

# CHAPTER 2

# DIVERSITY

# AND

# DISTRIBUTION



## **2.1. INTRODUCTION**

Orchids are the most fascinating group of flowering plants having incredible range of diversity in floral and vegetative features (Pijl and Dodson, 1966; Holttum, 1977; Faden et al., 1985). The family comprises 28,484 species representing about 779 genera worldwide (Govaerts et al., 2017). Orchids survive in a wide range of habitats (ranging from tropical, humid plains and valley to subtropical, temperate and alpine hilly zones) wherein, their growth is influenced by the number of biotic and abiotic factors. Nearly 70% of the orchids are epiphytic (Zotz, 2013) and distributed mainly in tropical and subtropical environments.

India is the seventh largest country in the world with a total geographical area of 3.29 million sq. km. The northeastern part of India (*i.e.* Eastern Himalayas and the Northeast region) is also considered to be the place of orchid origin as they are very prominent species among the vegetation of the origin (Paul and Kumaria, 2017). Orchidaceae is the second largest family of flowering plants in India with about 1,331 species belonging to 184 genera, contributing about 10% of Indian flora (Jain and Rao, 1977; Kumar and Manilal, 1994). Orchids naturally grow in various regions of the country having annual rainfall ranging from 60 to 110 cm. They flourish well at an altitude ranging from sea level to over 4,000 m, despite relative temperature differences. The epiphytic orchids are abundant up to 1,800 m and their frequency decreases with higher altitude (Chowdhury et al., 1971; Chowdhury, 1987). In India, the orchid diversity is mainly concentrated in Eastern Himalaya, Western Himalaya and Western Ghats (Hooker, 1890, 1895; Brühl, 1926; King and Pantling, 1967).

Orchids are more vulnerable to the habitat destruction that can be caused by natural threats, human encroachment and threats posed by invasive species. So, the conservation of orchid is most crucial for orchid cultivators as well as plant taxonomists. Various aspects of conservation are pointed out by various conservationists, namely Santapau and Kapadia (1959), Anderson (1968), Hunt (1968, 1970), Moir (1968), Subramanyan (1969), Pradhan (1974), Katakai (1976), Baruah and Boissya (1978). Deforestation for excessive production of timber plays a major role in the loss of orchids growing on the forest trees as well as the terrestrial one. Thus, conservation of orchids is very crucial from the scientific point of view.

**2.1.1. Work on Orchidaceae in India**

The understanding of Indian flora was commenced somewhere between 17<sup>th</sup> to 19<sup>th</sup> centuries, when many European botanists and naturalists visited India (Singh, 2001). The first scientific account of Indian orchids was given by Van Rheedee (1693) in his 12 volume book 'Hortus malabaricus', in which 16 orchid taxa have been described. Linnaeus (1753) described 12 species of orchids under the genus *Epidendrum* from Malabar tract in his book "Species Plantarum". The subsequent taxonomic work carried out by Roxburgh (1832), Griffith (1851), Lindley (1857, 1858), Drury (1864), Aitchison (1869) and Atkinson (1882) was comprehended into the immense work of Hooker (1890, 1894). The work elucidates detailed descriptions of about 1200 orchids belonging to 113 genera from erstwhile British India. He described ca. 100 species of Indian orchids with illustrations. Pradhan (1976) enlisted 130 genera representing 810 taxa in his book entitled "Indian Orchids: Guide to Identification & Culture I -II". Ghose (1978) described 150 taxa in the account for 27 genera with special emphasis on cultivation and propagation of Indian orchids. Rao (1979) enumerated a total of 180 species belonging to 50 genera from India with additional information on culture practices of some orchids. Bose and Bhattacharjee (1980) described 834 species in 127 genera in his book "Orchids of India". Das and Jain (1980) provided a revision of genus *Coelogyne* Lindl. in "Fascicles of Flora of India". The revisionary work of Indian *Calanthe* R.Br. and *Cymbidium* Sw. were carried out by Rathore (1979, 1983). Jain and Mehrotra (1984) listed 925 species from 144 genera with original citation, corrected nomenclature and proper distribution in "A preliminary inventory of Orchidaceae in India". The revisionary work on Indian *Oberonia* was carried out by Ansari and Balakrishnan (1990) in volume IV of "Orchid Monograph". Sarkar (1995) provided an updated census of Indian orchids which incorporates approximately 1100 species belonging to 153 genera. Singh (2001) gave an overview of Indian orchid diversity (1229 species under 184 genera) based on their phytogeographical affinities, endemism, economic significance and conservation status. Misra (2007) enumerated 1331 species represented by 184 genera, mainly confined to the Himalayas, Eastern and Western Ghats.

Phytogeographically the country has been divided into various phytogeographical zones based on ecological Parameters (Clarke, 1898; Hooker, 1906; Chatterjee, 1939, 1962; Razi, 1955). The latest classification given by Chatterjee (1962) was adopted for

writing the review of the literature. Chatterjee (1962) divided the country into nine phytogeographical regions *viz.* **1. The Eastern Himalaya 2. The Western Himalaya 3. The Indus Plains 4. The Gangetic Plain 5. Central India 6. Deccan 7. Western coasts of Malabar 8. Assam and 9. Bay Islands of Andaman and Nicobar.**

**The Eastern Himalaya and Assam** extend from central Nepal to Northwest Yunnan in China, encompassing Bhutan and North East in India. The region has huge floral diversity due to its tropical temperature and rainfall conditions. The foremost work on Sikkim Himalaya was carried out by King and Pantling (1967) describing many novel species from the area. Later on, Brühl (1926) described 461 species representing 92 genera in his book “A guide to orchids of Sikkim Himalaya”. On the basis of phylogeny and distribution, Katak (1971) described 271 species embodying 75 genera from United Khasi and Jaintia Hills, Meghalaya. Tuyama (1975) published a book entitled “The flora of Eastern Himalayas”. Baruah (1978) listed 115 species and four varieties under 50 genera from Brahmaputra valley, Assam. About 33 species representing 22 genera were recorded by Deb (1983) from Tripura. Hynniewta (1984) reported 238 species and four varieties under 59 genera from Nagaland with several new records to the state and country. A plant conservation Bulletin “Distribution of Orchids of Sikkim and North-East India” published by Katak et al. (1984), wherein, he described 128 genera representing 690 species. Subsequently, Katak and Goswami (1986) accounted 280 species from Meghalaya in his book entitled “Orchids of Meghalaya”. Chawngthantluanga (1996) reported 253 species in the book “Orchids of Mizoram”. A checklist of orchids from Arunachal Pradesh was published by Chowdhury and Pal (1997). Chowdhery (1998) reported 545 species belonging to 123 genera in a book on the “Orchid Flora of Arunachal Pradesh”. 241 species and four varieties under 63 genera were reported from Nagaland by Hynniewta et al. (2000). Barua (2001) published a book on “Orchid flora of Kamrup District, Assam” with detailed description and illustration. Deb and Imchen (2008) enumerated 396 species of orchids under 92 genera in a book entitled “Orchids of Nagaland”. Bhattacharjee (2009) reported 61 species of orchids from South Assam with special emphasis on conservation aspect. An intensive work was carried out on *Paphiopedilum* of North-East by Mao (2010). Sharma et al. (2013) enumerated 65 species of Monopodial orchids belonging to seven subtribes from Meghalaya. 28 species representing four genera of tribe Orchideae was accounted by Verma et al. (2015) from Meghalaya. De and Medhi (2014) recorded 850 species of

orchids from North East India in “Diversity and Conservation of Rare and Endemic orchids of North East India - A Review”. Gogoi (2015) reported nine species of *Paphiopedilum* Pfitzer from Assam.

**The Western Himalaya** region includes North and South Kashmir, part of Punjab and Kumaon region of Uttarakhand. These regions encompass less outnumbered diversity than that of eastern Himalaya because of its dryness and very low temperature of its tropical and temperate zones. Collett and Hemsley (1902) enumerated 38 species of orchids under 18 genera from Shimla and adjoining regions. Duthie (1906) has been described 173 species belonging to 45 genera from North Western Himalayas with some beautiful illustrations. Banerjee and Thapa (1978) described 189 species accounting for 54 genera from Nepal and adjoining areas of India. Raizada et al. (1981) revised the work of Duthie and listed 89 species in 35 genera from Mussoorie. An alphabetic inventory of 250 species under 24 genera from North-western Himalaya was reported by Seidenfaden and Arora (1982). Dhar and Kachroo (1983) critically studied the flora of Kashmir Himalayas and described single species from all orchid genera. Vij et al. (1983) enumerated 112 species from Nainital and neighbouring hills in the Central Himalayas. Later, Vij et al. (1986) recorded 54 orchids under 23 genera from Simla and adjoining hills in the North-Western Himalayas. Jalal et al. (2008) gave a checklist of 237 species of orchid from Uttarakhand, of which 127 are terrestrial, 99 epiphytic and 11 saprophytic. Verma (2008) accounted 84 species belonging to 39 genera from Himachal Pradesh and Jammu & Kashmir in the Northwest Himalaya and the adjacent plains. 236 species under 72 genera were reported from Uttarakhand by Joshi et al. (2009). Kusum (2014) reported 39 species of orchid from Himachal Pradesh. Jalal and Jayanthi (2015) carried out a comprehensive work on the orchid diversity of Western Himalaya and enumerated a total of 239 species under 72 genera.

**The Indus Plains** includes some parts of Punjab, Delhi, Rajasthan, few parts of Gujarat and Kutch. The major flora includes tropical thorn forests and grasslands whereas the orchid diversity recorded in this zone is less compared to the other phytogeographical regions. Singh (1983) reported two orchids in “Flora of Banswara District, Rajasthan”. Bakshi (1984) enlisted six species of orchids in “Flora of Murshidabad district”. Shetty and Singh (1991) accounted 10 species from six genera in “Flora of Rajasthan”.

**The Gangetic plains** comprise of Delhi, Uttar Pradesh, Bihar, West Bengal and part of Orissa. The vegetation comprises tropical moist deciduous forests, dry deciduous forests, thorn forests and mangrove forests. Haines (1922) enlisted 73 species from 28 genera in “Botany of Bihar and Orissa”. Maheshwari (1963) reported *Zeuxine strateumatica* from Delhi. Srivastava (1976) accounted *Oberonia falconeri* and *Z. strateumatica* in “Flora Gorakhpurensis”. Raizada and Duthie (1976) reported four genera representing seven species from upper Gangetic plains. Misra (2004) enumerated 130 species of orchids from Orissa with detailed illustration and morphological description followed by flowering and fruiting period, field notes and their distribution within and outside India. Kumar et al. (2007) provided a checklist of 63 species of orchids from Chota Nagpur, Jharkhand.

**The Deccan** region includes southern Peninsular India from southern Madhya Pradesh to Kanyakumari excluding Western Ghats. The vegetation consists of tropical dry evergreen, dry deciduous and swamp forests. Fyson (1915) provided a detailed description and illustration of 58 orchid species belongs to 24 genera from Nilgiris and Pulney Hill-tops. Fischer (1928) with the progression of Gamble’s work on Flora of Presidency of Madras brought out a volume on the Orchidaceae. It contains admirable and accurate descriptions of 60 genera possessing 199 species from erstwhile Presidency of Madras. Blatter (1928) worked on orchid species of Madurai district, Tamil Nadu. Few orchids from Madras and surrounding areas were reported by Mayuranathan (1929) with a short description. Joseph (1982) provided a brief description of 116 species from Nilgiris which was further increased to 121 species representing 49 genera (Joseph, 1987). Nayar (1982) reported 267 species from 60 genera in “Endemic Flora of Peninsular India”. On the basis of collections made by Mathew and co-workers, Seidenfaden (1983) described 73 species under 36 genera from Tamil Nadu and Karnataka. Ahmedullah and Nayar (1986) enumerated 123 species of endemic orchids under 33 genera from Peninsular India. Manilal and Kumar (1993) explored the peninsular region and enlisted 322 orchids. Pullaiah (1997) listed 67 orchids in “Flora of Andhra Pradesh”. Rao (1998) has described 65 species of orchids from Tamil Nadu. 190 species under 54 genera recorded by Reddy et al. (2006a, b) from Eastern Ghats. Kottaimuthu et al. (2008) provided a preliminary checklist of 25 species under 17 genera from Sirumalai, Tamil Nadu. Raju et al. (2008) enumerated 77 species under 36 genera

from Andhra Pradesh. 130 endemic species of orchids belonging to 38 genera were enumerated by Jalal and Jayanthi (2012) from Peninsular India.

**Western coasts of Malabar** tract are a small region extending from Gujarat to Kanyakumari along with the Western Ghats. The vegetation consists of tropical wet evergreen, moist evergreen and moist deciduous forests. Wet temperate forests (Sholas) are present in Nilgiris while mangrove forests are found in the saline swamps on the coasts. The first novel work on Malabar tract was carried out by Gammie (1886), in “The Orchids of Bombay Presidency”. Rao (1914) enumerated 171 species of orchids with their medicinal value from Travancore district of South India. Fischer (1921) described 42 species representing 23 genera from Annamalai Hills. Blatter and McCann (1931) revised the orchid flora of the Bombay Presidency. Santapau (1957) enlisted about 19 species of orchids under seven genera from Purandhar. Cooke (1958) described 74 species representing 31 genera from the erstwhile Presidency of Bombay which mainly includes Maharashtra, Gujarat, Sindh and Karnataka. Santapau and Kapadia (1966) together revised the family for Bombay and enlisted 27 species belongs to 17 genera. 95 species under 41 genera were enumerated by Saldanha and Nicolson (1976) from Hassan district of Karnataka. Rao and Razi (1981) described 62 species from Mysore while Arora et al. (1981) enlisted four species from South Kanara. Yoganarasimhan et al. (1982) reported 38 species under 26 genera from Chickmagalur district of Karnataka. Abraham and Vatsala (1981) enumerated 150 South Indian orchids along with detail description and cytological analysis. Manilal and Sivarajan (1982) documented 10 species belongs to nine genera in “Flora of Calicut”. Sharma et al. (1984) described 173 species representing 51 genera from Karnataka. Murthy and Yoganarasimham (1990) was able to locate all the species reported by Sharma et al. (1984) from the same area with some additional information on their medicinal property and its phytoconstituents. Kumar (1990) reported 214 species of orchids representing 68 genera from Kerala. Kumar and Manilal (1994) provided a comprehensive key for 216 orchids distributed in Kerala. 109 species and three varieties under 34 genera were enumerated by Lakshminarasimhan et al. (1996) from Maharashtra. Yadav and Sardesai (2002) listed 78 orchids representing 29 genera from Kolhapur, Maharashtra and again Sardesai and Yadav (2004) revised the genus *Habenaria* from the same area. A systematic description of 155 species representing 60 genera was given by Rao and Sridhar (2007) in the book “Wild Orchids in Karnataka: A Pictorial Compendium”. Gurav (2007) recorded 114 taxa

of orchids under 41 genera from Western Ghats with the details on distribution, cytology, physiology and tissue culture. Pande et al. (2010) enumerated 99 wild orchids from Northern Western Ghats with detailed information on their distribution, ecology and threats. Udupa (2012) accounted 93 species from Chikmagalur district, Karnataka. Dangat (2015) studied the systematic of 40 species of genus *Habenaria* from Western Ghats.

**The Andaman and Nicobar Islands** comprise of littoral mangrove, evergreen, semi-evergreen and deciduous forests. Karthigeyan et al. (2014) reported 140 species and three subspecies represented by 66 genera from Andaman and Nicobar Islands. Alappatt (2016) accounted *Bulbophyllum odoratissimum* (Sm.) Lindl. and *Dendrobium spatella* Rchb.f. (Orchidaceae) from Andaman and Nicobar Islands, so far only known from eastern Himalaya and northeast India.

The natural diversity within and among orchids confused the experts resulting in great difficulty in circumscribing natural groups with the explanation that the family is still actively evolving. Hence the exact number species within the family always remains obscure due to continuous addition and deletion of various taxa.

### **2.1.2. Orchidaceae in Gujarat**

Gujarat is endowed with a great floral, habitat and ecosystem diversity (Stanley, 2004). There is no comprehensive account available on the orchid flora of Gujarat. Some information about the family is available in floras, thesis on floristic studies and taxonomic reports. Some species of orchids were described by Cooke (1958) from Gujarat in the Flora of Bombay Presidency. The first proper enumeration on Orchidaceae of Gujarat was culminated in the “Flora of Gujarat” by Shah (1978). He enlisted 25 species in the account for 10 genera from Gujarat. Raghavan et al. (1981), enlisted 29 species under 13 genera in the checklist on the floristic diversity of Gujarat. Later, Gujarat Ecology Commission (Anonymous, 1996) provided an updated checklist on biodiversity of Gujarat in which Orchidaceae were represented by 33 species from 14 genera. Four species of orchids with their population details were listed in report “Conservation of Rare and Endangered Biodiversity of Gujarat (CREB)” (Anonymous, 2002). Singh and Parabia (2003) reported *Eulophia spectabilis* which was a new addition

to the orchid diversity of Gujarat in their publication “Floral Diversity of Gujarat State: A review”.

The zonal review of literature on orchis has been dealt here with as per Rodgers et al. (2002) classification on biogeographical zones of Gujarat. Thus, based on his classification four biogeographic zones *viz.* **1. Western Ghats** **2. Semiarid Zone (Rajwara)** **3. Desert Zone (Kachchh)** and **4. Coastal zone** were analysed.

**The Western Ghats** comprises of South and South East regions of the Gujarat state. The possible occurrence of Epiphytic orchid *Aerides* or *Acampe* in Dangs was first time reported by Santapau (1955) in book “Contribution to the Botany of the Dangs forest”. Suryanarayana (1968) described 12 species of orchids under seven genera from the forest region of Dangs. Singh (1969) listed three species from eastern part of Rajpipla forest. Inamdar and Patel (1971) reported three species of orchids from Bulsar, Tithal and Dungari. Furthermore Patel (1971) enlisted six taxa belonging to five genera during the floristic survey of Bulsar environs. More (1972) recorded four species from Parnera hills, Pardi and Udhawada area in South Gujarat. Desai (1976) accounted 10 species representing six genera from Bansda forest of South Gujarat. Yadav (1979) reported *Vanda tessellata* from South Gujarat. Joshi (1980) accounted four species representing three genera from Surat and its environs. Vora (1980) carried out a floristic survey of Dharampur, Kaprada and Nana ponda ranges of Bulsar and briefly described eight species of orchids under five genera. Mac (1982) accounted six species under five genera from Kamrej, Vyara, Songadh, Uchchhal and Nizar talukas of Surat District. Joshi (1983) reported *Vanda* sp. in his work on “Floristic and Phytosociological survey of some parts of South Gujarat with special reference to Medicinal and Ethanobotanical plants”. Contractor (1986) recorded *H. marginata* and *Vanda testacea* from Vapi and Umargaon areas of South Gujarat. Bhatt (1987) reported *H. marginata*, *H. foliosa* and *V. testacea* from Navsari with special emphasis on Ethanobotany. 11 species representing eight genera including two new records (*Eria dalzelli* and *Rhynchostylis retusa*) were reported by Reddy (1987) from Dharampur. Pradeepkumar (1993) accounted four genera representing eight species from Shoolpaneshwar WLS. Sharma (2010) reported *Nervilia plicata* which is having good medicinal properties from Shoolpaneshwar WLS. Tadv (2013) enlisted 25 species under 12 genera with one new generic record to the state *i.e.* *Geodorum densiflorum* during the floristic survey of Dang district.

**The Semi-Arid Zone** (Rajwara province) comprises north, central and Saurashtra region of the state. Thaker (1910) and Santapau (1953) reported *Zeuxine strateumatica* from Rajkot and Saurashtra respectively. Santapau and Raizada (1954) accounted *Nervilia aragoana* from Gir in their publication on “Contribution to the flora of the Gir forest in Saurashtra”. Chavan et al. (1961) reported *V. tessellata* from Devgad Hills, Devgad Bariya. Furthermore Chavan and Oza (1966) provided a brief description of *Aerides maculosa* in “Flora of Pavagadh”. Eight species of orchids under six genera were accounted by Bedi (1968) from Ratanmahal and surrounding hills. Bhatt (1971) has reported *V. tessellata* from Khedbrahma region of North Gujarat with a note on the chromosome number and karyotype of some taxa. Bedi (1973) reported five species under four genera from Ratanmahal hills. Karatela (1973) recorded three species of orchids under two genera from Chhota Udepur forest division. *A. maculosa*, *P. goodyeroides* and *V. tessellata* were reported from Kawant forest range of Central Gujarat by Thaker (1974). Bhatt (1975) reported *V. tessellata* from Panchmahal district. Bole and Pathak (1988) reported *N. aragoana* from Gir Sanctuary in Flora of Saurashtra. Three species of orchids were accounted by Sisodia (2007) from Gir NP and Gir (WLS) of Junagadh. Pandey (2011) accounted four species from Bhiloda (west) range of Sabarkantha district. *V. tessellata* was reported by VEDIYA and KHARADI (2011) from Megharj range of Sabarkantha. Four species representing four genera were reported by Desai (2013) from Jessore WLS of Banaskantha district.

