specificity with regard to pollinators and mycorrhizal symbionts. Additionally, a great deal of them are uncommon and vulnerable to alterations in the environment. Only through

the establishment of mycorrhizal associations with the plant's roots can orchids continue their life cycle within a terrestrial ecosystem. The fact that orchid roots are linked to fungi is widely recognized. However, the habitat range of these mutualistic partners varies, ranging from endophytically establishing to living epiphytically at various tissue layers. The orchid mycorrhiza is an exclusive kind of mycorrhiza found only in Orchidaceae members and is one of the most noteworthy mycorrhizal groups in terms of evolutionary perspectives, ecological aspects and economical angle. Orchids can be classified as mixotrophic or myco-heterotropic / holomycotrophic based on their mycorrhizal dependency. Orchids can be classified as mixotrophic or myco-heterotropic / holomycotrophic based on their mycorrhizal dependency (Hossain, *et al.*, 2022) [34]. Due to their photosynthetic nature, the majority of orchids are only dependent on mycorrhizal fungi during the seed germination stages; this type of orchid is known as a mixotrophic orchid. Whereas holomycotrophic orchids are those achlorophyllous orchids which entirely depends on mycorrhizal fungi for growth and nourishment throughout their life history. Once the mixotrophic orchids achieved photosynthetic activity, they were able to decrease their reliance on fungi. All photosynthetic orchids have mycorrhizal associations throughout their life cycle, but only during their rapid vegetative growth and flowering period was there a greater colonization rate noted. Certain orchids can also be observed developing on rock faces and on debris of rocks which are termed as lithophytes. The lithophytes have the same culture as the epiphytes because in nature they get their nutrients in a comparable manner. In both the cases, either nutrients carried down the rock face or the surface of the tree bark, are absorbed by the clinging roots of the orchids. In lithophytic orchids certain portion of the roots stays exposed, whereas other roots can grow into cracks and crevices and where they consume the mycelium (natural fungal spawn) that naturally occurs there. Some frequently create dense mats of fine roots for fungal mycelium to grow in them which they later utilizes. But it is not always the case that an orchid species growing as lithophytes only grows on rocks; it can also grow as ground orchid or as epiphytes in a variety of habitats. The above statement holds true for many orchids where a single species can have different habitat forms. For instance, *Coelogyne corymbosa*, an endangered species of ornamental orchid, grows as an epiphyte and lithophyte in subtropical to subalpine regions (Qin *et al.*, 2020) [43]. Although certain orchid species coexist in the same habitat as lithophytes and epiphytes, little is known about how their mycorrhizal fungal communities differ. Investigation of orchid mycorrhizal fungal communities in lithophytes and epiphytes in China using *Coelogyne viscosa*, which occurs as both an epiphyte and a lithophyte showed that composition of the mycorrhizal fungal communities varied between them (Xing *et al.*, 2015) [48].

Table 1: List of terrestrial orchids of Assam and their distribution

Sl no.	Genus	Species	Distribution
1.	<i>Acanthophippium</i>	<i>A. striatum</i> <i>A. sylhetense</i>	Endangered Common
2.	<i>Ania</i>	<i>A. augustifolia</i> <i>A. penangiana</i> <i>A. viridifusca</i>	Rare Rare Rare
3.	<i>Anoectochilus</i>	<i>A. brevilabris</i>	Rare

		<i>A. roxburghii</i>	Rare
4.	<i>Anthogonium</i>	<i>A. gracile</i>	Rare
5.	<i>Aphyllorchis</i>	<i>A. montana</i>	Endangered
6.	<i>Apostasia</i>	<i>A. nuda</i> <i>A. wallichii</i>	Endangered Endangered
7.	<i>Arundina</i>	<i>A. graminifolia</i>	Rare
8.	<i>Brachycorythis</i>	<i>B. galeandra</i> <i>B. helferi</i>	Rare Rare
9.	<i>Calanthe</i>	<i>C. alismifolia</i> <i>C. biloba</i> <i>C. densiflora</i> <i>C. herbacea</i> <i>C. lyroglossa</i> <i>C. mannii</i> <i>C. odora</i> <i>C. masuca</i> <i>C. sylvatica</i> <i>C. triplicata</i>	Endangered Endangered Rare Rare Endangered Rare Rare Common Common Common
10.	<i>Cephalanthera</i>	<i>C. longifolia</i>	Endangered
11.	<i>Cephalantheropsis</i>	<i>C. obcordata</i> <i>C. longipes</i>	Endangered Endangered
12.	<i>Cheirostylis</i>	<i>C. griffithii</i>	Rare
13.	<i>Chrysoglossum</i>	<i>C. ornatum</i> <i>C. assamicum</i>	Rare Endangered
14.	<i>Collabium</i>	<i>C. chinensi</i>	Common
15.	<i>Corymborkis</i>	<i>C. veratrifolia</i>	Rare
16.	<i>Cremastra</i>	<i>C. appendiculata</i>	Rare
17.	<i>Crepidium</i>	<i>C. acuminatum</i> <i>C. bauritum</i> <i>C. calophyllum</i> <i>C. purpureum</i>	Common Rare Rare Rare
18.	<i>Cryptostylis</i>	<i>C. arachnites</i>	Rare
19.	<i>Cymbidium</i>	<i>C. lancifolium</i> <i>C. munroanum</i>	Rare Endangered
20.	<i>Cyrtosia</i>	<i>C. javanica</i>	Endangered
21.	<i>Didymoplexis</i>	<i>D. pallens</i>	Common
22.	<i>Dienia</i>	<i>D. ophrydis</i>	Common
23.	<i>Epipogium</i>	<i>E. roseum</i>	Rare
24.	<i>Erythrorchis</i>	<i>E. altissima</i>	Rare
25.	<i>Eulophia</i>	<i>E. bicallosa</i> <i>E. dabia</i> <i>E. graminea</i> <i>E. herbacea</i> <i>E. kamarupa</i> <i>E. mannii</i> <i>E. pauciflora</i> <i>E. spectabilis</i> <i>E. zollingeri</i>	Rare Common Rare Rare Rare Endangered (Endemic) Rare Rare Endangered
26.	<i>Galeola</i>	<i>G. lindleyana</i>	Endangered
27.	<i>Geodorum</i>	<i>G. densiflorum</i> <i>G. appendiculatum</i> <i>G. laxiflorum</i> <i>G. pallidum</i>	Common Rare Rare Rare
28.	<i>Goodyera</i>	<i>G. foliosa</i> <i>G. hispida</i> <i>G. procera</i> <i>G. repens</i> <i>G. viridiflora</i>	Rare Rare Common Rare Rare
29.	<i>Habenaria</i>	<i>H. acutifera</i> <i>H. digitata</i> <i>H. arietina</i> <i>H. furcifera</i> <i>H. mandersii</i> <i>H. reniformis</i> <i>H. plantagine</i> <i>H. stenopetala</i>	Rare Rare Rare Rare Rare Rare Rare Rare
30.	<i>Herminium</i>	<i>H. lanceum</i>	Rare
31.	<i>Hetaeria</i>	<i>H. affinis</i>	Common
32.	<i>Liparis</i>	<i>L. deflexa</i> <i>L. nervosa</i>	Rare Rare

		<i>L. odorata</i>	Rare
33.	<i>Nephelaphyllum</i>	<i>N. cordifolium</i>	Rare
34.	<i>Nervilia</i>	<i>N. concolor</i> <i>N. juliana</i> <i>N. macroglossa</i> <i>N. plicata</i>	Common Common Rare Rare
35.	<i>Odontochilus</i>	<i>O. elwesii</i> <i>O. lanceolatus</i> <i>O. tortus</i>	Rare Rare Rare
36.	<i>Pachystoma</i>	<i>P. pubescens</i>	Rare
37.	<i>Paphiopedilum</i>	<i>P. venustum</i> <i>P. spicerianum</i> <i>P. villosum</i>	Critically endangered Critically endangered Critically endangered
38.	<i>Pecteilis</i>	<i>P. susannae</i>	Rare
39.	<i>Peristylus</i>	<i>P. constrictus</i> <i>P. densus</i> <i>P. goodyeroides</i>	Rare Rare Rare
40.	<i>Phaius</i>	<i>P. flavus</i> <i>P. tankervilleae</i> <i>P. mishmensis</i> <i>P. wallichii</i>	Rare Common Common Rare
41.	<i>Phalaenopsis</i>	<i>P. pulcherrima</i>	Rare
42.	<i>Satyrium</i>	<i>S. nepalense</i>	Rare
43.	<i>Spathoglottis</i>	<i>S. plicata</i>	Rare
44.	<i>Spiranthes</i>	<i>S. sinensis</i> <i>S. himalayensis</i>	Common Rare
45.	<i>Tainia</i>	<i>T. latifolia</i> <i>T. minor</i> <i>T. wrayana</i>	Common Rare Rare
46.	<i>Thunia</i>	<i>T. alba</i>	Rare
47.	<i>Tropidia</i>	<i>T. angulosa</i> <i>T. curculigoides</i> <i>T. formosana</i>	Rare Common Rare
48.	<i>Vanilla</i>	<i>V. borneensis</i>	Rare
49.	<i>Vrydagzynea</i>	<i>V. nuda</i>	Endangered
50.	<i>Zeuxine</i>	<i>Z. strateumatica</i> <i>Z. nervosa</i> <i>Z. longilabris</i> <i>Z. grandis</i> <i>Z. lindleyana</i> <i>Z. gracilis</i> <i>Z. goodyeroides</i> <i>Z. flava</i> <i>Z. glandulosa</i> <i>Z. clandestina</i>	Common Common Rare Rare Common Rare Rare Rare Rare Rare