There is no report of orchids from Desert zone (Kachchh) and Coastal zone probably owing to arid condition.

The compilation of literature shows that the family is represented by 35 species under 15 genera in Gujarat. Among them, 10 are endemic to Peninsular India (Nayar et al., 2014). People now a day understood the economical and medicinal importance of orchids and have started cultivating few species like *Dendrobium aphyllum* (Roxb.) C.E.C.Fisch., *Anthogonium gracile* Wall. ex Lindl. and *Vanilla planifolia* Jacks. ex Andrews in some gardens of Surat and Valsad (Patel, 1971; More, 1972; Joshi, 1980).

Majority of orchid habitats are under anthropogenic pressures and several species are facing varying levels of threat to their survival. On the basis of scientific review on Orchidaceae an attempt has been made to understand the diversity and distribution of orchids.

**2.2. STUDY AREA - GUJARAT**

**2.2.1. Location**

The floristic exploration was conducted in the major part of the state except for Kutch (the habitat is not appropriate for the orchid growth). Gujarat lies between 20°1' N to 24°7' N and 68°4' E to 74°4' E covering a geographical area of 196,024 sq. km on the west coast of Indian Peninsula. Gujarat has a very strategic position from the biogeographic point of view as it covers four biogeographic zones of India (Rodgers et al., 2002). Table 2.1 explains the biogeographical zones of Gujarat, along with the biotic provinces and biomes. The state is bounded by the Arabian Sea in the West and Southwest, Pakistan in the North, Rajasthan in the North-east, Madhya Pradesh in the Southeast and Maharashtra and Union Territories of Daman, Diu and Nagar Haveli in the South (Figure 2.1). It has four NP and 24 WLS, which comprised of 8.84% of the total geographical area of the state (FSI, 2009).

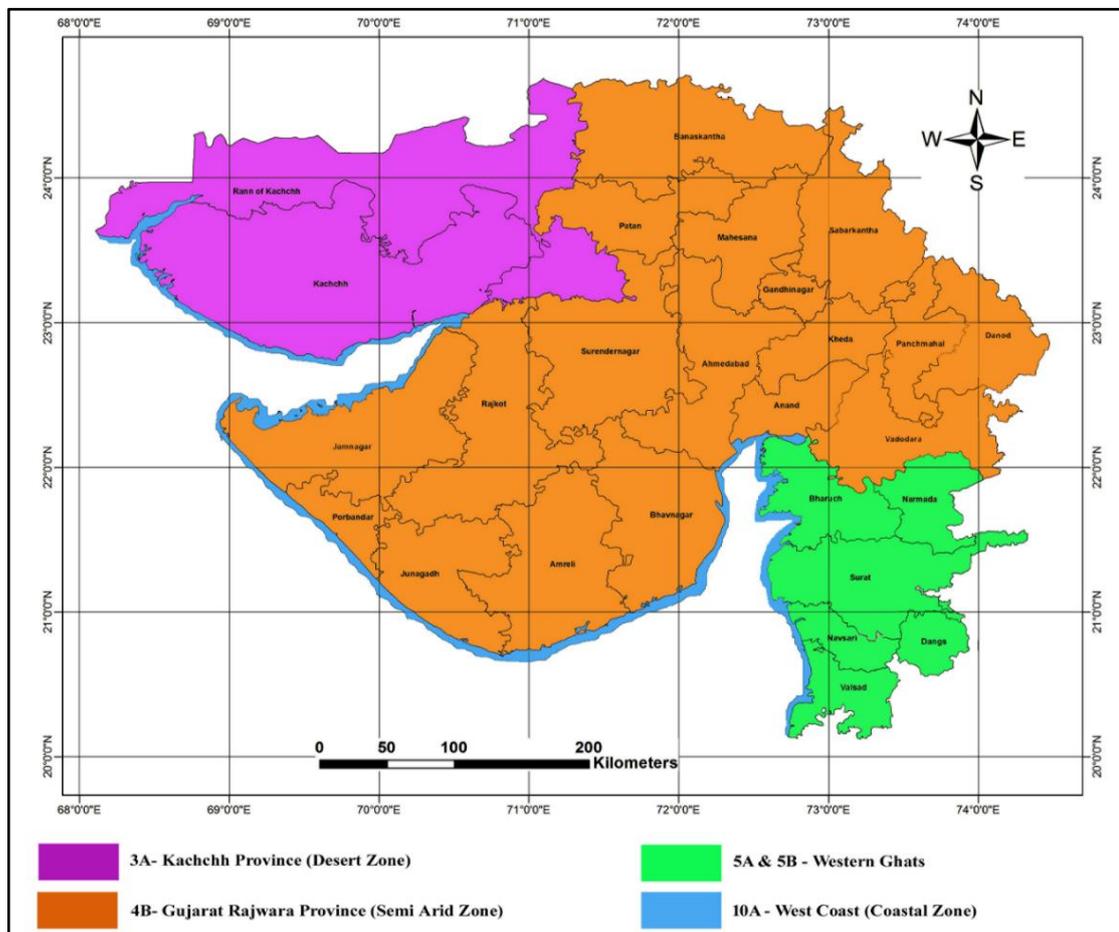
**Table 2.1:** Biogeographical zones of Gujarat, along with biotic provinces and biomes

SN	Biogeographic Zone	Biotic Province	Biomes
1.	Desert Zone	3A - Kachchh Province	Salt flats Scrublands
2.	Semi-Arid Zone	4B - Gujarat Rajwara Province	Dry Deciduous and Thorn forests, Grasslands, Wetlands
3.	Western Ghats	5A & 5B - Western Ghats	Moist Deciduous Forest
4.	Coastal Zone	10A - West Coast	Mangrove, Mudflats, Sandy/Rocky Shores

**2.2.2. Topography and Drainage**

The hilly terrains are the chief natural feature of forest wealth of Gujarat and are closely associated with the religious and historical currents. The Aravallis are the most ancient mountain range starting from Abu in the Rajasthan and merges with the Vindhyas near Pavagadh in Gujarat. The western tail of Vindhya range lies on the eastern part of the Gujarat Peninsula and rises to the height at Chhota Udepur. The part of Aravalli range includes Taranga hills which lie on the line from Mehsana to Visnagar. The Satpura range lies between the Narmada and Tapi and it is separated from the Vindhyas by the Narmada River flowing majestically through them. The Rajpipla hills, the western-most spurs of

the Satpura ranges lie to the south of Narmada River. The ranges of Sahyadri lie across the Tapi are having the highest rainfall in Gujarat and the densest forest in the state.



**Figure 2.1:** Detailed map of Gujarat

The rocky region of Saurashtra Peninsula comprises of famous hilly mountain ranges of Girnar, Barda, Shetrunjaya and Talaja. Girnar is the highest mountain in the state (1,145 m). The region is connected with the mainland by the neck of low lying land.

The Kachchh region has three mountain ranges. Northern mountain range consists of Pachham, Khadir and Pranjal. Southern mountain range commences from Madh to Roha. The Kala Parvat mountain range lies between Kachchh and Sind.

The major rivers of the state are Narmada, Sabarmati and Mahi flowing through central and northern part of Gujarat. The small rivers like Aji, Mithi, Khari, Bhadar, Shetrunji and Bhogavo are in Saurashtra and Tapi, Purna, Ambika, Auranga and Damanganga are in South Gujarat.

### **2.2.3. Climate and rainfall**

The Gujarat state comes under subtropical climatic zone because of the tropic of cancer which passes through northern border of Gujarat. Moreover, there is a great variation in the climatic conditions and it is greatly influenced by the Arabian Sea and Gulf of Cambay in the west and the hilly ranges in the east.

The average rainfall data of 30 years (from 1987 to 2017) showed a range from 464 to 1913 mm in Gujarat. The southern region receives more average rainfall (713 – 1398 mm), compared to northern region of Gujarat (433 – 848 mm). Dang district has the highest average rainfall of about 2137 mm whereas the semi-desert area of Kachchh has very low rainfall (434 mm) (<http://www.gujaratweather.com>)

The salient aspects of climate in Gujarat are listed below:

- The **winter** (November – February) is mild, pleasant and dry, with moderate temperatures. Maximum temperature rises up to 39 °C in day and minimum temperature fall down up to 0 °C in the night.
- **Summer** (March – June) is very hot and dry, with maximum temperature reaches around 50 °C whereas minimum temperature is around 13 °C.
- **Monsoon** (July – October) is generally humid with maximum temperature 47 °C and minimum 7 °C. During rains, some places of the state may be flooded due to heavy rain.

### **2.2.4. Geology and Soil**

Geologically the state provides a broad continuum of rock types of diverse ages. It exposes rocks ranging in the age from oldest the Pre-Cambrian, Mesozoic, Cenozoic era to recent.

The soil quality of the state varies from region to region and also in places of the same region. Black soil is the most common soil type in the west region of southern districts (Valsad, Surat and Bharuch). In Dangs and east Valsad, the soil varies from mixed red to black. The change in soil condition is noticeable towards the north. Thus, central Gujarat (Baroda, Chhota Udepur, Ahmedabad and Panchmahal), east Mehsana and east Sabarkantha has sandy loam soil, locally known as Goradu. The northern districts (Mehsana, Banaskantha and Sabarkantha) have coarse shallow soil derived from

granites. In Saurashtra Peninsula and Kachchh the soils are formed of sheets of Deccan lava interspersed with trap dykes. The northern part of Saurashtra (Rajkot and Surendranagar) has sandy soils. Alluvium or saline soil type was found along with the coastal track of Kachchh, Saurashtra and South Gujarat.

### 2.2.5. Forests Types

The unique geographic position coupled with climatic variability has enabled many distinctive and diverse biotic elements to flourish the area. Total area under forest in Gujarat was about 18,648.51 sq. km (FSI, 2009).

Champion and Seth (1968) have classified forests of Gujarat into 23 forest types. It comprises four major sub-groups of forests in different regions as the climate is the major influencing factor. The four sub-groups are;

3B – South Indian Moist Deciduous Forests

4B – Swamp or Tidal Forests of Mangroves

5A – Southern Tropical Dry Deciduous Forests

6B – Northern Tropical Thorn Forests

The detail of sub-groups with the type and distribution is given below:

#### **3B – South Indian moist deciduous forests**

This forest type occurs in all parts of India with medium rainfall. These forests are recorded in Madhya Pradesh, Maharashtra, Kerala, Karnataka and South Gujarat. This sub-group is further divided into following types:

**3B/C<sub>1b</sub>** - Moist teak forest: Valsad, Dangs, Navsari and Shoolpaneshwar WLS.

Deciduous associates predominate in this subtype. Characteristic species are *Tectona grandis*, *Haldinia cordifolia*, *Dalbergia latifolia*, *Terminalia crenulata*, *Pterocarpus marsupium*, *Dendrocalamus strictus* and *Bambusa bambos*.

**3B/C<sub>1c</sub>** - Slightly moist teak forest: Surat and Tapi.

The proportion of dry deciduous associates is higher than in the last subtype. Characteristic species are *Embllica officinalis*, *Mitragyna parvifolia* and *Syzygium cumini*. Both of these moist forests are rich in epiphytes as well as terrestrial orchids and ferns populations.

**3B/C<sub>2</sub>** - Southern moist mixed deciduous forest: Surat, Tapi, Bharuch, Narmada, Valsad, Ratanmahal and Dangs.

Teak is present occasionally and may be an indicator of secondary succession. Dominant species are *Madhuca indica* and *Grewia tiliifolia*.

**3B/C<sub>2</sub>S<sub>1</sub>** - Southern secondary moist deciduous forest: Dangs, Valsad, Navsari, part of Surat, Bharuch and Narmada.

These forest types are modified due to human intervention. Such forests have poor regeneration of evergreen species and as they are subjected to annual burning for agriculture, only grass dominates the ground cover.

#### **4B – Tidal Swamp forests**

These types of forest are recorded in some parts of West Bengal, Orissa and coastal states of India. The rainfall varies greatly without much influence on vegetation. It has two types in the Gujarat state.

**4B/TS<sub>1</sub>** - Mangrove scrub: Kachchh, Jamnagar, Rajkot, Bhavnagar, Bharuch, Surat and Porbandar.

These forests comprise of more or less dense forest with very low average height trees. *Avicennia officinalis* is the dominant species in this type of forests.

**4B/TS<sub>2</sub>** - Mangrove forest: Kachchh and Jamnagar.

These are closed evergreen forests having trees with moderate height. *A. officinalis*, *A. marina* and *Rhizophora mucronata* are the dominant species.

#### **5A – Sothern Tropical Dry Deciduous Forest**

These forests are recorded throughout the Indian Peninsula, with exception of the Western Ghats where rainfall exceeds 1900 mm. It merges into thorn forests wherever the rainfall drops below 750 mm. In Gujarat this sub-group has 16 types based on the presence of selective dominant species.

**5A/C<sub>1a</sub>** - Very dry teak forest: Gir, Girnar, dry areas of Panchmahal, Dahod and Sabarkantha.

The representative species are *T. grandis*, *T. crenulata*, *Sterculia urens*, *Acacia catechu* and *Anogeissus latifolia*.

**5A/C<sub>1b</sub>** - Dry teak forest: Vadodara (Chhota Udepur), Dahod, Panchmahal, Sabarkantha, Banaskantha, Gir and Girnar.

*T. grandis* usually forms the major proportion of crop in this subtype. Other emissary species are *T. crenulata*, *Butea monosperma*, *Lagerstroemia parviflora*, *Wrightia tinctoria*, *A. catechu* and *Lannea coromandelica*.

**5A/C<sub>3</sub>** - Southern dry mixed deciduous forest: Surat, Tapi, Bharuch, Vadodara, Dahod, Panchmahal, Sabarkantha, Banaskantha, Gir and Girnar.

This sub-group is widespread in drier localities, thus, covers maximum area in the state. *A. latifolia* and *T. crenulata* are the characteristic species of this subtype. Other species often found are *Aegle marmelos*, *Ziziphus jujuba*, *Balanites aegyptiaca*, *W. tinctoria* and *Dendrocalamus strictus*.

**5/DS<sub>1</sub>** - Dry deciduous scrub: Districts of Saurashtra, Sabarkantha, Banaskantha and Panchmahals.

These forests are dominated by *Acacia leucophloea*, *B. monosperma*, *Ziziphus jujuba*, *Cassia fistula*, *B. aegyptiaca* and *Salvadora persica*.

**5/DS<sub>2</sub>** - Dry savannah forest: Districts of Saurashtra, Kachchh and Panchmahal.

These forests are dominated by grasses and fire-resistant plants. The dominating tree species are *Butea monosperma*, *Z. jujuba*, *B. aegyptiaca* and *Acacia senegal*.

**5/DS<sub>3</sub>** - *Euphorbia* scrub: Districts of Saurashtra, Kachchh and North Gujarat.

These forests are chiefly dominated by *Euphorbia neriifolia*. The other dominating thorny species are *Acacia leucophloea*, *A. senegal* and *Capparis decidua*.

**5/DS<sub>4</sub>** - Dry grassland: Kachchh and Part of Saurashtra.

These forests are formed due to degraded grasslands. The characteristic perennial species are *Heteropogon contortus*, *Aeluropus lagopoides*, *Eragrostis* sp. and *Chloris* sp.

**5/E<sub>1</sub>** - *Anogeissus pendula* forest: Sabarkantha and Banaskantha.

This sub-type is largely determined by the presence of *Anogeissus pendula* which forms nearly pure crops. Other associated species found in these forests are *B. monosperma*, *Z. jujuba* and *S. urens*.

**5/E<sub>2</sub>** - *Boswellia* forest: Sabarkantha, Banaskantha, Gir and Mitiyala forest of Bhavnagar.

This forest comprises *Boswellia serrata* as a main dominating species. Other species are *W. tinctoria*, *T. crenulata* and *S. urens*.

**5/E<sub>3</sub>** - Babul forest: Gir, Saurashtra, Kheda, Ahmadabad and Kachchh.

The forest is entirely dominated by *A. nilotica* which is markedly gregarious in habit and forms a denser cover. The other species are *B. aegyptiaca*, *Z. jujuba*, *P. cineraria*, *A. senegal*, *Acacia planifrons* and *Dichrostachys cinerea*.

**5/E<sub>5</sub>** - *Butea* forest: Panchmahal, Sabarkantha, Banaskantha and Gir.

These forests are an indicator of degradation of original forest and comprised of small trees of *B. monosperma* in association with *C. auriculata*.

**5/E<sub>6</sub>** - *Aegle* forest: Small pockets in hills of Poshina, Gir and Banaskantha.

Forest mainly represented by *Aegle marmelos*. Forms a pure patch on the hilly region of Poshina, Gir and Banaskantha.

**5/E<sub>8</sub>** - Saline/alkaline scrub Savannah: Little Rann of Kachchh, Kachchh and Surendranagar.

These forests have association of *A. nilotica* and *Salvadora tamarix* scrub.

**5/E<sub>9</sub>** - Dry bamboo forests: Surat, Tapi, Bharuch, Panchmahal, Sabarkantha and Banaskantha.

Only single species, *D. strictus* occurs and it forms relatively low but often dense brakes.

**5/1S<sub>1</sub>** - Dry tropical riverine forests: Bharuch, Surat, Tapi, Panchmahal, Vadodara, Sabarkantha, Banaskantha, Gir and Girnar.

These forests comprise *Syzygium cumini*, *T. crenulata*, *T. arjuna*, *T. bellirica*, *B. monosperma*, *Pongamia pinnata* and *Ficus* sp., as few dominating species.

**5/2S<sub>1</sub>** - Secondary dry deciduous forest: Panchmahal, Sabarkantha, Bharuch, Banaskantha and Gir.

These forests are developed from the heavy forest cutting in the past and original old tree are replaced by moderate to small sized trees.

**6B – Northern tropical thorn forests**

This subgroup is similar to the Southern form but exhibits all stages of reduction of vegetation to the true climatic desert. *Acacia*'s remains the characteristic but less predominating while fleshy *Euphorbia*'s are dominant. These forests are recorded in Punjab, Uttar Pradesh, Madhya Pradesh and Rajasthan. In Gujarat these subgroups are further divided into nine types:

**6B/C<sub>1</sub>** - Desert Thorn Forest: Saurashtra, Kachchh, Narayan Sarovar Sanctuary in Kachchh and North Banaskantha.

The representative species are *Acacia Senegal*, *A. leucophloea* and *Prosopis cineraria*. The other species are *Z. jujuba*, *B. aegyptiaca*, *S. persica* and *Commiphora wightii*.

**6B/C<sub>2</sub>** - Ravine thorn forest: Antarsuba range in Kheda, patches in ravines of Sabarmati, Mahi and Vatrak rivers.

These forests mainly support small trees of *Acacia* spp. along with *Z. jujuba*, *P. cineraria*, *A. leucophloea*, *A. senegal* and *Capparis decidua*.

**6B/DS<sub>1</sub>** - *Ziziphus* scrub: Gir, Saurashtra, Kachchh, Banaskantha and Sabarkantha.

These forests occur in patches with the dominance of *Z. jujuba* along with *Prosopis juliflora*, *A. leucophloea*, *A. senegal*, *C. decidua* and *Euphorbia nerifolia*.

**6B/DS<sub>2</sub>** - Tropical *Euphorbia* scrub: Okhamandal in Jamnagar and Kachchh.

These forests are present in small patches with pure patches of *E. nerifolia*.

**6/E<sub>2</sub>** - *Acacia senegal* forest: Amreli, Jamnagar, Rajkot, Porbandar and Bhavnagar.

Typically, an open overwood of pure *A. senegal* with little undergrowth. Other associates are *Z. jujuba*, *A. leucophloea*, *P. juliflora*, *P. cineraria*, *B. aegyptiaca* and *E. nerifolia*.

**6/E<sub>3</sub>** - Rann saline thorn forest: Little Rann and Great Rann of Kachchh, Bhal region, Rajkot, Jamnagar, Patan, Surendranagar, Kachchh, Banaskantha, Porbandar and Bhavnagar.

These forests are periodically inundated by the sea for longer or shorter periods so the natural vegetation is very sparse. It mainly consists of *S. persica*, *Capparis decidua*, *Calotropis gigantia* and *Suaeda vermiculata*.

**6/E<sub>4</sub>** - *Salvadora* scrub: Kachchh, on bets of Rann of Kachchh.

Found in Saline zone with *S. persica* and *S. Oleoides*. Form a mixed vegetation with other plants like *S. vermiculata*, *C. gigantia*, *E. neriifolia* and *P. juliflora*.