(Gogoi K, 2017 “Wild Orchids of Assam” Assam Biodiversity; Board Basumatary *et al.*, 2008 [5]; Bhattacharjee *et al.*, 2005 [7]; Bora *et al.*, 2008 [10]; Chawnglantluangu 1995; Hooker *et al.*, 1895 [33]; Chowdhury *et al.*, 1994 [14]; Bhattacharjee *et al.*, 2008 [8]; Bruhl and Paul, 1926 [11]; Gogoi, 2012 [28]; Gogoi and Yonzone, 2012 [49]; Barua *et al.*, 2021; Gogoi *et al.* 2021 [31]; Gogoi *et al.*, 2012; Rao and Hajra, 1974; Gogoi and Hondiqui, 2021; Gogoi *et al.*, 2022 [26]; Barua *et al.*, 2019; Das and Kumar, 2017 [16]; Gogoi, 2017) [23]

Lithophytic orchid species of Assam

Ania penangiana, *Calanthe clavate*, *Collabium chinense*, *Crepidium acuminatua*, *Cymbidium lancifolium*, *Galeola lindleyana*, *Goodyera procera*, *G. viridiflora*, *Liparis nervosa*, *L. deflexa*, *Paphiopedilum villosum*, *P. venustum*, *P. spicerianum* and *Phalaenopsis pulcherrima* are 14 lithophytic orchid species found in Assam that are also found as ground orchids. *Arachnis labrosa*, *Bulbophyllum cylindraceum*, *B. leopardinum*, *B. reptans*, *B. retusiusculum*, *Ceratostylis himalaica*, *Cleisostoma tenuifolium*, *C. williamsonii*, *Coelogyne cristata*, *C. ovalis*, *C. punctulate*,

C. suaveolens, *C. trinervis*, *C. viscosa*, *Conchidium muscicola*, *Cymbidium mastersii*, *C. iridioides*, *C. hookerianum*, *C. erythraeum*, *C. eburneum* *Dendrobium amplum*, *D. chrysanthum*, *D. chrysotoxum*, *D. eriiflorum*, *D. hookerianum*, *D. macraei*, *D. moniliformae*, *D. spatella*, *Eria javanica*, *Liparis distans*, *L. cespitosa*, *L. bootanensis*, *Oberonia obcordate*, *Otochilus porrectus*, *Panisea uniflora*, *Pholidota articulata*, *P. chinensis*, *P. pallida*, *Pinalia stricta*, *P. spicata*, *Thunia alba* var. *alba.*, *Trichotosia pulvinata* and *Vandopsis undulata* are the 43 species of lithophytic orchids found in Assam that are also present as epiphytes. Whereas *Luisia filiformis* and *Dendrobium moschatum* are generally found as epiphytes, rarely found as lithophytes.

Discussion

At least 50 distinct terrestrial genera are represented by the approximately 120 species of terrestrial orchids that have been described from Assam. The genus *Zeuxine* and *Calanthe* has demonstrated the greatest number of species among all the terrestrial orchid species that have been described from Assam. Ten species from each of the two