**6B/1S<sub>1</sub>** - Desert dune scrub: North Banaskanth and Kachchh.

In this subtype the trees are thorny and all vegetation is markedly xerophytic.

**6/DS<sub>1</sub>** - *Cassia auriculata* scrub: North Gujarat, Saurashtra and Kachchh.

*C. auriculata* is commonly spread in open areas mainly among wastelands in scrub lands.

## **2.3. MATERIALS AND METHOD**

### **2.3.1. Literature and Herbarium Survey**

Significant information associated to the family Orchidaceae were gathered from various sources such as books, floras, monographs and journals. Electronic sources were used for acquiring relevant information about the present study. The Biodiversity Heritage Library ([www.biodiversitylibrary.org](http://www.biodiversitylibrary.org)), eFloras (<http://efloras.org>), eMonocot (<http://emonocot.org>), International Plant Names Index (<http://www.ipni.org>), JSTOR Global Plants (<https://plants.jstor.org>), Plant List (<http://www.theplantlist.org>), Tropicos (<http://www.tropicos.org>), World checklist of selected plant families (<http://wmsp.science.kew.org>), were the principal sources to retrieve the data. Specimens were observed and studied in detail at various herbaria such as, Western Circle Herbarium, Pune (BSI); Arid Zone Herbarium, Jodhpur (BSI); Jawaharlal Nehru Tropical Botanical Garden Research Institute, Kerala (JNTBGRI); University of Calicut, Kerala; Shivaji University, Kolhapur and Sardar Patel University, Vallabh Vidyanagar, but only a few specimens are cited here.

### **2.3.2. Field Survey and Photography**

Periodic field surveys were carried out for four years (2014 – 2017) to locate various species of orchids from various biogeographic regions of Gujarat. The duration of each field survey was ranged between 1 – 10 days. A preliminary survey was carried out throughout the state to recognize the areas rich in orchid diversity. The identified areas were thoroughly investigated by proper observations and taking all the measures. The most important duration for orchid collection is the flowering period so more than

150 tours were arranged in accordance with their flowering season. Orchids were collected from 75 different localities of 12 Districts (Table 2.2). The species were photographed in their natural habitats as well as in the laboratory using various digital cameras (Nikon Coolpix P600, Nikon 5300). Details on habit, habitat, flowering and fruiting period of orchids were recorded at the time of collection. For epiphytic orchids the information about host species were also recorded. The photographs taken during the survey were edited and assembled in the form of plates using Adobe Photoshop 7.0 (San Jose, CA, USA).

**Table 2.2:** Localities surveyed during the present study and their Forest Type (Champion and Seth, 1968)

SN	District	Localities	Forest type
1	Banaskantha	Jessore and Balaram-Ambaji (2)	5A/C <sub>3</sub> , 5/E <sub>1</sub> , 5/E <sub>2</sub> , 5/E <sub>5</sub> , 5/E <sub>6</sub> , 5/2S <sub>1</sub>
2.	Chhota Udepur	Zand Hanuaman, Jetpur Pavi, Sukhidam and Bobada Kuva (4)	5A/C <sub>3</sub>
3.	Dahod	Ratanmahal (1)	5A/C <sub>3</sub>
4.	Dangs	Ambabari, Ambapada, Bardipada, Bevlapani, Bokdiya Dungar, Borkhet, Chikhali, Chinchli, Devinamal, Don, Ghoghali Ghat, Gira, Jamlapada, Kalibel, Kilad, Mahal, Malegaon, Patala Dungar, Pimpri, Piplaidevi, Piplemal, Saputara, Subir, Susarda and Waghai (27)	3B/C <sub>1b</sub> , 3B/C <sub>2</sub> , 3B/C <sub>2</sub> S <sub>1</sub>
5.	Junagadh	Datar and Girnar (2)	5A/C <sub>3</sub> , 5/1S <sub>1</sub>
6.	Narmada	Saghai, Dediapada, Fulsar and Ninaidodh (4)	3B/C <sub>1b</sub> , 3B/C <sub>2</sub> , 3B/C <sub>2</sub> S <sub>1</sub>
7.	Navsari	Vansda and Anaval (2)	3B/C <sub>1b</sub> , 3B/C <sub>2</sub> S <sub>1</sub>
8.	Panchmahal	Pavagadh, Jambughoda and Shivarajpur (3)	5A/C <sub>3</sub> , 5/2S <sub>1</sub>

SN	District	Localities	Forest type
9.	Porbandar	Ranavav, Kileshwar, Bileshwar, Ghumali, Abhapara and Venu (6)	5/DS <sub>1</sub> , 5/DS <sub>2</sub> , 5/DS <sub>3</sub> , 5/E <sub>3</sub> , 6B/C <sub>1</sub> , 6B/DS <sub>1</sub>
10.	Sabarkantha	Jerdhareshwar and Vijaynagar-Polo (2)	5A/C <sub>3</sub> , 5/2S <sub>1</sub>
11.	Tapi	Vyara, Sonagadh and Padam Dungri (3)	3B/C <sub>1c</sub> , 3B/C <sub>2</sub> , 5A/C <sub>3</sub>
12.	Valsad	Wilson Hill, Pangarbari, Heydari, Gundiya, Shankar Dodh, Chau Shala, Javara Javari, Nana Ponda, Dabkhal, Vavar, Sutharpada, Jamguban, Manala, Kangvi, Rajpuri, Sidumbar, Mandva, Ambapada, Parnera Hills and Arnala (20)	3B/C <sub>1b</sub> , 3B/C <sub>2</sub> , 3B/C <sub>2</sub> S <sub>1</sub>

### 2.3.3. Herbarium Preparation and Identification

Plant materials collected during field survey were used for the preparation of herbarium specimens. All the representative parts for identification of orchids were collected and used for herbaria preparation. Very rare orchids were collected without tubers and used for herbarium preparation. The collected specimens were washed, wiped and pressed in blotting paper. Specimens were further processed as per the conventional methods of drying, poisoning, mounting and labelling (Jain and Rao, 1977). Poisoning was done with an alcoholic solution of HgCl<sub>2</sub> (0.1%). All the processed specimens were deposited at BARO, The Maharaja Sayajirao University of Baroda and Botanical Survey of India, Arid Region Centre, Jodhpur (BSI). The herbarium specimens were arranged alphabetically under each genus for the sake of convenience.

All the species were studied for its gross morphological characters during the collection. The collected species were critically examined under a microscope for their taxonomic identification. The Identification and confirmation of plant specimens were done using standard references (Hooker, 1894; Cooke, 1958; Santapau and Kapadia, 1966; Shah, 1978; Abraham and Vatsala, 1981; Ansari and Balakrishnan, 1990; Kumar and Manilal, 1994 and Misra, 2004). Indented keys have been prepared for easy identification of genera and species. WCSP (Royal Botanic Gardens, Kew), Tropicos and Plant list have been followed for the species nomenclature. For each species, the correct

botanical name followed by important synonyms has been cited. The citation was followed by diagnostic description, information about different developmental stages (like flowering, fruiting) and its geographical distribution (globally as well as in India specifically in Gujarat). The distribution map for each orchid species in Gujarat was prepared using ArcGIS (v. 10.2). The taxonomic notes on its habitat or any peculiar feature have also been provided if found necessary.

**2.3.4. Status analysis of Orchids at Regional level (Jalal, 2012)**

A formula was developed to assign a status to each species at the regional level. Five quantification parameters were taken into consideration for assessing orchids (Table 2.3). For getting the rarity value (R) (on the scale of rarity index; 1 – 5), the sum of all five parameters were divided by five. The species with the least number were ranked rarer in comparison with those with greater values. All the data were entered into an Excel spreadsheet and summarized using descriptive statistics.

$$R = \frac{h^1 + s^1 + p^1 + p^2 + p^3}{5}$$

Where,  $h^1$  = number of habitats,  $s^1$  = number of sites in Gujarat,  $p^1$  = distribution in India,  $p^2$  = phytogeographical distribution within the Indian subcontinent,  $p^3$  = phytogeographical distribution globally.

Rarity ranking (very rare: 0.5 – 1; sparse: 1.1 – 2; occasional 2.1 – 3; common: >3).

**Table 2.3:** Quantification parameters of the rarity for each orchid species

SN	Parameters	Documentation	Scoring (Quantification)
1	Number of Habitats ( $h^1$ )	Number of habitats in which each orchid species found was recorded.	3 habitats depending on how many habitats, a particular orchid occurred in.
2	Number of Sites ( $s^1$ )	Number of sites in which each orchid found was recorded.	“1” for single site; “2” for <5 sites; “3” for <10 sites; “4” for <15 sites and “5” for >15 sites.

SN	Parameters	Documentation	Scoring (Quantification)
3	Distribution in India (p <sup>1</sup> )	Divided into five divisions 1. Andaman and Nicobar Islands 2. North East 3. Western Himalaya 4. Western Ghats 5. Central India	1 to 4 divisions depending on the occurrence of species in a particular division.
4	Phytogeographical Distribution (p <sup>2</sup> )	Indian subcontinents (Bangladesh, Bhutan, Nepal, Pakistan, Sri Lanka)	Depending on how many species are spread in a particular region.
5	Phytogeographical Distribution (p <sup>3</sup> )	Europe, Sino-Japan, China, Indo-Malaya, Africa, Australia, North and South America	Depending on how many species are spread in a particular region.

### 2.3.5. *Ex-Situ* Conservation

The *ex-situ* conservation of orchids was made at Arboretum of The Maharaja Sayajirao University of Baroda, Vadodara as well as Waghai Botanical Garden, Dangs.

**2.3.5.1. Conservation of terrestrial orchids:** A plot of 15 × 50 ft was made at arboretum of the Maharaja Sayajirao University Baroda where all collected species were grown together. At Waghai Botanical Garden individual plots of 10 × 10 ft were made for each species and plants from wild were introduced.

**2.3.5.2. Conservation of epiphytic orchids:** The hanging net pots with cocopeat and moss were used while some species were tied directly on trunk of suitable host tree or portion of branches of trees with the patch of coconut husk and grown in Green house.

## 2.4. RESULTS AND DISCUSSION

### 2.4.1. Diversity and Distribution

The work of Hooker (1894, 1895), Blatter and McCann (1931), Cooke (1958) and Santapau and Kapadia (1966) forms the base for understanding the distribution of orchids in Western India. Anonymous (1996) has compiled all the available literature enlisting 33 species and one variety of orchid under 14 genera from Gujarat. Singh and Parabia (2003) and Tadvī (2013) added one more species and genus respectively to the orchid diversity of Gujarat. The amalgamation of above references resulted in 35 species of orchids representing 15 genera as occurring in Gujarat.

Gujarat is a conjunction of complex ecosystem which includes Western Ghats, Semi-arid and arid zone (as mentioned in sect. 2.2.). The complexity has resulted in diverse type of species in this region which imparts endemic orchids of India. The extensive study in the Semi-arid and Western Ghat region of Gujarat resulted in 30 species of orchids representing 13 genera of which 12 are epiphytic and 17 are terrestrial. Among the 13 reported genera, five (*Acampe*, *Crepidium*, *Geodorum*, *Rhynchostylis* and *Zeuxine*) are represented by single species, five (*Aerides*, *Eulophia*, *Nervilia*, *Oberonia* and *Vanda*) by two species and two (*Dendrobium* and *Peristylus*) by four species. *Habenaria*, the third largest genus (59) of the family in India, is also a dominating genus in Gujarat represented by seven species.

Orchidaceae is the second largest family in India comprising 23.5% endemics (Nayar, 1996). Western Ghats comprises about 300 species of orchids (Rao, 2012) out of which 95 are strictly endemic to the region (Jalal and Jayanthi, 2012). Among the neighbouring states, the endemic species of orchids in Gujarat are comparatively higher than Rajasthan and Madhya Pradesh as Gujarat forms the part of Western Ghats. Maharashtra have highest number of endemic orchids than all respective states as mentioned in Table 2.4. From Gujarat perspective, 10 endemic species are also a significant number because orchids are mainly distributed in evergreen and moist forest which is the most appropriate habitat for their growth, development and regeneration (Jalal, 2012).

**Table 2.4:** Comparative account of Orchidaceae in surrounding states

SN	States	No. of Genera	No. of Species	Endemic species
1.	Gujarat <sup>€</sup>	13	30	10
2.	Rajasthan <sup>z</sup>	7	12	02
3.	Madhya Pradesh*	34	89	08
4.	Maharashtra <sup>§</sup>	32	106	41

<sup>€</sup>Anonymous, 1996; <sup>z</sup>Shetty and Singh, 1991; \*Singh et al., 2001; <sup>§</sup>Jalal and Jayanthi, 2018

### Biogeographical Distribution

Gujarat has been divided into four biogeographic regions as described in the study area (section 2.2.). A comparative study of the later showed that Western Ghats region of the state represents maximum orchid diversity as compared to other biogeographic zones. The higher diversity of orchids in moist deciduous forest of Western Ghats (3B/C<sub>1b</sub>, 3B/C<sub>2</sub>, 3B/C<sub>2</sub>S<sub>1</sub>) reveals that it is the most suitable habitat for the growth of orchids (Figure 2.2). The diversity of orchid in this zone is owing to higher precipitation. In the semi-arid zone orchids were mainly distributed in secondary dry deciduous (5/2S<sub>1</sub>) and southern dry mixed deciduous forest (5A/C<sub>3</sub>).

The Western Ghats region in Gujarat (South and South-East region of Gujarat) comprises 98% of orchid diversity which includes 13 genera encompassing 28 species. In contrast semi-arid region of Gujarat (Northern, Central and Saurashtra) was represented by 60% orchid diversity which comprises 9 genera representing 18 species. The diversity of orchids in this region was less compared to Western Ghats as the forest is mainly of dry deciduous type. The Dangs district consist of maximum orchid diversity (25 species) as compared to other districts of Gujarat. The abundance of *Vanda tessellata* and *Acampe praemorsa* were comparatively higher in the places having low rainfall (Semi-arid zone). High temperature and availability of water, in the form of dew, particularly during the dry seasons allow these species to flourish successfully in a deciduous forest (Rosa-Manzano et al., 2014). In the Desert of Kachchh and coastal zone, no orchids were located owing to poor rainfall which leads to thorny scrub vegetation (Figure 2.3).

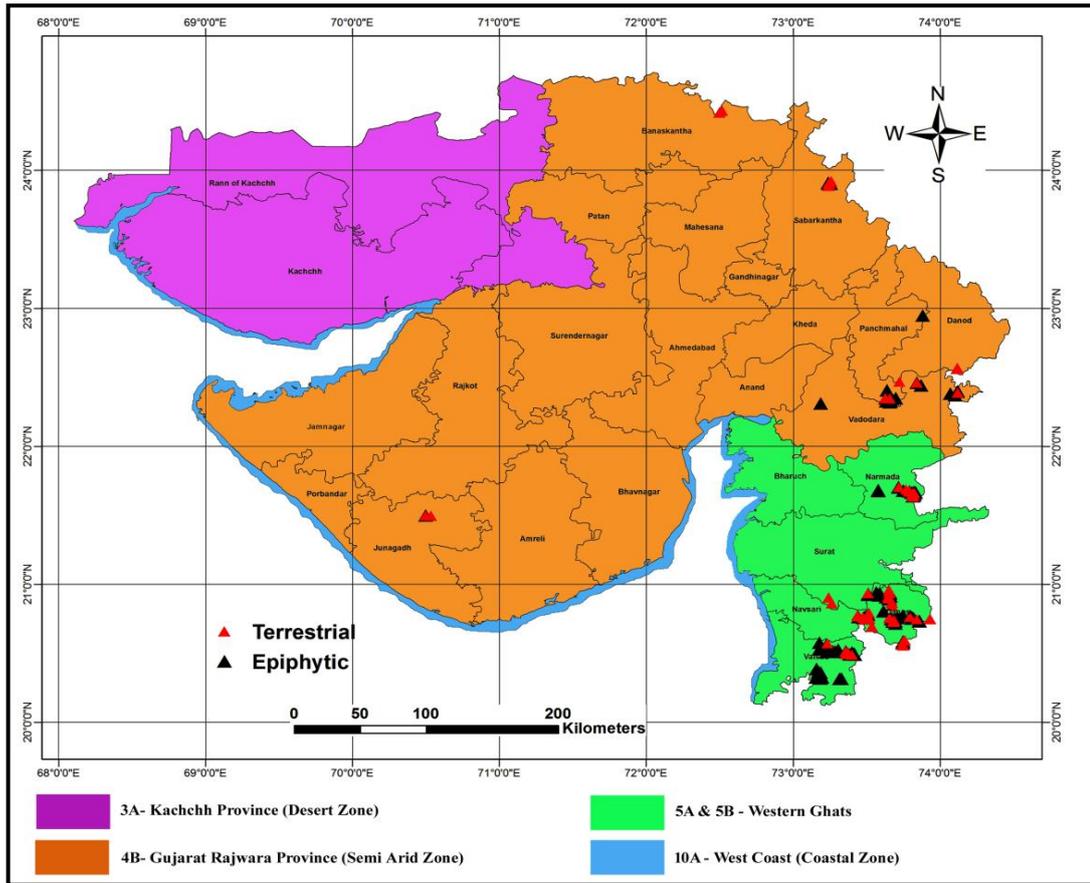


Figure 2.2: Distribution of Orchids in Gujarat

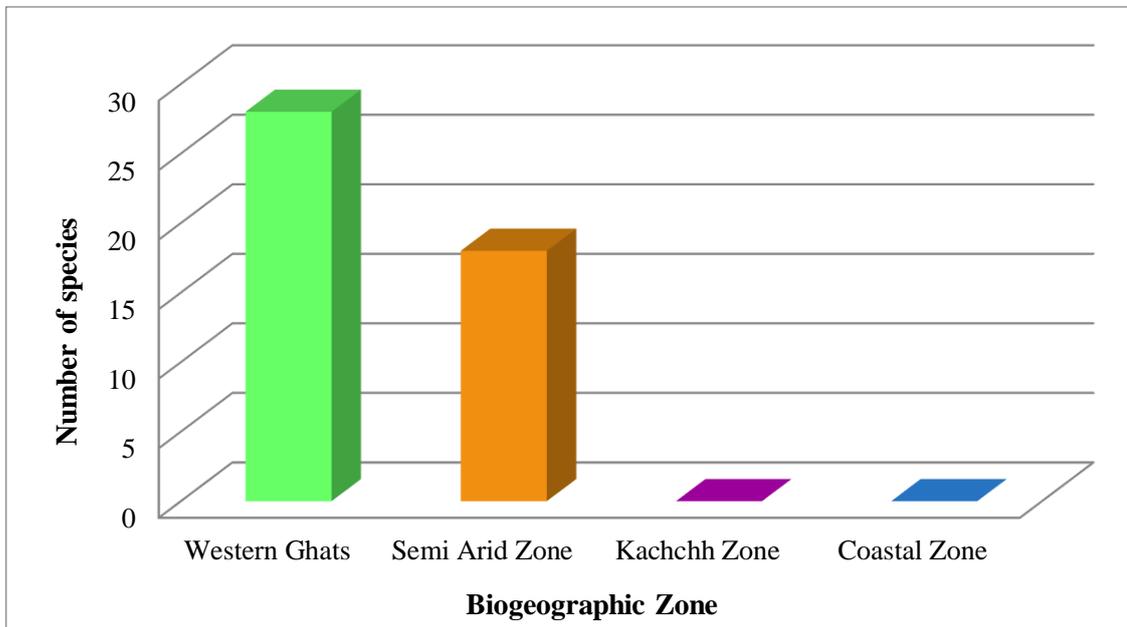


Figure 2.3: Orchid diversity in Various Biogeographical zones of Gujarat

**2.4.2. Keys and Macromorphological Characters**

Macromorphological characters are the prime features for identification of species. An effort has been made to study the orchids in elaborative manner using different characters which includes habit, phyllotaxy, leaf shape and detailed morphology of flower. It is one of the most accepted conventional method to distinguish various species (Dressler, 1981). This section includes macromorphological characters of 30 species of orchids with their flowering and fruiting period. Furthermore, the detailed information about habit, habitat, distribution of orchids in Gujarat, India as well as globally was also provided here.

The flowering patterns in orchids are irregular because of complex biotic and abiotic factors. These factors include: 1) weather, 2) grazing by mammals, by insects and underground grazing of storage organs, 3) cost of reproduction in species, in which reproductive success varies substantially, 4) habitat management and 5) habitat deterioration (Kindlmann and Balounová, 2001; Pfeifer, 2006). The species of *Vanda* and *Acampe* flowers during peak summer while the species of *Dendrobium* and *Zeuxine* flowers during cold night of winter. Most of the terrestrial orchids and some epiphytic genera (*Aerides*, *Oberonia* and *Rhynchostylis*) flowers during monsoon.

**Orchidaceae Juss.**

**Key to the Genera**

1a. Plants epiphytic .....2  
 1b. Plants terrestrial .....7  
 2a. Plants with distinct pseudobulbs.....**Dendrobium**  
 2b. Plants without pseudobulbs.....3  
 3a. Plants without distinct stem; leaves articulate radicle.....**Oberonia**  
 3b. Plants with distinct stem; leaves not articulate.....4  
 4a. Leaf apex bilobed, lobes unequal or subequal.....5  
 4b. Leaf apex irregularly toothed with 1 – 3 sharp teeth.....6  
 5a. Inflorescence always drooping.....**Aerides**  
 5b. Inflorescence not drooping.....**Acampe**  
 6a. Inflorescence compact drooping raceme.....**Rhynchostylis**  
 6b. Inflorescence lax raceme, not drooping.....**Vanda**  
 7a. Leaves one, appear after flowering.....**Nervilia**

7b. Leaves more than one, appear simultaneously.....	8
8a. Lip spurred or distinctly saccate at base.....	9
8b. Lip not spurred.....	<b>Crepidium</b>
9a. Lip saccate at base.....	10
9b. Lip spurred.....	11
10a. Inflorescence glabrous, lip entire .....	<b>Geodorum</b>
10b. Inflorescence glandular pubescent; lip lobed.....	<b>Zeuxine</b>
11a. Pollinia granular, powdery or in small masses.....	12
11b. Pollinia waxy.....	<b>Eulophia</b>
12a. Ovary and capsule nearly erect and parallel to peduncle, not spreading at angle to it; stigmatic surfaces in the form of small swellings on edge of lip.....	<b>Peristylus</b>
12b. Ovary and capsule widely spreading at angle to peduncle; stigmatic surfaces standing out as stalked appendages.....	<b>Habenaria</b>

**Acampe Lindl.**

**Acampe praemorsa** (Roxb.) Blatt. and McCann. in J. Bombay Nat. Hist. Soc. 35: 495. 1932; Santapau and Kapadia, Orchids Bombay 233, t. 54. 1966; Abraham and Vatsala, Introd. Orchids 450, t. 135. 1981; Raghavan et al. in Bull. Bot. Surv. India 83. 1981; Lakshmi. in Sharma et al., Fl. Maharashtra: Monocot 2: 11. 1996; Anonymous 149. 1996; Singh et al., Fl. Madhya Pradesh 3: 13. 2001. *Saccolabium praemorsum* (Roxb.) Hook.f., Fl. Brit. India 6: 62. 1890.

*Epiphytic herbs. Stem* 1.5 – 2.0 cm thick, covered with sheath of fallen leaves, woody. *Leaves* ca. 22.0 × 2.5 – 3.0 cm coriaceous, channelled, oblong, entire, apex emarginate with two equal rounded lobes. *Inflorescence* 4.5 – 5.0 cm long including peduncle, corymbose panicle, with closely arranged copular sheaths. *Flowers* ca.1.5 × 1.0 cm, densely arranged at apex of peduncle, fleshy, bracteate, pedicellate. *Bract* ca. 0.2 × 0.2 cm, ovate – oblong, acute, brown, persistent. *Pedicel* with *Ovary* 0.3 – 0.6 cm long. *Sepals and Petals* similar, coriaceous, entire, creamy – yellow with dark brownish – red irregular transverse strips. *Dorsal sepal* ca. 0.9 × 0.5 cm, obovate – oblong, obtuse; *lateral sepals* as long and as broad as dorsal ones, ovate, obtuse, rarely subretuse. *Petals* ca. 0.9 × 0.3 cm, oblong, acute apex. *Lip* 0.8 – 0.9 × 0.4 cm, white with purplish strips; lateral lobes small, erect subentire; midlobe dilated beyond lateral lobes, margin irregularly waved, obtuse. *Spur* short, rounded sac. *Column* ca. 0.2 × 0.2 cm, broadly

margined with deep brownish-red. *Pollinia* 2, large, globose, waxy, yellow. *Capsules* 7.0 – 8.0 × 0.7 – 1.0 cm subcylindric, longitudinally ribbed (Plate 2.1).

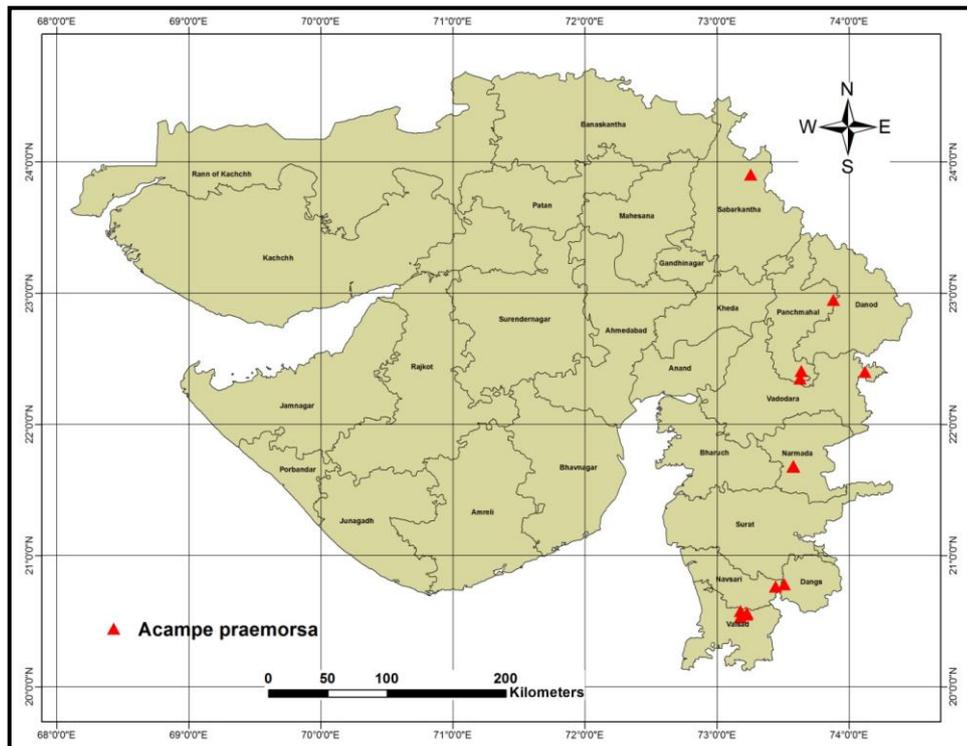
**Flowering & Fruiting:** April – August.

**Habit & Habitat:** Epiphytic herbs, found in moist and dry deciduous forests up to 519 m a.s.l. Common host species are *Madhuca indica* J.F.Gmel., *Mangifera indica* L., *Tamarindus indica* L., *Tectona grandis* L.f.

**Specimens examined:** India, **Gujarat**, Valsad, Dharampur, 18<sup>th</sup> June 2014, M. R. Bhatt, 33453 (BSI, Jodhpur!); **Maharashtra**, 13<sup>th</sup> April 1968, K. V. Billore, 75899 (BSI, Pune!); 19<sup>th</sup> August 2013, J. S. Jalal and S. C. Patil, 133272 (BSI, Pune!); **Daman** 09<sup>th</sup> May 1963, S. R. Rolla, 87427 (BSI, Pune!).

**Gujarat:** Chhota Udepur (5A/C<sub>3</sub>), Dahod (5A/C<sub>3</sub>), Dangs (3B/C<sub>2</sub>), Narmada (3B/C<sub>1b</sub> and 3B/C<sub>2</sub>), Navsari (3B/C<sub>1b</sub>), Panchmahal (5A/C<sub>3</sub> and 5/2S<sub>1</sub>), Valsad (3B/C<sub>1b</sub>, 3B/C<sub>2</sub> and 3B/C<sub>2</sub>S<sub>1</sub>) and Sabarkantha (5A/C<sub>3</sub> and 5/2S<sub>1</sub>) (Figure 2.4).

**Global Distribution:** India (Andhra Pradesh, Chattishgarh, Jharkhand, Goa, Karnataka and Kerala, Maharashtra, Madhya Pradesh, Odisha, Rajasthan and Tamil Nadu), Myanmar, Nepal and Sri Lanka.



**Figure 2.4:** Distribution of *Acampe praemorsa* in Gujarat

**Aerides** Lour.

1. Midlobe of lip broadly obovate, deep pink–mauve, spur about half as long as lip.....**A. maculosa**  
 1. Midlobe of lip linear – oblong, white or pale lilac, spur about equalling lip.....**A. ringens**

**Aerides maculosa** Lindl. in Edwards's Bot. Reg. 31: 58. 1845; Hook.f., Fl. Brit. India 6: 45. 1890; T. Cooke, Fl. Pres. Bombay 3: 203. 1958 (Repr.); Santapau and Kapadia, Orchids Bombay 120, t. 30. 1966; Shah, Fl. Gujarat 2: 653. 1978; Abraham and Vatsala, Introd. Orchids 444, t. 132. 1981; Raghavan et al. in Bull. Bot. Surv. India 83. 1981; Pandey in Shetty and Singh Fl. Rajasthan 2: 821. 1991; Lakshmi. in Sharma et al., Fl. Maharashtra 2: 13. 1996; Anonymous 149. 1996; Singh et al., Fl. Madhya Pradesh 3: 16. 2001.

*Epiphytic herbs. Stem* 1.0 – 2.0 cm thick, sheathed. *Leaves* ca. 18.5 × 1.2 cm, coriaceous, green spotted with purple, linear – oblong, with two unequally lobed apex. *Inflorescence* 23.0 – 37.0 cm long with pedicel, lax raceme, pendulous, much longer than leaves. *Flowers* ca. 2.0 × 2.5 cm, pedicellate, bracteate, faintly perfumed, pinkish violet. *Bract* minute, ovate, acute, entire. *Pedicel* with *Ovary* 1.3 – 1.6 cm long. *Sepals and Petals* white flushed with pink mauve towards extremities, usually speckled with darker coloured spots. *Dorsal sepals* ca. 0.8 × 0.7 cm, subequal, obovate – orbicular, obtuse, *lateral sepals* ca. 0.9 × 0.7 cm suboblique, mucronulate. *Petals* 1.0 × 0.4 – 0.5 cm, oblong – elliptic, subfalcate, obtuse or slightly retuse, entire. *Lip* ca. 2.0 × 1.7 cm, tri-lobed; lateral lobes small, spreading, faintly pinkish white, rounded, with a fleshy white callus in between; midlobe ca. 1.4 × 1.4 cm, deep rose-pink flushed with mauve, obtusely quadrate, obtuse or truncate, irregularly crenate and finely crisped on margins. *Spur* ca. 0.8 cm long, curved downwards like hook, tapering to an obtuse subclavate greenish apex. *Column* pink, oblong, slightly upturned above. *Pollinia* 2, waxy, yellow. *Capsules* 3.0 – 4.0 × 0.8 – 1.0 cm, obovoid, strongly ribbed, shortly stalked (Plate 2.1).

**Flowering & Fruiting:** July – October.

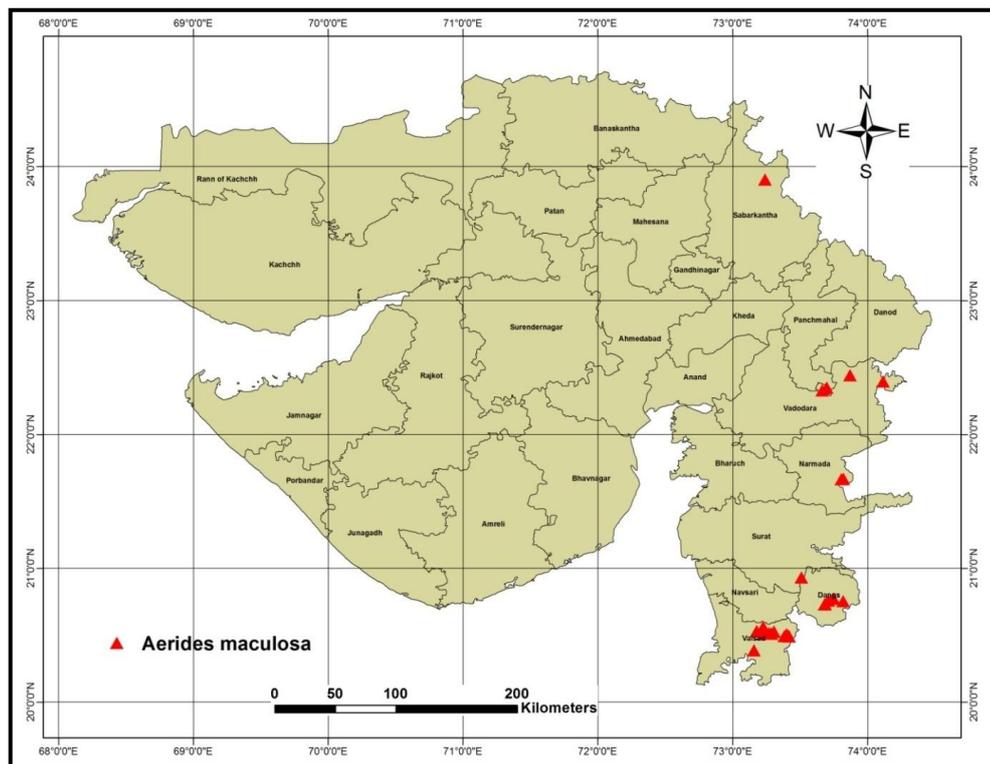
**Habit & Habitat:** Epiphytic herbs, found in moist and dry deciduous forests up to 426 m a.s.l. Common host species are *Acacia chundra* (Rottler) Willd., *Bridelia retusa* (L.) A.Juss., *Butea monosperma* (Lam.) Taub., *Dalbergia sissoo* DC., *Heterophragma*

*quadriloculare* (Roxb.) K.Schum., *Madhuca indica* J.F.Gmel., *Tamarindus indica* L., *Terminalia crenulata* Roth, *Wrightia tinctoria* R.Br. etc.

**Specimens examined:** India, **Gujarat**, Valsad, Dharampur, Mandva, 17<sup>th</sup> June 2014, M. R. Bhatt, 33432 (BSI, Jodhpur!); **Karnataka**, Mookambika WLS, 25<sup>th</sup> June 2008, P. G. Diwakar and R. K. Singh, 129811 (BSI, Pune!); Mysore, 16<sup>th</sup> June 1961, R. S. Raghawan, 45253 (BSI, Pune!); **Maharashtra**, Pune, Ambe plateau, Junnar, 13<sup>th</sup> August 2013, J. S. Jalal, 200825 (BSI, Pune!).

**Gujarat:** Chhota Udepur (5A/C<sub>1b</sub>), Dahod (5A/C<sub>3</sub>), Dangs (3B/C<sub>1b</sub> and 3B/C<sub>2</sub>S<sub>1</sub>), Narmada (3B/C<sub>1b</sub> and 3B/C<sub>2</sub>), Navsari (3B/C<sub>1b</sub> and 3B/C<sub>2</sub>S<sub>1</sub>), Panchmahal (5A/C<sub>3</sub> and 5/2S<sub>1</sub>), Valsad (3B/C<sub>1b</sub> and 3B/C<sub>2</sub>) and Sabarkantha (5A/C<sub>3</sub> and 5/2S<sub>1</sub>) (Figure 2.5).

**Global Distribution:** Endemic to Peninsular India (Andhra Pradesh, Goa, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha, Rajasthan and Tamil Nadu).



**Figure 2.5:** Distribution of *Aerides maculosa* in Gujarat

*Aerides ringens* (Lindl.) C.E.C.Fisch, Fl. Madras 1442. 1928; Cooke, Fl. Pres. Bombay 3: 204. 1958 (Repr.); Santapau and Kapadia, Orchids Bombay 119, t. 29. 1966; Abraham and Vatsala, Introd. Orchids 446, t.134. 1981; Lakshmi. in Sharma et al., Fl. Maharashtra 2: 43. 1996; Bhatt and Nagar in J. Orchid Soc. India 28: 115. 2014. *A. radicata* A.Rich.

in Ann. Sci. Nat., Bot., ser. 2, 15: 65. 1841; Hook.f., Fl. Brit. India 6: 46. 1890; T. Cooke, Fl. Pres. Bombay 3: 204. 1958 (Repr.). *A. linearis* Hook.f., Fl. Brit. India 6: 47. 1890.

*Epiphytic herbs. Stem* 1.0 – 2.0 cm thick, woody, covered with a sheath of decayed leaves. *Leaves* 22.0 – 27.0 × 1.0 – 2.0 cm, coriaceous, linear or linear – oblong, apex bilobed with two unequal, rounded lobes, purplish green very often speckled with deeper-coloured spots. *Inflorescence* ca. 27.0 – 37.0 cm long including peduncle, lax raceme, erect, branched. *Flowers* ca. 1.7 cm long, pedicellate, bracteate. *Bracts* ca. 0.2 × 0.2 cm triangular, scaly. *Pedicel with Ovary* 0.6 – 0.8 cm long. *Sepals and Petals* white tinged with pale mauve – lilac. *Dorsal sepal* ca. 0.7 × 0.4 cm, obovate – oblong, mucronulate; *lateral sepals* ca. 0.6 × 0.3 cm, oblong, broader at base than dorsal sepal. *Petals* ca. 0.6 × 0.5 cm, obovate, tapering at base, obtuse, entire. *Lip* 0.7 – 0.9 cm long, tri-lobed, white or pale lilac with several deeper-coloured longitudinal streaks along middle; lateral lobes ca. 0.3 × 0.3 cm, erect, triangular – cuneate, obtuse, entire, with a callus; midlobe ca. 0.7 × 0.4 cm, broadly linear – oblong, inflated about middle, entire, apex upturned, retuse or rarely truncate. *Spur* ca. 0.6 × 0.2 cm, white, broadly funnel-shaped, incurved, subclavate. *Column* white, convex and centrally grooved. *Pollinia* 2, yellow, waxy. *Capsules* ca. 1.5 × 0.6 cm, obovoid – oblong, strongly ribbed (Plate 2.2).

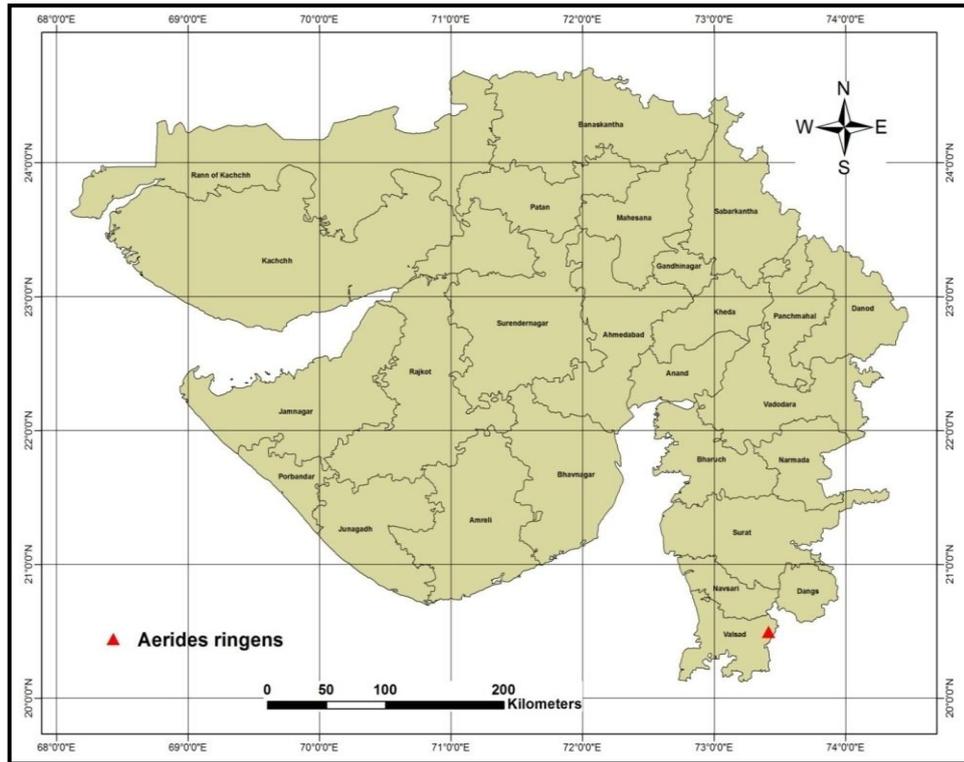
**Flowering & Fruiting:** July – September.

**Habit & Habitat:** Epiphytic herbs, found in moist deciduous forests up to 253 m a.s.l. The preferable host is *Madhuca indica* G.F.Gmel.

**Specimen examined:** India, **Gujarat**, Valsad, Dharampur, Gundiya, 18<sup>th</sup> June 2014, M. R. Bhatt, 0050 (BARO!).