genera have been found spread out across Assam. Regarding *Zeuxine*, it has been observed that three species—*Z. strateumatica*, *Z. nervosa*, and *Z. lindleyana*—are widely distributed, while the remaining species are considered rare. Comparably, only three species of *Calanthe*—*C. masuca*, *C. sylvatica*, and *C. triplicata*—are widely distributed; the remaining species are either rare or endangered. *Eulophia*, with nine species that are primarily rare in distribution, was the second most frequently found genus after *Zeuxine* and *Calanthe*, followed by *Habenaria*, with eight rare terrestrial species. The most commonly distributed ground orchids found in Assam includes *Acanthophippium sylhetense*, *Calanthe masuca*, *Calanthe sylvatica*, *Calanthe triplicate*, *Collabium chinensi*, *Crepidium acuminatum*, *Didymoplexis pallens*, *Didymoplexis ophrydis*, *Eulophia dabia*, *Geodorum densiflorum*, *Goodyera procera*, *Hetaeria affinis*, *Nervilia concolor*, *Nervilia juliana*, *Phaius tankervilleae*, *Phaius mishmensis*, *Spiranthes sinensis*, *Tainia latifolia*, *Tropidia curculigoides*, *Zeuxine strateumatica*, *Zeuxine nervosa* and *Zeuxine lindleyana*. There are at least 59 different species of orchids that can be described as lithophytes in the state, and they belong to about 27 different genera. At least nine species in the genus *Dendrobium* are found to grow as lithophytes in Assam. There are at least six species in each of the genera *Coelogyne* and *Cymbidium* that exhibit lithophytic adaptations. The genus *Liparis*, which has at least five species that exhibit lithophytic habits, is next to them. The majority of the described species, despite being classified as lithophytes, can also be found in nature as epiphytes, though some are also known to exist as ground orchids.

References

- Barua KN, Bora B, Borah A. Diversity and ex situ conservation of orchid species in Lekhapani Reserve Forest under Makum Coal Field, Assam. *J. Orchid Soc. India*,2019;33:113-19.
- Barua KN, Hazarika P, Gogoi G. Orchid diversity of Tropical Wet Evergreen forests in Digboi Forest Division, Assam, India. *Journal of Non-Timber Forest Products*,2021;28(3):79-88.
- Baruah B. Studies on systematics of orchids in Brahmaputra valley, Assam, 1978.
- Baruah IC. Orchid Flora of Kamrup District, Bishen Singh Mahendra Pal Singh, Dehradun, India, 2001.
- Basumatary N, Bora RK, Sarma CM. Diversity and Ecology of orchids on Kokrajhar District (Assam) in *J. Orchid Soc. India*,2008;22(1-2):21-28.
- Bentham G. *Genera plantarum ad exemplaria imprimis in herbariis Kewensibus servata definita: Sistens dicotyledonum gamopetalorum ordines VI: caprifoliaceas-compositas*, 1873, 2(1).
- Bhattacharjee B, Dutta BK. *Paphiopedilum spicerianum* (Reichb. f.) Pfitz- A first disappearing Lady's Slipper orchid in Cachar District, Assam, in: *J. Orchid Soc. India*,2005;19(1-2):71-72.
- Bhattacharjee B, Dutta BK. Notes on a collection of *Coelogyne viscosa* Reichb. f.- a rare orchid in Cachar district of Assam, in: *Phytotaxonomy*,2008;8:71-73.
- Bhattacharjee A. A note on the identity of *Anoectochilus roxburgii* (Orchidaceae). *The McAllen International Orchid Society Journal*,2013;14:8-13.
- Bora RK, Basumatary N, Sarma CM. Terrestrial and Epiphytic Orchid Flora of Kokrajhar, Assam II: Report of some more orchids of the district in: *Phytotaxonomy*,2008;8:58-61.
- Bruhl Paul. *A Guide to the Orchid of Sikkim*. Thacker & Spink & Co., Simla, India, 1926.
- Chawngphantluanga. *Orchids of Mizoram*. Vol-I. Env. & Forest Department, Govt. of Mizoram, 1995.
- Chowdhury S. Assam's Flora (Present status of vascular plants); a partial documentation of the project Environmental Atlas of Assam. *ASTEAC, Guwahati*, 2005.
- Chowdhury S, Katak SK, Barua IC. Floristic analysis of Angiosperms of Kamrup District (sensu lato), Assam. In *Journ. Econ. Taxon. Bot*,1994;18(3):697-703.
- Cribb PJ, Kell SP, Dixon KW, Barrett RL. Orchid conservation: a global perspective. *Orchid conservation*, 2003, 124.
- Das R, Kumar S. Note on the presence of *Spiranthes himalayensis* (Orchidaceae) in the state of Assam, India. *Methods*, 2017, 115.
- De LC. Chapter-6 Indian Orchids in CITES Appendices. *Forestry Sciences*, 2022, 107.
- De LC, Medhi RP. Diversity and conservation of rare and endemic orchids of North East India-A Review. *Indian Journal of Hill Farming*,2014;7(1):138-153.
- De LC, Medhi RP. Orchid-A diversified component of farming systems for profitability and livelihood security of small and marginal farmers. *Journal of global biosciences*,2015;4(2):1393-1406.
- Deb Chitta, Jamir N, Imchen Temjensangba. ORCHID DIVERSITY OF NAGALAND -A REVISED STATUS, 2003.
- Dressler RL. *Phylogeny and classification of the orchid family*. Cambridge University Press, 1993.
- Gaskett AC, Gallagher RV. Orchid diversity: Spatial and climatic patterns from herbarium records. *Ecology and Evolution*,2018;8(22):11235-11245.
- Gogoi K. "Wild Orchids of Assam" Assam Biodiversity Board, 2017.
- Gogoi J, Mathiyazhagan M, Chutia M, Doley DK. Orchid resources of Poba Reserve forest in Dhemaji district of Assam, India. *Int J Bot Stud*,2022;7(6):45-51.
- Gogoi K. A checklist of orchids in Tinsukia District of Assam, India. *Pleione*,2012;6(1):5-26.
- Gogoi K. An annotated checklist of orchids of Dhemaji district of Assam (India) with an addition of one rare orchid for the flora of Assam. *Richardiana*,2022;6:55-72.
- Gogoi K, Rajendra Yonzone. Terrestrial Orchid Diversity of Dibrugarh District of Assam of North East India in: *The McAllen International Orchid Society Journal*,2012b;13(9):5-20.
- Gogoi K, Borah RL, Das R, Yonzone R. Present status of orchid species diversity resources of Joypur Reserve forest of Dibrugarh District (Assam) of North East India. *International Journal of Modern Botany*,2012;2(3):47-67.
- Gogoi K, Das R, Yonzone R. Orchids of Assam, North East India-An annotated checklist. *International Journal of Pharmacy & Life Sciences*, 2015, 6(1).
- Gogoi K, Gogoi A, Shyam MP. A Checklist of orchids of Chala Reserve Forest, Charaideo district (Assam, India).