**Gujarat:** Valsad (3B/C<sub>2</sub>S<sub>1</sub>) (Figure 2.6).

**Global Distribution:** India (Andhra Pradesh, Goa, Karnataka, Kerala, Maharashtra, Odisha and Tamil Nadu) and Sri Lanka.



**Figure 2.6:** Distribution of *Aerides ringens* in Gujarat

### **Crepidium Blume**

**Crepidium mackinnonii** (Duthie) Szlach., *Fragm. Florist. Geobot. Suppl.* 3: 128. 1995. *Malaxis mackinnonii* (Duthie) Ames, *Orchidaceae* 6: 289. 1920; Santapau and Kapadia, *Orchids Bombay* 140. 1966; Shah, *Fl. Gujarat* 2: 659. 1978; Abraham and Vatsala, *Introd. Orchids* 394. 1981; Raghavan et al. in *Bull. Bot. Surv. India* 83. 1981; Lakshmi. in Sharma et al., *Fl. Maharashtra* 2: 43. 1996; Anonymous 149. 1996; Singh et al., *Fl. Madhya Pradesh* 3: 52. 2001.

*Terrestrial herbs*, 10.0 – 50.0 cm high; tuber 1 – 2, small, 0.7 – 1.0 cm in diam., corm-like. *Leaves* 1 – 3, clustered at base, subfleshy, subplicate, 3.0 – 13.0 × 1.3 – 7.0 cm, oblong – lanceolate, acute or obtuse, entire, *Inflorescence* 15.0 – 50.0 cm long with scape, lax raceme, angled, often slightly winged. *Flowers* 0.3 – 0.4 cm, pale yellow or yellowish green, bracteate, pedicellate. *Bracts* 0.4 × 0.1 – 0.15 cm, pale yellowish green, narrowly subulate, subacuminate or acute, entire. *Pedicel* with *Ovary* 0.2 – 0.3 cm long. *Sepals* ca. 0.35 × 2.0 cm, spreading, subequal, narrowly oblong, obtuse, margin revolute. *Petals* 0.15 – 0.2 cm long, narrowly linear to filiform, obtuse, twisted and much reflexed. *Lip* 0.5 × 0.3 cm, pale yellow, auricled, ovate – oblong in outline, slightly curved forwards, somewhat hooded, bilobed at apex, lobes obtuse. *Column* ca. 0.2 cm long, pale yellow.

*Pollinia* 4, in pairs, ovoid – pyriform. *Capsules* ca. 1.0 × 0.4 cm, erect, obovoid, ribbed (Plate 2.2).

**Flowering & Fruiting:** August – September

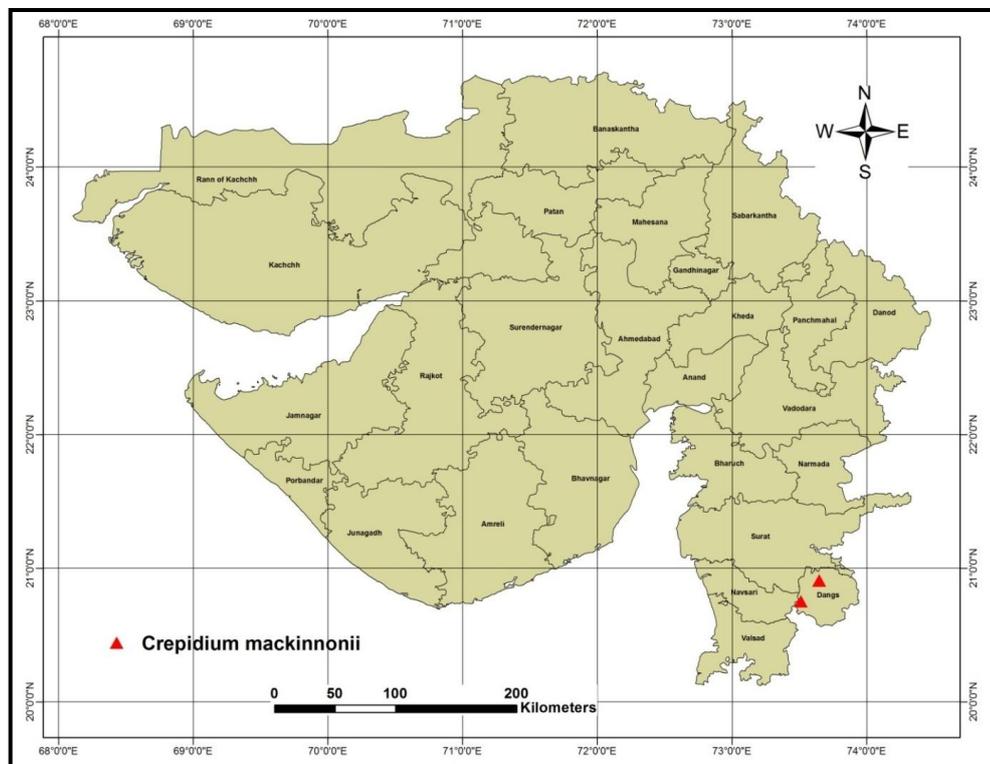
**Habit & Habitat:** Terrestrial herbs, found under the forest undergrowth as well as in open area of moist deciduous forests up to 235 m a.s.l.

**Specimen examined:** India, **Gujarat**, Dangs, Waghai, 30<sup>th</sup> October 2014, M. R. Bhatt, 33426 (BSI, Jodhpur!).

**Gujarat:** Dangs (3B/C<sub>1b</sub> and 3B/C<sub>2</sub>) (Figure 2.7).

**Global Distribution:** India (Bihar, Jharkhand, Kerala, Madhya Pradesh, Maharashtra, Odisha, Uttarakhand and West Bengal) Bangladesh, China, Myanmar, Nepal and Sri-Lanka.

**Note:** Generally, the plant height was 10.0 – 25.0 cm but few specimens located in Mahal WLS were of 40.0 – 50.0 cm of height.



**Figure 2.7:** Distribution of *Crepidium mackinnonii* in Gujarat

**Dendrobium** O. Sw. (*nom. cons.*)

- 1. Pseudobulbs 2 – 3 cm long.....**2**
- 1. Pseudobulbs up to 40 cm long.....**3**
- 2. Leaves membranous; peduncles 4 – 5 cm long; disc with callus.....**D. microbulbon**
- 2. Leaves fleshy; peduncles very short; disc with a broad fleshy ridge.....**D. peguanum**
- 3. Pseudobulbs swollen at base, flowers pure white or pinkish tinge.....**D. barbatulum**
- 3. Pseudobulbs not swollen at base, flowers yellow or buff coloured .....**D. ovatum**

**Dendrobium barbatulum** Lindl., Gen. Sp. Orchid. Pl. 84. 1830; Hook.f., Fl. Brit. India 5: 719. 1890; T. Cooke, Fl. Pres. Bombay 3: 184. 1958 (Repr.); Santapau and Kapadia, Orchids Bombay 93, t. 22. 1966; Shah, Fl. Gujarat 2: 654. 1978; Raghavan et al. in Bull Bot. Surv. India 83. 1981; Lakshmi. in Sharma et al., Fl. Maharashtra 2: 19. 1996; Anonymous 149. 1996.

*Epiphytic herbs*, leafless at time of flowering. *Pseudobulbs* 6.0 – 35.0 × 0.5 – 1.0 cm, swollen at base and tapering at apex, in tufts, several-nodded; nodes 1.5 – 3.0 cm long, with longitudinal striations. *Leaves* 5.0 – 11.0 × 1.5 – 3.0 cm, alternate, sheathing at base, ovate – lanceolate, acute, entire. *Inflorescence* 9.0 – 15.0 cm long including peduncle, terminal or lateral racemes. *Flowers* 2.5 – 0.4 × 2.5 – 4.5 cm, often white or white suffused with pink – lilac, bracteate, pedicellate. *Bracts* ca. 0.3 × 0.1 cm, broadly ovate, sub acuminate, pale brown, scarious. *Pedicel* with *Ovary* ca. 1.3 cm long. *Sepals* and *Petals* spreading, recurved, acute, entire. *Sepals* ca. 1.5 × 0.4 cm, subequal, acute; *dorsal sepal* ovate – lanceolate; *lateral sepals* oblong – lanceolate, slightly falcate. *Petals* ca. 1.6 × 0.5 cm, obovate – lanceolate, acute, tapering to base, entire. *Lip* ca. 1.8 cm long, tri-lobed; lateral lobes ca. 1.0 × 0.3 cm, obtuse, with red brown veins inside; midlobe ca. 1.2 × 0.6 cm, bearded with yellow hairs at base, ovate – oblong, apiculate, entire. *Mentum* (spur) ca. 1.0 × 0.5 cm, broadly conical, obtuse, pale yellow, straight or slightly incurved. *Column* ca. 0.3 × 0.2 cm. *Pollinia* in 2 pairs, waxy, yellowish green. *Capsules* ca. 2.0 × 1.0 cm, curved, ribbed (Plate 2.3).

**Leaves:** July – September.

**Flowering & Fruiting:** January – March.

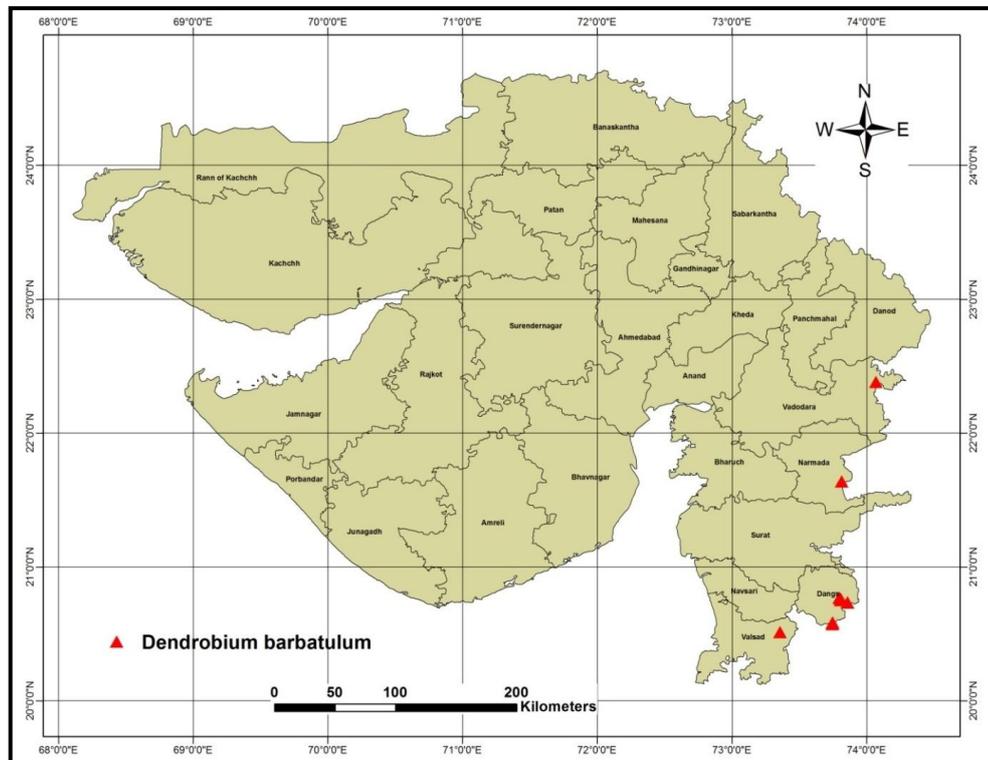
**Habit & Habitat:** Epiphytic herbs, found in moist and dry deciduous forests up to 878 m a.s.l. Common host species are *Bridellia retusa* (L.) A. Juss., *Casuarina equisetifolia* L., *Erythrina stricta* Roxb., *Heterophragma quadriloculare* (Roxb.) K.Schum., *Meyna laxiflora* Robyns, *Mitragyna parvifolia* (Roxb.) Korth., *Peltophorum pterocarpum* (DC.) K.Heyne, *Tectona grandis* L.f., *Terminalia crenulata* Roth etc.

**Specimens examined:** India, **Gujarat**, Dangs, Ahwa, 22<sup>nd</sup> February 2015, M. R. Bhatt, 137 (BARO!); **Karnataka**, Mysore, 26<sup>th</sup> February 1963, R. S. Raghawan, 40182 (BSI Pune!); **Maharashtra**, Pune, Ambe ghat, Junnar, 13<sup>th</sup> August 2013, J. S. Jalal, 200819 (BSI Pune!).

**Gujarat:** Dangs (3B/C<sub>1b</sub> and 3B/C<sub>2S1</sub>), Narmada (3B/C<sub>2</sub>) and Panchmahal (5A/C<sub>3</sub>), Valsad (3B/C<sub>1b</sub> and 3B/C<sub>2</sub>) (Figure 2.8).

**Global Distribution:** Endemic to Western Ghats (Goa, Karnataka, Kerala, Maharashtra and Tamil Nadu).

**Note:** The flower colour varies from white to pink – lilac.



**Figure 2.8:** Distribution of *Dendrobium barbatulum* in Gujarat

**Dendrobium microbulbon** A.Rich. in Ann. Sci. Nat., Bot., ser. 2, 15: 19. 1841; Hook.f., Fl. Brit. India 5: 716. 1890; T. Cooke, Fl. Pres. Bombay 3: 183. 1958 (Repr.); Santapau

and Kapadia, Orchids Bombay 87, t. 19. 1966; Abraham and Vatsala, Introd. Orchids 358, t. 86. 1981; Shah, Fl. Gujarat 2: 655. 1978; Raghavan et al. in Bull. Bot. Surv. India 83. 1981; Lakshmi. in Sharma et al., Fl. Maharashtra 2: 22. 1996; Anonymous 149. 1996.

*Epiphytic herbs*, leafless at time of flowering. *Pseudobulbs* 1.5 – 2.5 × 1.5 cm, conical, 1 – 3 noded, clustered, mauve – brown and covered with a network of fibres formed by decayed membranous sheaths. *Leaves* 2.0 – 5.0 × 0.5 – 1.0 cm, usually two from top of pseudobulbs, caducous, linear – lanceolate, acute, entire. *Inflorescence* 4.0 – 10.0 cm long including peduncle, terminal racemes. *Flowers* 1.0 – 1.2 × 0.7 – 0.8 cm, faintly perfumed, bracteate, pedicellate. *Bracts* ca. 0.2 – 0.3 × 0.1 cm scaly, membranous, ovate – lanceolate, acute, entire. *Pedicel* with *Ovary* 0.7 – 1.0 cm long. *Sepals* white, entire; *dorsal sepal* 0.4 – 0.6 × ca. 0.2 cm, linear – lanceolate, subacute; *lateral sepals* 0.5 – 0.7 × 0.3 – 0.4 cm, spreading, subacute, falcate. *Petals* ca. 0.8 × 0.2 cm, white, oblanceolate, obtuse, entire. *Lip* 4.0 × 5.0 – 5.5 cm, greenish – pale mauve with purple veins inside, trilobed, sidelobes small, sub-acute; midlobe ca. 1.3 cm long, truncate, crenulated. *Mentum* (spur) white flushed with purple, ca. 0.6 × 0.4 cm, broadly infundibuliform at mouth. *Column* ca. 0.2 cm long, pale mauve – green. *Pollinia* 4, waxy, yellow. *Capsules* ca. 1.0 × 0.6 cm, broadly ellipsoid, smooth (Plate 2.3).

**Leaves:** July – October.

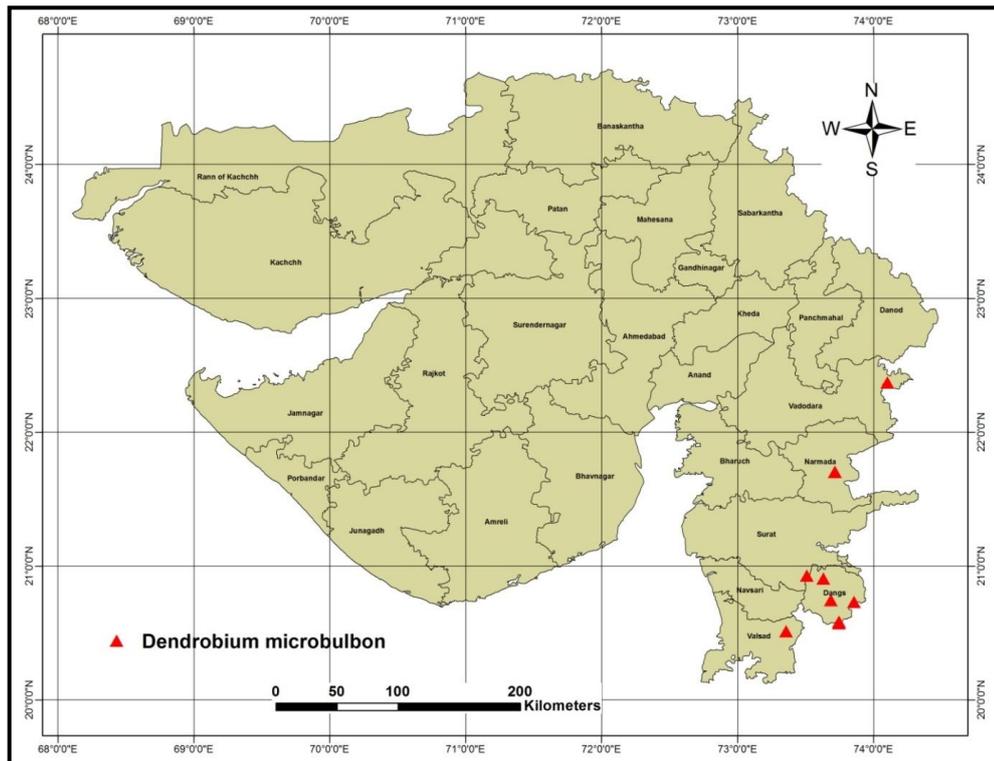
**Flowering & Fruiting:** December – March.

**Habit & Habitat:** Epiphytic herbs, found in moist and dry deciduous forests up to 920 m a.s.l. Common hosts are *Casurina equisetifolia* L., *Mitragyna parviflora* (Roxb.) Korth., *Peltophorum pterocarpum* (DC.) K. Heyne, *Syzygium cumini* (L.) Skeels, *Tectona grandis* L.f. *Terminalia crenulata* Roth., *Trewia polycarpa* Benth., *Wrightia tinctoria* R.Br. etc.

**Specimens examined:** India, **Gujarat**, Dangs, Ahwa, Don, 3<sup>rd</sup> January 2015, M. R. Bhatt, 146 (BARO!); **Maharashtra**, Bhimashankar, 14<sup>th</sup> March 2012, J. S. Jalal, 132432 (BSI, Pune!); 14<sup>th</sup> March 2012, J. S. Jalal, 133711 (BSI, Pune!).

**Gujarat:** Dangs (3B/C<sub>1b</sub> and 3B/C<sub>2S1</sub>), Narmada (3B/C<sub>2</sub>), Navsari (3B/C<sub>1b</sub>), Panchmahal (5A/C<sub>3</sub>) and Valsad (3B/C<sub>2</sub>) (Figure 2.9).

**Global Distribution:** Endemic to Western Ghats (Goa, Karnataka, Kerala, Maharashtra and Tamil Nadu).



**Figure 2.9:** Distribution of *Dendrobium microbulbon* in Gujarat

***Dendrobium ovatum*** (L.) Kraenzl., H.G.A. Engler (ed.), Pflanzenr. IV, 50 II B 21: 71. 1910; Santapau and Kapadia, Orchids Bombay 91, t. 21. 1966; Abraham and Vatsala, Introd. Orchids 353, t. 83. 1981; Shah, Fl. Gujarat 2: 655. 1978; Raghavan et al. in Bull. Bot. Surv. India 83. 1981; Lakshmi. in Sharma et al., Fl. Maharashtra 2: 23. 1996; Anonymous 149. 1996. *D.chlorops* Lindl., Edwards's Bot. Reg. 30 (Misc.): 44. 1844; Hook.f., Fl. Brit. India 5: 719. 1890; T. Cooke, Fl. Pres. Bombay 3: 184. 1958 (Repr.).

*Epiphytic herbs*, leafless at time of flowering. *Pseudobulbs* 15.0 – 25.0 cm long; in tufts, internodes many, 2.0 – 3.5 cm long, longitudinally ribbed, nodes slightly swollen. *Leaves* 5.0 – 8.0 × 1.2 – 3.0 cm, caducous, alternate, membranous, sheathing at base, oblong – lanceolate, acute, entire. *Inflorescence* 3.0 – 15.0 cm long including peduncle, terminal racemes, sub-pendulous. *Flowers* 1.4 – 1.8 cm across, cream – yellow with pale green centres, bracteates, pedicellate. *Bracts* 0.2 – 0.3 cm long, membranous, scarious, ovate – lanceolate, acute. *Pedicels* with *Ovary* ca. 1.3 cm long. *Sepals* 0.7 – 1.0 × 0.3 – 0.4 cm, spreading, sub-equal, ovate – oblong, obtuse, entire. *Petals* 0.7 – 0.9 × 0.5 – 0.6 cm, obovate – oblong, entire, glabrous. *Lip* 0.7 – 0.8 cm long, pale creamy yellow, slightly



**Dendrobium peguanum** Lindl. in J. Proc. Linn. Soc., Bot. 3: 19. 1858. Santapau and Kapadia, Orchids Bombay 84, t. 18. 1966; Shah, Fl. Gujarat 2: 655. 1978; Raghavan et al. in Bull. Bot. Surv. India 83. 1981; Lakshmi. in Sharma et al., Fl. Maharashtra 2: 24. 1996; Anonymous 149. 1996. *D. pygmaeum* Lindl., Gen. Sp. Orchid. Pl. 85. 1830 nom. illeg.; Hook.f., Fl. Brit. India 5: 717. 1890.

*Epiphytic herbs*, leafless at time of flowering. *Pseudobulbs* 1.0 – 6.0 × 2.0 cm, ovoid – conical, 2 – 4 noded, clustered, sheathed, sheaths membranous with prominent veins. *Leaves* 2.5 – 5.0 × 0.6 – 2.0 cm, 2 – 3 towards apex of pseudobulb, fleshy, coriaceous, caducous, elliptic – oblong, subacute, *Inflorescence* 4.0 – 6.0 cm long including peduncle, terminal or lateral racemes, 4 – 10 flowered. *Flowers* 1.0 – 1.5 cm long, bracteate, pedicellate, faintly perfumed. *Bracts* ca. 0.5 cm long, dry, membranous, persistent, narrowly linear – lanceolate, entire. *Pedicel* with *Ovary* ca. 0.4 cm long. *Sepals* 0.8 – 1 × 0.2 – 0.3 cm, subequal, pale green or faintly suffused with pink, oblong, sharply acute, entire. *Petals* ca. 0.8 × 0.2 cm long, white, obspathulate, subacute. *Lip* ca. 0.8 cm long, pale green flushed with purple colour at tip, tri-lobed; sidelobes erect, subacute; midlobe ca. 0.2 × 0.4 cm, decurved broadly, triangular acute, margins crenulate, curving upwards. *Mentum* (spur) 0.2 – 0.4 cm long, narrowly conical, curved, subacute. *Column* ca. 0.3 × 0.2 cm, *Pollinia* 2 pairs, waxy, golden-brown. *Capsules* ca. 0.7 × 0.4 cm, ribbed, on a very short pedicel (Plate 2.4).

**Leaves:** June – October.

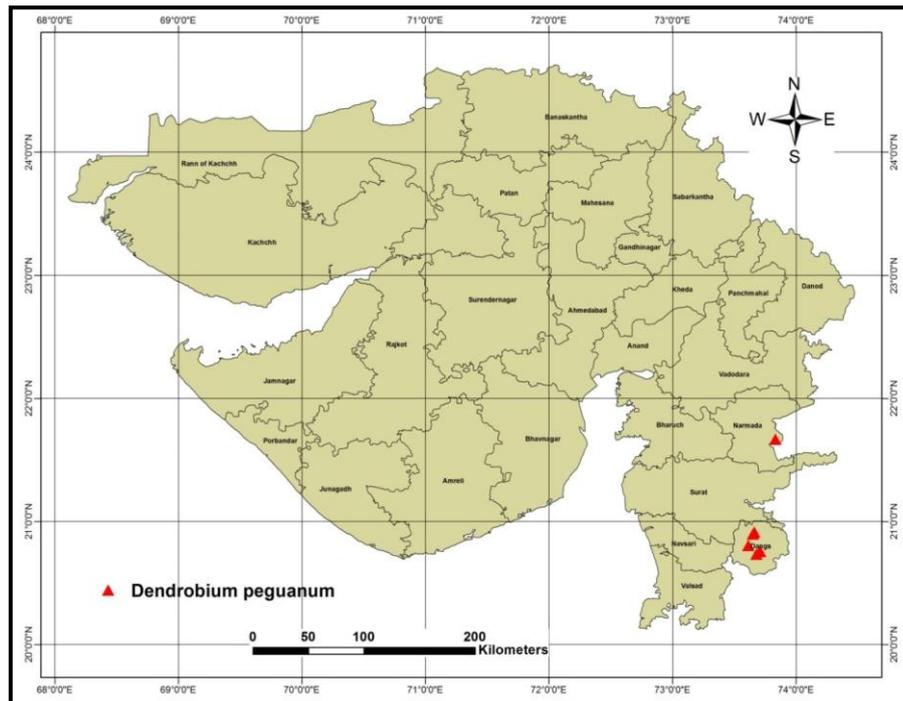
**Flowering & Fruiting:** December – March.

**Habit & Habitat:** Epiphytic herbs, found in moist deciduous forests up to 476 m a.s.l. The frequent host species are *Mitragyna parvifolia* (Roxb.) Korth., *Tectona grandis* L.f., *Terminalia crenulata* Roth., *Wrightia tinctoria* R.Br. etc.

**Specimen examined:** India, **Gujarat**, Dangs, Subir, 3<sup>rd</sup> January 2015, M. R. Bhatt, 142 (BARO!).

**Gujarat:** Dangs (3B/C<sub>1b</sub> and 3B/C<sub>2</sub>) and Narmada (3B/C<sub>2</sub>) (Figure 2.11).

**Global Distribution:** India (Chhattisgarh, Jharkhand, Karnataka, Maharashtra, Manipur, Mizoram, Odisha, Sikkim and West Bengal), Indonesia, Myanmar, Nepal and Thailand.



**Figure 2.11:** Distribution of *Dendrobium peguanum* in Gujarat

***Eulophia* R. Br. ex Lindl. (*nom. cons.*)**

- 1. Flowers ca. 1.2 cm long, deep yellow with a few brown spots; lip scarcely lobed, spur 0.1 – 0.2 cm long, minutely saccate at base.....**E. ochreatea**
- 1. Flowers 1.8 – 2.2 cm long, greenish white, often flushed with pale mauve; lip 3-lobed; spur 0.3 – 0.4 cm long, elliptic obtuse .....**E. herbacea**

***Eulophia herbacea*** Lindl., Gen. Sp. Orchid. Pl. 182. 1833. Hook.f., Fl. Brit. India 6: 2. 1890; T. Cooke, Fl. Pres. Bombay 3: 196. 1958 (Repr.); Santapau and Kapadia, Orchids Bombay 111. 1966; Raghavan et al. in Bull. Bot. Surv. India 83. 1981; Lakshmi. in Sharma, et al., Fl. Maharashtra 2: 43. 1996; Anonymous 149. 1996; Singh et al., Fl. Madhya Pradesh 3: 34. 2001.

*Terrestrial herbs. Pseudobulbs* hypogeal, tuberous, 2.0 – 3.0 cm in diam., ovoid to broadly conical, with transverse circular markings. *Leaves* 15.0 – 40.0 × 3.0 – 9.0 cm, usually 2 – 5, sheathing at base, elliptic – lanceolate to broadly elliptic, acute or subacuminate, entire, many-nerved. *Inflorescence* 30.0 – 60.0 cm long, lax raceme, erect, arising from pseudostem. *Flowers* 1.8 – 2.0 cm long, bracteate, pedicellate. *Bracts* 1.0 – 3.0 × 0.2 – 0.8 cm, lanceolate, acuminate, entire. *Pedicel* with *Ovary* 1.5 – 2.5 cm long, ribbed. *Sepals* 1.8 – 2.2 × 0.3 – 0.5 cm, green, lanceolate, acute, entire. *Petals* 1.5 – 1.7 × 0.7 – 1.0 cm, pure white or white flushed with pale lilac towards apex, oblong – elliptic,

obtuse or subacute, subentire. *Lip* 1.5 – 2.0 cm long, oblong – elliptic in outline, tri-lobed; lateral lobes 0.2 cm broad, erect, obtuse or acute, white faintly tipped with pale purple; midlobe ca. 1.0 × 0.9 cm, oblong or obovate – oblong, obtuse, pale mauve to deep magenta with white and purple hairy nerves. *Spur* ca. 0.4 cm long, white flushed with purple. *Column* 0.3 – 0.5 cm long. *Pollinia* 2, globose – ovate, yellow, attached by a short, thick caudicle to a quadrate gland. *Capsules* 3.0 – 5.0 cm long, ellipsoid, faintly nerved (Plate 2.5).

**Flowering & Fruiting:** July – August.

**Habit & Habitat:** Terrestrial herbs, found under the shade of tropical dry deciduous forest on slopes and rocky areas up to 567 m a.s.l.

**Specimen examined:** India, Gujarat, Sabarkantha, Vijaynagar, 25<sup>th</sup> August 2017, M. R. Bhatt, 162 (BARO!).

**Gujarat:** Sabarkantha (5A/C<sub>3</sub>) (Figure 2.12).

**Global Distribution:** India (Chhattisgarh, Himachal Pradesh, Karnataka, Madhya Pradesh, Maharashtra, Manipur, Mizoram, Odisha, Sikkim, Tripura, Uttarakhand and West Bengal), Bangladesh, China, Laos, Myanmar, Nepal, Philippines and Thailand.

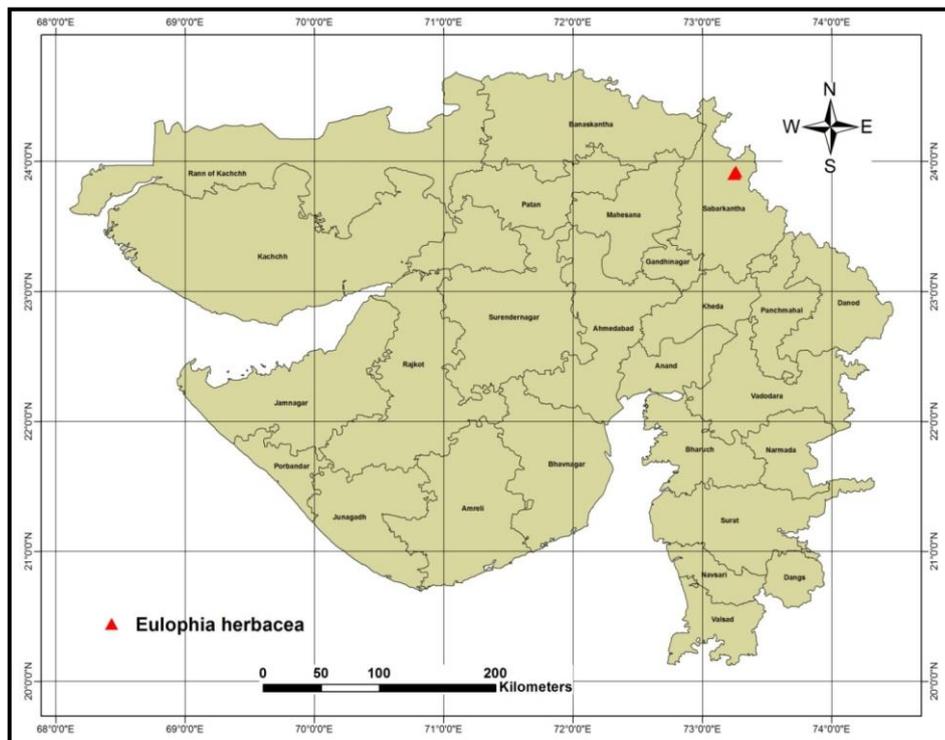


Figure 2.12: Distribution of *Eulophia herbacea* in Gujarat

**Eulophia ochreatea** Lindl. in J. Proc. Linn. Soc., Bot. 3: 24. 1858; Hook.f., Fl. Brit. India 6: 2. 1890; T. Cooke, Fl. Pres. Bombay 3: 196. 1958 (Repr.); Santapau and Kapadia, Orchids Bombay 109. t. 27. 1966; Raghavan et al. in Bull. Bot. Surv. India 83. 1981; Lakshmi. in Sharma, et al., Fl. Maharashtra 2: 29. 1996; Pandey in Shetty and Singh, Fl. Rajasthan 2: 822. 1991; Anonymous 149. 1996; Singh et al., Fl. Madhya Pradesh 3: 36. 2001.

*Terrestrial herbs. Pseudobulbs* ca.  $4.0 \times 2.5$  cm, hypogeal, ovoid – conical with irregular transverse and longitudinal markings. *Leaves*  $18.0 - 32.0 \times 6.0 - 10.0$  cm, 3 – 5, arising from base of pseudobulb, sheathing at base, oblong – lanceolate or ovate – elliptic, acute, entire, glabrous. *Inflorescence* 25.0 – 40.0 cm long, dense raceme, clustered at top of scape. *Flowers* 1.0 – 1.5 cm across, bracteate, pedicellate. *Bracts*  $0.4 - 1.3 \times 0.1 - 0.2$  cm, narrowly linear, acute, entire. *Pedicel* with *Ovary* 1.3 cm long. *Sepals*  $1.6 - 2.0 \times 0.2 - 0.4$  cm, yellowish green with purple or brown color spots on inner surface near base, linear – lanceolate, subacuminate, entire. *Petals*  $1.1 - 1.4 \times 0.3 - 0.4$  cm, similar to sepals in colour, ovate – oblong, acute, entire. *Lip* 1.1 – 1.3 cm long, pale cream coloured with purple tinge, obscurely 3-lobed, elliptic – orbicular in outline when spread out. *Spur* 0.1 – 0.2 cm long, small sac like. *Column* 0.3 – 0.4 cm long, whitish with purplish rim. *Pollinia* 2, waxy, yellow, ca. 0.1 cm long, globular. *Capsules* ca.  $2.8 \times 1.2$  cm, broadly ovoid, strongly ridged (Plate 2.5).

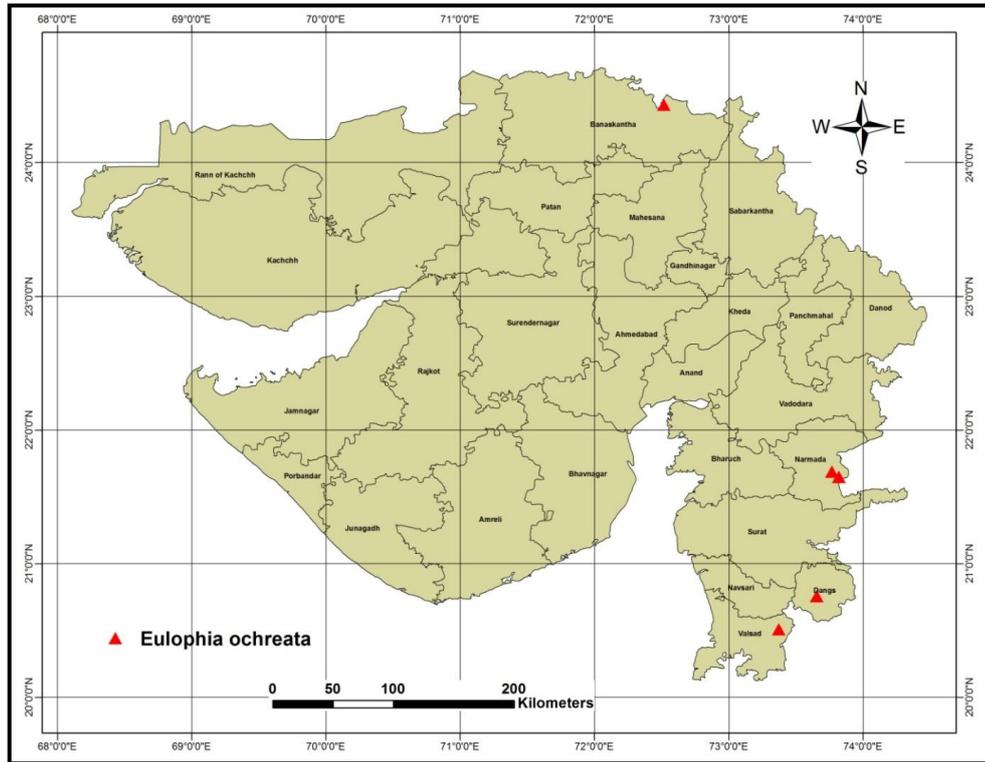
**Flowering & Fruiting:** June – August.

**Habit & Habitat:** Terrestrial herbs, found in undergrowth of moist deciduous forests on slopes and rocky areas up to 800 m a.s.l.

**Specimen examined:** India, **Gujarat**, Narmada, Saghai Forest range, 19<sup>th</sup> July 2016, M. R. Bhatt, 127 (BARO!).

**Gujarat:** Banaskantha (5A/C<sub>3</sub>), Dangs (3B/C<sub>1b</sub>), Narmada (3B/C<sub>2</sub>) and Valsad (3B/C<sub>2S1</sub>) (Figure 2.13).

**Global Distribution:** Endemic to Peninsular India (Maharashtra, Karnataka, Rajasthan and Tamil Nadu).



**Figure 2.13:** Distribution of *Eulophia ochreata* in Gujarat

**Geodorum** G. Jacks.

**Geodorum laxiflorum** Griff. in Calcutta J. Nat. Hist. 5: 356. 1845; Hook.f., Fl. Brit. India 6: 18. 1890; Bhatt et al. in Richardiana XV: 335. 2015

*Terrestrial herbs*, 30.0 – 50.0 cm high. *Pseudobulbs* 4.5 – 5.0 cm, ovoid, slightly compressed, greenish brown, with scars of fallen leaves. *Pseudostem* ca. 10.0 cm × 1.0 cm, ovoid – conical, enclosed by four foliar imbricating sheaths. *Leaves* 13.0 – 36.0 × 8.0 – 12.0 cm, usually 2 – 4, cauline, alternate, elliptic – lanceolate, acute, undulate. *Inflorescence* 40.0 – 53.0 cm long including scape, lax raceme, lateral from base of newly developed leafy shoot and shorter than it, decurved at top. *Flowers* 1.5 – 2.5 cm, white – off-white, bracteate, pedicellate. *Bracts* green, oblong – lanceolate, ca. 1.1 × 0.3 cm, membranous with acute apex. *Pedicel* with *Ovary* 1.3 cm long, ribbed. *Sepals* 2.1 – 2.2 × 0.6 – 0.8 cm, subequal, oblong – lanceolate, acute, entire, off white. *Petals* ca. 2.3 × 1.2 cm, oblong, acute – obtuse, off white. *Lip* ca. 2.1 × 1.5 – 1.7 cm, broadly obovate, emarginated, entire, white with yellow base and pink tip. *Column* 0.5 – 0.6 cm long, oblong. *Pollinia* ca. 0.2 × 0.15 cm, yellow, porate behind. *Capsules* 3.6 × 1.8 cm, ellipsoid, conspicuously 6- ribbed (Plate 2.6).

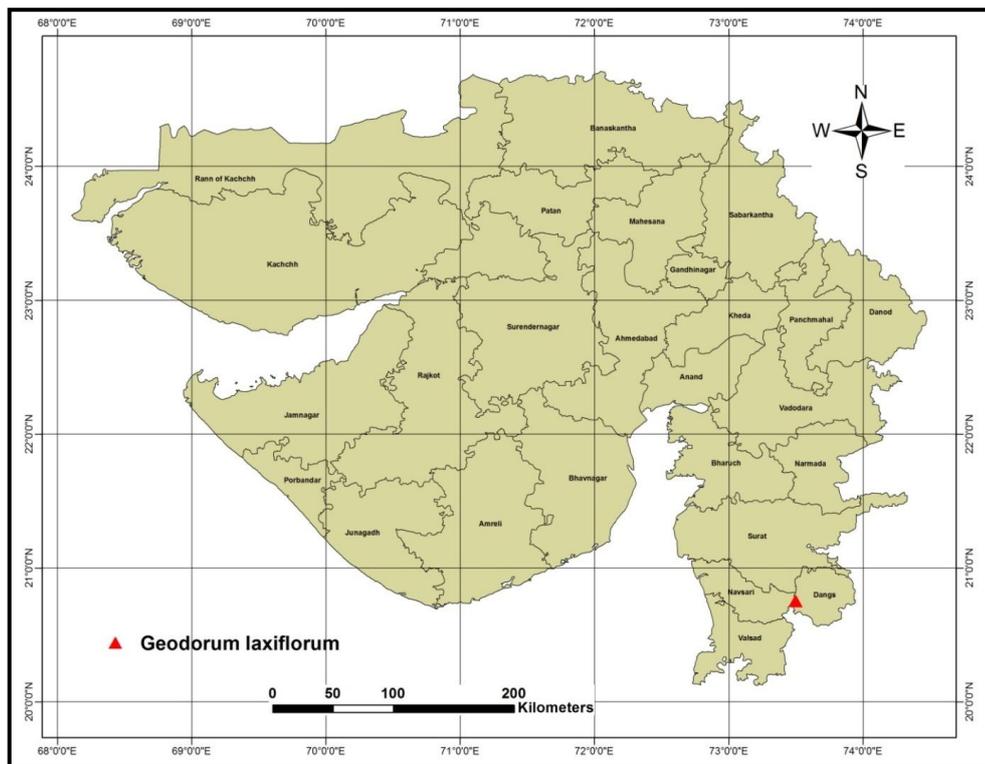
**Flowering & Fruiting:** June – August.