31. Gogoi K, Gogoi R, Sonowal R, Borah D. Checklist of orchids of Lakhimpur district of Assam (India) with the addition of two rare orchids. *Richardiana*,2021:5:59-75.
32. Hooker JD. *Flora Of British India Vol-5*. L. Reeve; London, 1885.
33. Hooker JD. A century of Indian Orchids. In Ann. Roy. Bot. Gard. Calcutta, 1895, 5.
34. Hossain MM. Orchid mycorrhiza: Isolation, culture, characterization and application. *South African Journal of Botany*,2022:151:365-384.
35. Jain SK, Rao RR. A handbook of field and herbarium methods. Today and Tomorrow. *Prin. & pub. New Delhi, India*, 1977.
36. Jalal JS. Distribution pattern of orchids in Uttarakhand, Western Himalayas, India. *International Journal of Plant Biology*,2012:3(1):e5.
37. Jalal JS, Jayanthi J. Endemic orchids of peninsular India: a review. *Journal of Threatened Taxa*,2012:4(15):3415-3425.
38. Katak SK. Orchids of Meghalaya, 1986.
39. Linnaeus C. *Species plantarum* (Vol. 3). Impensis GC Nauk, 1799.
40. Medhi RP, Chakrabarti S. Traditional knowledge of NE people on conservation of wild orchids, 2009.
41. Medhi RP, Chakraborti M. Orchid biodiversity in India: conservation and utilization. *Indian Journal of Genetics and Plant Breeding*,2012:72(02):148-156.
42. Pal R, Nagrare VS. Orchid diversity of India: Its conservation and sustainable utilization. *Technical Bulletin, National Research Centre for Orchids, Sikkim, India*, 2006, 1-21.
43. Qin J, Zhang W, Zhang SB, Wang JH. Similar mycorrhizal fungal communities associated with epiphytic and lithophytic orchids of *Coelogyne corymbosa*. *Plant Diversity*,2020:42(5):362-369.
44. Rajendran A, Rao NR, Kumar KR, Henry AN. Some medicinal orchids of southern India. *Ancient Science of Life*,1997:17(1)10.
45. Raju VS, Reddy CS, Reddy KN, Rao KS, Bahadur B. Orchid wealth of Andhra Pradesh, India. *Proc AP Acad Sci*,2008:12(1):180-192.
46. Rao AN. Orchid flora of Arunachal Pradesh-an update. *Bulletin of Arunachal forest research*,2010:26(1-2):82-110.
47. Singh Jalal J, Jayanthi J. An updated checklist of the orchids of Maharashtra, India. *Lankesteriana*,2018:18(1):23-62.
48. Xing X, Ga X, Liu Q, Hart MM, Guo S. Mycorrhizal fungal diversity and community composition in a lithophytic and epiphytic orchid. *Mycorrhiza*,2015:25:289-296.
49. Yonzon R, Lama D, Bhujel RB, Rai S. Orchid species diversity of Darjeeling Himalaya of India. *International Journal of Pharmacy & Life Sciences*, 2012, 3(3).