**Habit & Habitat:** Terrestrial herbs, usually found in undergrowth of moist and dry deciduous forests on sloppy ground at 250 m a.s.l.

**Specimens Examined:** India, **Gujarat**, Dangs, Waghai, 17<sup>th</sup> July 2015, M. R. Bhatt, 0142 (BARO!); Dangs, Waghai, 8<sup>th</sup> October 2014, M. R. Bhatt, 33424 (BSI Jodhpur!).

**Gujarat:** Dangs (3B/C<sub>1b</sub>) (Figure 2.14).

**Global Distribution:** Endemic to India (Assam, Chhattisgarh, Jharkhand and Odisha).



**Figure 2.14:** Distribution of *Geodorum laxiflorum* in Gujarat

**Habenaria Willd.**

- 1. Leaves cordate, appressed to the ground.....**H. grandifloriformis**
- 1. Leaves oblong, linear – lanceolate, not appressed to the ground.....**2**
- 2. Flowers bright yellow coloured.....**H. marginata**
- 2. Flowers other than bright yellow colour.....**3**
- 3. Leaves radical or subradical.....**4**
- 3. Leaves spreading or distributed along the stem.....**H. gibsonii**
- 4. Petals bipartite.....**H. rariflora**

4. Petals entire.....5  
 5. Spur more than 8 cm long.....**H. longicorniculata**  
 5. Spur less than 4 cm long.....6  
 6. Flowers pure white in colour.....**H. plantaginea**  
 6. Flowers greenish yellow in colour.....**H. furcifera**

**Habenaria furcifera** Lindl., Gen. Sp. Orchid Pl. 319. 1835; Hook.f., Fl. Brit. India 6: 149. 1890; Santapau and Kapadia, Orch. Bombay 39. t. 5, f. 20. 1966; Shah, Fl. Gujarat 2: 657. 1978; Raghavan et al. in Bull. Bot. Surv. India 83. 1981; Lakshmi. in Sharma et.al., Fl. Maharashtra 2: 37. 1996. Anonymous 149. 1996; Singh et al., Fl. Madhya Pradesh 3: 44. 2001.

*Terrestrial herbs*, 40.0 – 60.0 cm high. *Tubers* ca. 3.0 × 1.5 cm, 1 – 2, ovate – ellipsoid. *Leaves* 13.0 – 17.0 × 3.0 – 6.0 cm, oblanceolate or obovate, acute, clustered middle of stem. *Inflorescence* 25.0 – 40.0 cm long including scape, lax raceme, erect, many-flowered; *Flowers* ca. 1.0 cm long, green, bracteates, shortly pedicellate. *Bracts* ca. 1.3 × 0.3 cm, ovate – lanceolate, acuminate, slightly concave at base, about as long as the ovary. *Pedicel with Ovary* 1.0 – 1.3 cm long. *Sepals* subequal; *dorsal sepal* ca. 0.5 × 0.3 cm, somewhat falcate and concave at base, acute; *lateral sepals* ca. 0.5 × 0.2 cm, falcate. *Petals* ca. 0.4 × 0.2 cm, broadly oblong, obtuse. *Lip* ca. 0.6 × 0.6 cm, trifurcate right to base; lateral segments filiform, diverging, curved; midlobe linear, equal to or shorter than lateral segment, entire. *Spur* slightly longer than ovary, slender laterally compressed, involute at base. *Column* ca. 0.4 – 0.5 cm long. *Pollinia* two, ovoid with slightly curved slender caudicles. *Capsules* ca. 1.5 × 0.5 cm, fusiform, decurved, with strong ribs (Plate 2.6).

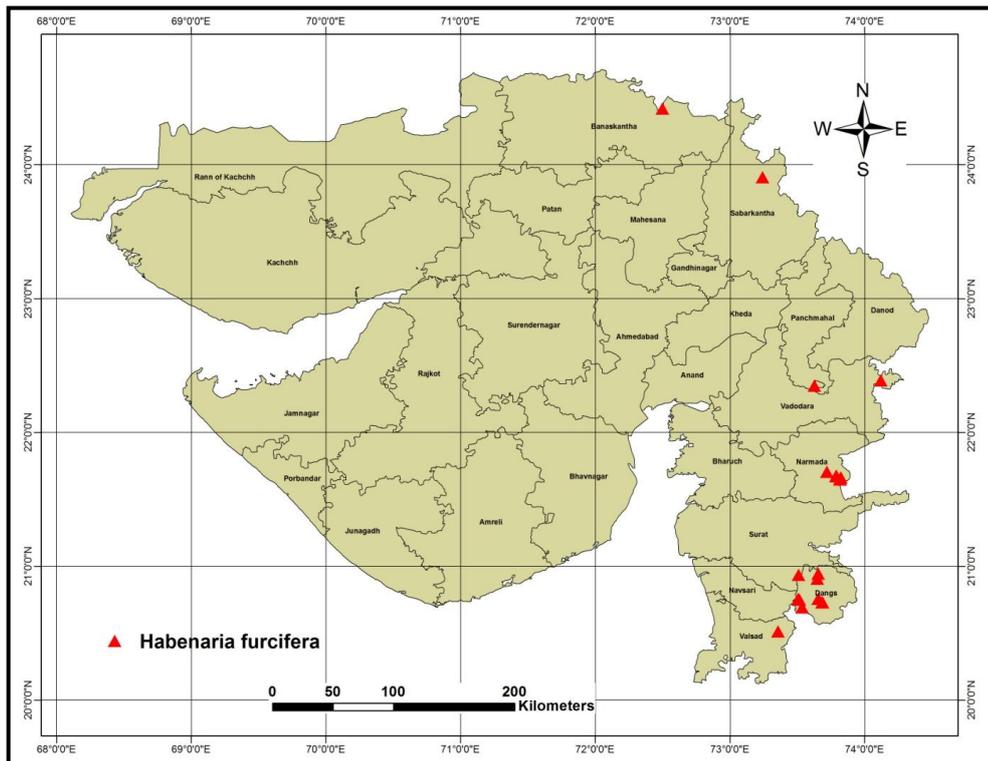
**Flowering & Fruiting:** August – November.

**Habit & Habitat:** Terrestrial herbs, found under the shade of moist and tropical dry deciduous forests up to 369 m a.s.l.

**Specimens Examined:** India, **Gujarat**, Sabarkantha, Vijaynagar, 29<sup>th</sup> August 2014, M. R. Bhatt, 33422 (BSI, Jodhpur!); **Maharashtra**, 25<sup>th</sup> September 1984, P. L. Narsimhan, 107601 (BSI, Pune!).

**Gujarat:** Banaskantha (5A/C<sub>3</sub>), Dahod (5A/C<sub>3</sub>), Dangs (3B/C<sub>1b</sub>, 3B/C<sub>2</sub>, 3B/C<sub>2</sub>S<sub>1</sub>), Narmada (3B/C<sub>2</sub>), Panchmahal (5A/C<sub>3</sub>, 5/2S<sub>1</sub>), Tapi (3B/C<sub>2</sub>, 3B/C<sub>2</sub>S<sub>1</sub>, 5A/C<sub>3</sub>) Sabarkantha (5A/C<sub>3</sub>, 5/2S<sub>1</sub>) and Valsad (3B/C<sub>1b</sub>, 3B/C<sub>2</sub>, 3B/C<sub>2</sub>S<sub>1</sub>) (Figure 2.15).

**Global Distribution:** India (Arunachal Pradesh, Assam, Chhattisgarh, Himachal Pradesh, Jammu & Kashmir, Jharkhand, Karnataka, Kerala, Maharashtra, Manipur, Mizoram, Nagaland, Odisha, Sikkim, Tamil Nadu, Tripura, Uttarakhand and West Bengal), Bhutan, China, Malaysia, Myanmar, Nepal, Pakistan, Sri Lanka and Thailand.



**Figure 2.15:** Distribution of *Habenaria furcifera* in Gujarat

***Habenaria gibsonii*** Hook.f., Fl. Brit. India 6: 135. 1890; *Habenaria gibsonii* var. *foliosa* (A. Rich.) Santapau and Kapadia in J. Bombay nat. Hist. Soc. 56: 194. 1959. Santapau and Kapadia, Orchids Bombay. 12. t. 2, f. 3 – 4. 1966; Lakshmi. in Sharma, et al., Fl. Maharashtra 2: 37. 1966; Raghavan et al. in Bull. Bot. Surv. India 83. 1981.

*Terrestrial herbs*, 25.0 – 45.0 cm high. *Tuber* usually one, somewhat cylindrical, ca. 2.5 cm in diam. *Leaves* 6.5 – 8.0 × 3.0 – 5.0 cm, alternate, ovate – oblong, acute; margins wavy. *Inflorescence* 8.0 – 12.0 cm long, lax, secund or subsecund raceme. *Flowers* 2.5 – 3.0 cm long, white, bracteate, pedicellate, not foul-smelling. *Bracts* 2.5 – 2.7 × 0.9 – 1.0 cm, sheathing, ovate – lanceolate, acute or subacuminate. *Pedicel* with *Ovary* 1.0 – 3.0 cm long. *Sepals* unequal, concave, green; *dorsal sepal* 0.8 – 1.0 × 0.7 – 0.9 cm, ovate –

elliptic, hooded, abruptly acute to sub-acuminate; *lateral sepals* 1.1 – 1.8 × 0.6 – 0.8 cm, ovate – lanceolate, sub-falcate, acute. *Petals* white, bipartite, upper segment ca. 1.1 × 0.1 cm, sickle shaped, acute; lower segment 0.8 – 1.0 cm long, narrower. *Lip* white, 3-partite nearly to base; lateral segments ca. 0.9 – 1.0 cm long, linear, acute to subacuminate, decurved; mid segment 1.3 – 1.5 × 0.1 cm, linear, acuminate, often a little abruptly curved at apex. *Spur* ca. 1.7 cm long, white, slightly longer than or equalling ovary, ending in a clavate, green, obtuse apex. *Column* 0.4 – 0.5 cm. *Pollinia* ca. 0.18 × 0.1 cm with a ca. 0.2 cm long caudicle, yellow. *Capsules* 2.0 – 4.0 cm long, slightly curved, ribbed (Plate 2.7).

**Flowering & Fruiting:** July – September.

**Habit & Habitat:** Terrestrial herbs, found under the shade of moist and tropical dry deciduous forests between 599 m a.s.l.

**Specimens Examined:** India, Gujarat, Valsad, Dharampur, Ambapada, 8<sup>th</sup> August 2014, M. R. Bhatt, 33423 (BSI, Jodhpur!); Maharashtra, Matheran, Raigadh, 25<sup>th</sup> July 1966, B. M. Wadhwa, 58657 (BSI, Pune!); Shivneri hills, 25<sup>th</sup> July 1963, M. Y. Ansari, 92160 (BSI, Pune!); East Godavari Forest, 13<sup>th</sup> August 1979, S. Karthikeyan, 109721 (BSI, Pune!).

**Gujarat:** Dangs (3B/C<sub>1b</sub>), Junagadh (5A/C<sub>3</sub>), Narmada (3B/C<sub>2</sub>), Panchmahal (5A/C<sub>3</sub>) and Valsad (3B/C<sub>2</sub>) (Figure 2.16).

**Global Distribution:** Endemic to Western Ghats of India (Chhattisgarh, Madhya Pradesh, Maharashtra Karnataka and Odisha).

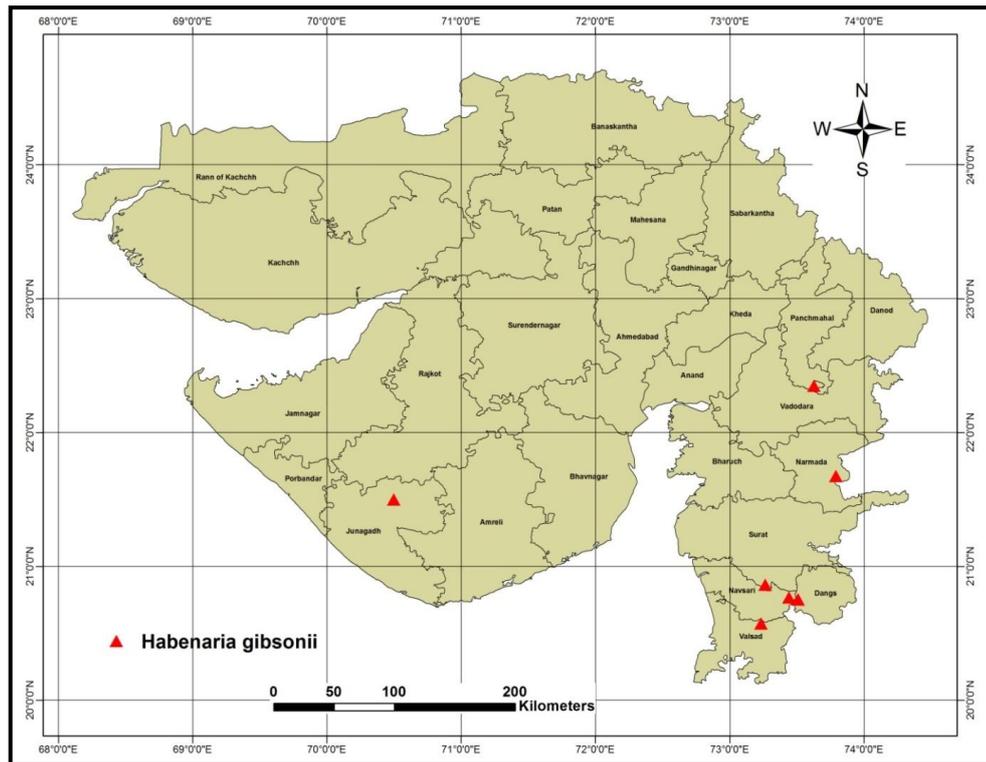


Figure 2.16: Distribution of *Habenaria gibsonii* in Gujarat

***Habenaria grandifloriformis*** Blatt. & McCann in J. Bombay Nat. Hist. Soc. 36: 17. 1932. Santapau and Kapadia, Orchids Bombay 29. t. 1, f. 2 – 2'. 1966; Shah, Fl. Gujarat 2: 657. 1978; Raghavan et al. in Bull. Bot. Surv. India 83. 1981; Lakshmi. in Sharma et al., Fl. Maharashtra 2: 38. 1996; Anonymous 149. 1996; Singh et al., Fl. Madhya Pradesh 3: 45. 2001. *Habenaria grandiflora* Lindl. ex Dalz. and Gibs., Bombay Fl. 267. 1861; Hook.f., Fl. Brit. India 6: 136. 1890; T. Cooke, Fl. Pres. Bombay 3: 221. 1958 (Repr.).

*Terrestrial herbs*, 15.0 – 25.0 cm high. *Tubers* 1.8 – 3.0 × 0.8 – 2.0 cm, 1 or 2, globose or ellipsoid. *Leaves* ca. 7.0 × 4.7 cm, 1 – 2, lying flat on ground, ovate to suborbicular, obtuse, entire, *Inflorescence* 5.0 – 20.0 cm long including scape, lax raceme, erect. *Flowers* 3.5 – 4.5 cm long, at top of scape, white, faintly perfumed, pedicellate, bracteate. *Bracts* ca. 1.5 × 0.7 cm, ovate or oblong – lanceolate, acute, amplexicaul. *Pedicel* with *Ovary* 3.0 – 3.5 cm long. *Sepals* unequal, white, acute or mucronulate; *dorsal sepal* ca. 0.6 × 0.5 cm, broadly ovate, concave; *lateral sepals* ca. 0.9 × 0.4 cm, obliquely ovate, rarely tapering apex, *Petals* bipartite; upper segment ca. 0.6 × 0.6 cm, obliquely ovate – triangular, acute, entire; lower segment ca. 0.5 cm long, filiform or narrowly linear – subulate, acute. *Lip* ca. 1.2 cm long, tri-partite, white; lateral segments 2.0 – 2.4 cm long, narrowly linear or filiform, spreading; midsegment linear, acute or subobtuse. *Spur* ca.

2.0 cm long, curved. *Column* ca. 0.4 cm long, greenish-white. *Pollinia* 2, ovoid, light yellow. *Capsule* 2.0 – 2.8 × ca. 5.0 cm, strongly ribbed (Plate 2.7).

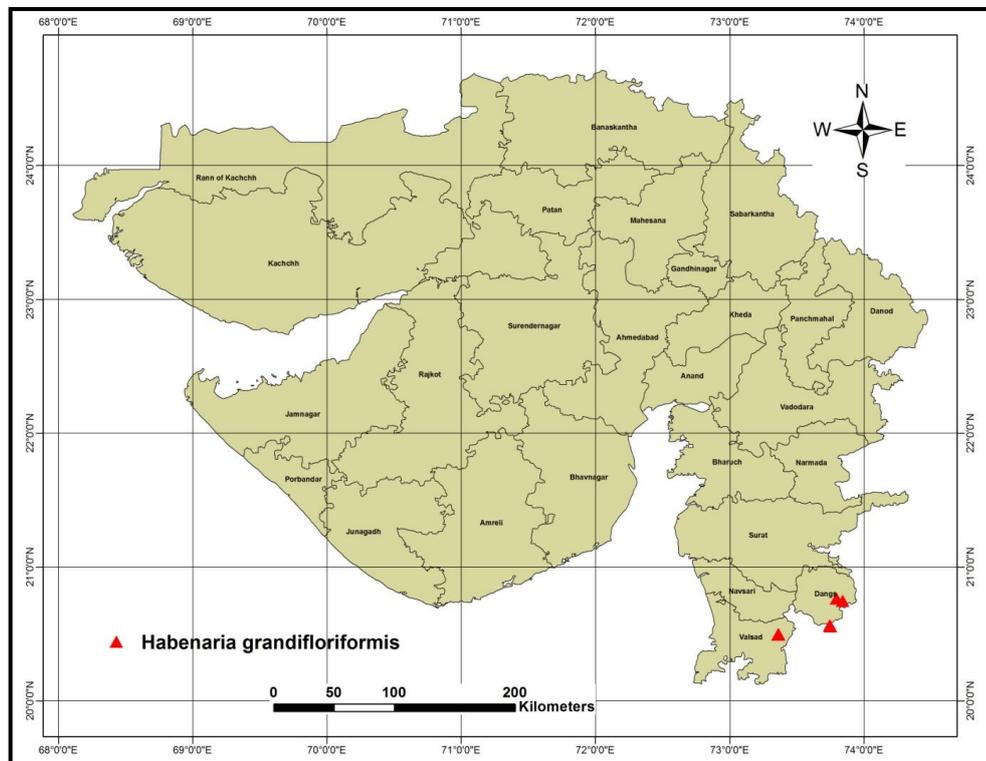
**Flowering & Fruiting:** July – October.

**Habit & Habitat:** Terrestrial herbs, found in moist deciduous forests on rocky plateaus among short grasses up to 1033 m a.s.l.

**Specimens examined:** India, **Gujarat**, Dangs, Saputara, 3<sup>rd</sup> August 2014, M. R. Bhatt, 33421 (BSI, Jodhpur!); **Karnataka**, 28<sup>th</sup> May 1962, R. S. Raghwan, 120110 (BSI, Pune!); **Maharashtra**, Sindhudurg, 24<sup>th</sup> July 2012, J. S. Jalal, 132692 (BSI, Pune!); Sawantwadi, 22<sup>nd</sup> July 2012, J. S. Jalal, 200471 (BSI, Pune!); Trimbhat, Nasik, 25<sup>th</sup> July 1983, P. L. Narsimhan, 163985 (BSI, Pune!).

**Gujarat:** Dangs (3B/C<sub>2</sub>S<sub>1</sub>) and Valsad (3B/C<sub>2</sub>S<sub>1</sub>) (Figure 2.17).

**Global Distribution:** Endemic to India (Assam, Chhattisgarh, Odisha, Gujarat, Maharashtra, Karnataka, Kerala and Tamil Nadu).



**Figure 2.17:** Distribution of *Habenaria grandifloriformis* in Gujarat

**Habenaria longicorniculata** J. Graham, Cat. Pl. Bombay 202. 1839; Santapau and Kapadia, Orchids Bombay 29. t. 1, f. 1 – 1'. 1966; Abraham and Vatsala, Introd. Orchids

238. 1981; Shah, Fl. Gujarat. 2: 658. 1978; Raghavan et al. in Bull. Bot. Surv. India 83. 1981; Lakshmi. in Sharma et al., Fl. Maharashtra St. Monocot 2: 39. 1996; Anonymous 149. 1996; Sharma in J. Bombay Nat. Hist. Soc. 99, 1: 256. 2002. *H. longecalcarata* A.Rich. in Ann. Sci. Nat., Bot, ser. 2, 15: 71, t. 3B. 1841; Hook.f., Fl. Brit. India 6: 141. 1890; T. Cooke, Fl. Pres. Bombay 3: 223. 1958 (Repr.).

*Terrestrial herbs*, 30.0 – 115.0 cm high. *Tubers* 3.0 – 6.0 × 1.0 – 3.0 cm, 1 – 2, unequal, ovate or ellipsoid. *Leaves* 3.0 – 23.0 × 1.5 – 4.0 cm, 3 – 10, clustered near base of stem, oblong – lanceolate, acute, margins paler. *Inflorescence* 50.0 – 100.0 cm long including scape, lax raceme. *Flowers* 4.4 – 5.0 cm long, faintly scented, bracteate, pedicellate. *Bracts* ca. 2.6 × 0.4 cm, oblong – lanceolate, acute. *Pedicel* with *Ovary* up to 4.0 cm long, pale green, ribbed. *Sepals* and *Petals* white, entire. *Sepals* subequal; *dorsal sepal* ca. 1.1 × 0.7 cm, concave, ovate, obtuse; *lateral sepals* 1.0 – 1.4 × 0.4 – 0.7 cm, obliquely ovate, somewhat semi-lunar, obtuse. *Petals* 1.0 – 1.2 × 3.5 – 4.0 cm, subfalcate, spatulate, subobtuse; *Lip* 1.4 – 2.9 cm long, white, with a claw which is 0.2 – 0.3 cm long, tri-lobed; lateral lobes ca. 1.0 × 0.7 cm, turning inwards, oblong, subcuneate, entire, obliquely and serrately cut into a fine point; midlobe ca. 0.9 × 0.3 mm, linear – oblong, shorter than equal to lateral lobes, subobtuse, entire. *Spur* ca. 10.0 cm long, pale green, somewhat thickened below middle. *Column* ca. 0.4 × 0.6 cm, greenish – white. *Pollinia* subfalcate, narrowly pyriform. *Capsule* 2.5 – 3.0 cm long, narrowly fusiform, ribbed (Plate 2.8).

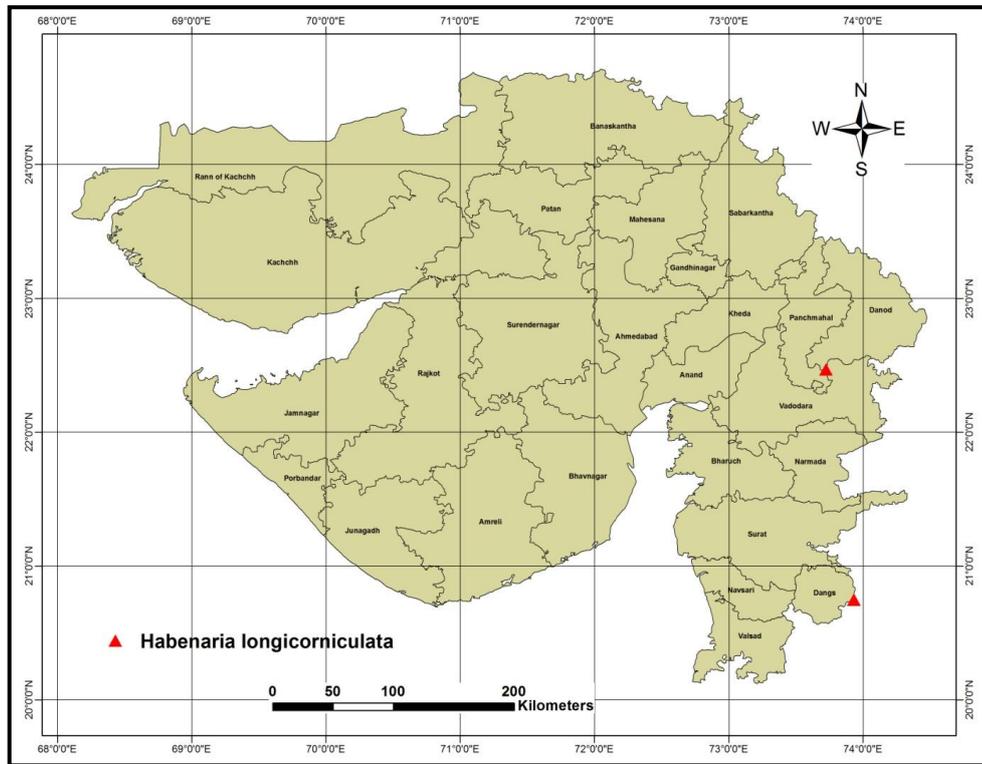
**Flowering & Fruiting:** July – October.

**Habit & Habitat:** Terrestrial herbs, usually found on sloppy grass fields of moist forests up to 790 m a.s.l.

**Specimens examined:** India, **Gujarat**, Dangs, Ahwa, Chinchali, 10<sup>th</sup> September 2017, M. R. Bhatt, 0157 (BSI, Jodhpur!); **Karnataka**, Chikmanglur District, 20<sup>th</sup> October 1979, R. S. Raghavan, 121529 (BSI, Pune!); Shimoga District, Mysore, 25<sup>th</sup> August 1963, R. S. Raghavan, 120132 (BSI, Pune!); **Maharashtra**, Mahabaleshwar, 5<sup>th</sup> October 1957, S. D. Mahajan, 16974 (BSI, Pune!); Matheran, 30<sup>th</sup> August 2012, J. S. Jalal and S. C. Patil, 132636 (BSI, Pune!); Kolhapur, 23<sup>rd</sup> August 2014, J. S. Jalal, 133754 (BSI, Pune!).

**Gujarat:** Dangs (3B/C<sub>2</sub>S<sub>1</sub>), Panchmahal (5A/C<sub>3</sub>) (Figure 2.18).

**Global Distribution:** India (Andhra Pradesh, Goa, Jharkhand, Madhya Pradesh, Maharashtra, Karnataka, Kerala, Odisha, Rajasthan and Tamil Nadu) and Sri Lanka.



**Figure 2.18:** Distribution of *Habenaria longicorniculata* in Gujarat

***Habenaria marginata*** Colebr., Exot. Fl. t. 136. 1824; Hook.f. Brit. India 6: 150. 1890; Cooke, Fl. Pres. Bombay. 3: 226. 1958 (Repr.); Santapau and Kapadia, Orchids Bombay 33. t. 5, f. 17. 1966; Shah, Fl. Gujarat 2: 658. 1978; Raghavan et al. in Bull. Bot. Surv. India 83. 1981; Pandey in Shetty and Singh, Fl. Rajasthan 2: 823. 1991; Lakshmi. in Sharma et al., (ed.) Fl. Maharashtra 2: 40. 1996; Anonymous 149. 1996; Singh et al., Fl. Madhya Pradesh 3: 45. 2001.

*Terrestrial herbs*, 8.0 – 36.0 cm tall. *Tubers* 2.5 – 5.0 × 0.6 – 1.2 cm, 1 – 2, ovoid or ellipsoidal. *Leaves* 3.0 – 9.0 × 1.5 – 3.0 cm, 2 – 5, clustered at base, fleshy, oblong, oblong – elliptic, obtuse, margins typically whitish – yellow. *Inflorescence* 4.0 – 26.0 cm long including scape, laxly or densely many-flowered spike. *Flowers* 1.2 – 1.6 cm long, bracteate, sessile. *Bracts* 1.0 – 2.0 × 0.3 – 0.5 cm, lower ones longer than ovary, upper ones shorter, ovate – lanceolate, acute. *Sepals* unequal, pale green, acute; *dorsal sepal* ca. 0.8 × 0.6 cm; concave, broadly ovate; *lateral sepals* ca. 0.7 × 0.3 cm drooping, obliquely oblong – lanceolate. *Petals* ca. 0.7 × 0.4 cm, yellow with a green tinge on

portions overlapped by dorsal sepal, oblong – lanceolate, falcate from a broad base, acute. *Lip* ca. 1.1 cm long, yellow, fleshy, trifurcate; lateral lobes ca.  $1.1 \times 0.1$  cm, more or less spreading, straight, with inward hook-shaped curve at apex, linear – lanceolate; midlobe 0.6 – 1.0 cm long, clavate towards the rounded apex. *Spur* ca. 1.0 cm long, more or less equalling ovary, yellowish – green, clavate, laterally compressed towards obtuse apex. *Column* ca.  $0.3 \times 0.3$  cm, faintly greenish – white. *Pollinia* deep cadmium yellow, ovoid, with a small curved caudicle and a small oblong gland. *Capsules* ca. 1.2 cm long, fusiform, obscurely beaked, ribbed (Plate 2.8).

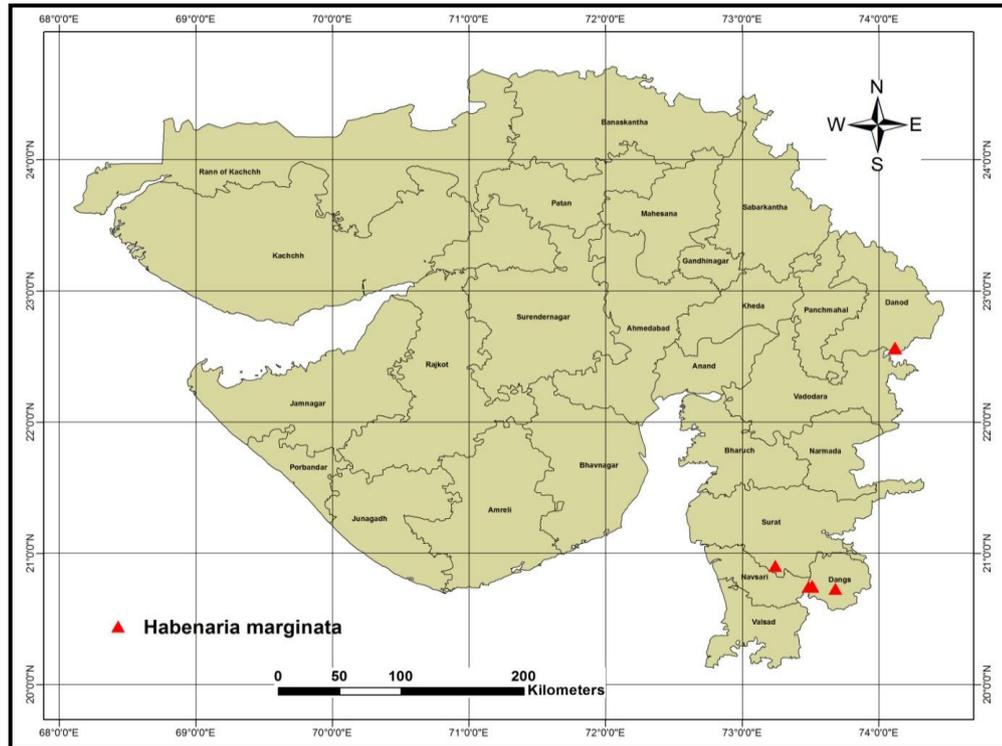
**Flowering & Fruiting:** August – November.

**Habit & Habitat:** Terrestrial herbs, found among short grasses under the shade of moist-deciduous forests up to 499 m a.s.l.

**Specimen examined:** India, **Gujarat**, Dahod, Ratanmahal WLS, 16<sup>th</sup> September 2014, M. R. Bhatt, 33429 (BSI, Jodhpur!); **Karnataka**, Shimoga, Mysore, 20<sup>th</sup> May 1962, R. S. Raghavan, 120109 (BSI, Pune!); **Maharashtra**, Sawantwadi, Ratanagiri, 14<sup>th</sup> October, B. G. Kalkar 100432 (BSI, Pune!); Raigad, 21<sup>st</sup> August 2013, J. S. Jalal, 133663 (BSI, Pune!); Khamapur, 4<sup>th</sup> September 1963, M. Y. Ansari, 102221 (BSI, Pune!).

**Gujarat:** Dahod (5A/C<sub>3</sub>), Dangs (3B/C<sub>2</sub>, 3B/C<sub>2</sub>S<sub>1</sub>), Navsari (3B/C<sub>2</sub>S<sub>1</sub>), Panchmahal (5A/C<sub>3</sub>) and Sabarkantha (5A/C<sub>3</sub>) (Figure 2.19).

**Global Distribution:** India (Andhra Pradesh, Chhattisgarh, Goa, Himachal Pradesh, Jammu & Kashmir, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Meghalaya, Odisha, Punjab, Rajasthan, Tamil Nadu, Uttarakhand and West Bengal), Bangladesh, Bhutan, China, Myanmar Nepal and Thailand.



**Figure 2.19:** Distribution of *Habenaria marginata* in Gujarat

***Habenaria plantaginea*** Lindl., Gen. Sp. Orchid. Pl. 323. 1835; Hook.f., Fl. Brit. India 6: 141. 1890; Cooke, Fl. Pres. Bombay 3: 224. 1958 (Repr.); Santapau and Kapadia, Orchids Bombay 28. t. 6, f. 25. 1966; Abraham and Vatsala, Introd. Orchids 238. 1981; Lakshmi. in Sharma et al., Fl. Maharashtra 2: 42. 1996; Anonymous 149. 1996; Singh et al., Fl. Madhya Pradesh 3; 45. 2001.

*Terrestrial herbs*, 30.0 – 50.0 cm tall. *Tubers* 2 unequal, suborbicular to elliptic. *Leaves* 7.0 – 15.0 × 2.0 – 4.5 cm, 3 – 5, radical or subradical, clustered at base, oblong – lanceolate, acute, entire. *Inflorescence* 15.0 – 35.0 cm long including scape, few to many flowered, secund or subsecund lax racemes. *Flowers* 7.0 – 10.0 cm long, white, shortly pedicellate, bracteate. *Bracts* ca. 1.5 × 0.4 cm, much shorter than ovary, ovate – lanceolate, acute or subacuminate. *Pedicel* with *Ovary* 1.5 – 2.0 cm long. *Sepals* unequal, entire, very minutely denticulate; *dorsal sepal* 0.5 × 0.2 cm, ovate, subacute; *lateral sepals* ca. 0.6 × 0.3 – 0.4 cm, falcately oblong, subacute. *Petals* 0.4 – 0.5 × 1.5 – 2.0 cm, linear or narrowly oblanceolate, subspathulate, acute, minutely and irregularly denticulate. *Lip* 0.7 – 1.2 × 0.7 – 0.9 cm, white, ovate – oblong in outline, narrowly clawed at base, tri-lobed; lateral lobes 0.5 – 0.7 × 0.3 – 0.4 cm, obliquely ovate, entire, subcuneate, acute; midlobe 0.4 – 0.6 × 0.1 – 0.2 cm, linear – oblong, subacute. *Spur* 2.0 – 3.0 cm long, curved, slender, pendulous, longer than ovary, somewhat clavate, acute.

*Column* ca. 0.25 × 0.2 cm, small, green, oblong, *Pollinia* pale yellow, pyriform, about as long as or slightly shorter than comparatively broad caudicle. *Capsules* 1.5 × 0.3 – 0.4 cm, curved, strongly ribbed, beaked. (Plate 2.9).

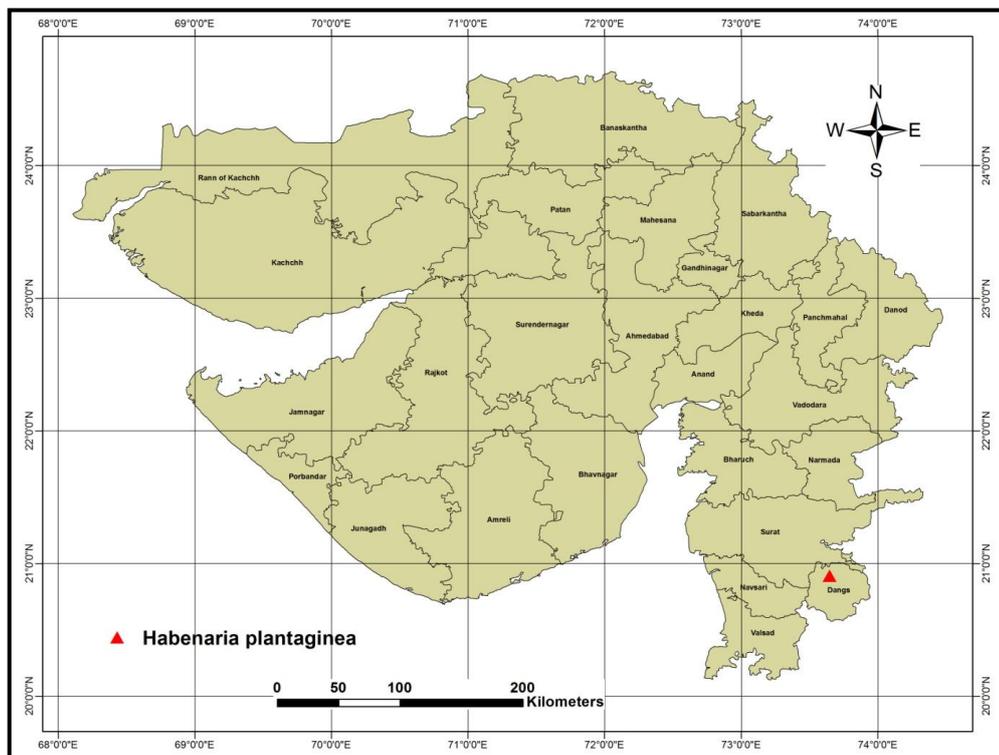
**Flowering & Fruiting:** September – November.

**Habit & Habitat:** Terrestrial herbs, found on sloping ground in moist deciduous forests up to 243 m a.s.l.

**Specimens Examined:** India, **Gujarat**, Dangs, Mahal, Purna WLS, 29<sup>th</sup> October 2014, M. R. Bhatt, 33428 (BSI, Jodhpur!); **Goa**, 6<sup>th</sup> October 1970, N. P. Singh, 81497 (BSI, Pune!); 13<sup>th</sup> October 1964, R. S. Raghavan, 49036 (BSI, Pune!); **Maharashtra**, Ratnagiri, 24<sup>th</sup> August 2013, J. S. Jalal, 133415 (BSI, Pune!).

**Gujarat:** Dangs (3B/C<sub>2</sub>S<sub>1</sub>) (Figure 2.20).

**Global Distribution:** India (Arunachal Pradesh, Assam, Bihar, Chhattisgarh, Haryana, Himachal Pradesh, Jammu and Kashmir, Jharkhand, Madhya Pradesh, Maharashtra, Meghalaya, Karnataka, Kerala, Odisha, Punjab, Rajasthan, Sikkim, Tamil Nadu, Uttarakhand, Uttar Pradesh and West Bengal), Nepal, Sri Lanka and Thailand.



**Figure 2.20:** Distribution of *Habenaria plantaginea* in Gujarat

**Habenaria rariflora** A. Rich. in Ann. Sci. Nat., Bot, ser. 2, 15: 70, t. 2D. 1841; Hook.f., Fl. Brit. India 6: 136. 1890; T. Cooke, Fl. Pres. Bombay 3: 221. 1958 (Repr.); Santapau and Kapadia, Orchids Bombay 15. t. 3, f. 9 – 10. 1966; Abraham and Vatsala, Introd. Orchids 216. 1981; Lakshmi. in Sharma, et al., Fl. Maharashtra 2: 43. 1996

*Terrestrial or Lithophytic herbs*, 13.0 – 15.0 cm high. *Tubers* 1 – 2, small, ovoid or oblong. *Leaves* 3 – 5 × 1.1 – 1.8 cm, radical, clustered at base, oblong – lanceolate, or broadly oblong, or ovate – elliptic, or even ovate. *Inflorescence* 10 – 12 cm long, 1 – 4 flowered terminal racemes. *Flowers* 2.0 – 2.5 cm long, white, pedicellate, bracteate. *Bracts* 1.9 – 2.2 × 0.7 – 0.8 cm, ovate – lanceolate, acute. *Pedicel* with *Ovary* 4.0 cm long. *Sepals* subequal, subacute; *dorsal sepal* 1.0 × 0.6 – 7cm, broadly ovate; *lateral sepals* 1.1 × 0.6 cm, obliquely ovate, spreading, apical portions slightly decurved. *Petals* 2-partite; upper segment 0.8 – 1.0 × 0.4 – 0.6 cm, obliquely triangular – ovate; lower segment 1.0 – 1.3 cm long, filiform, acute. *Lip* 1.5 cm long, tripartite from a little below middle; lateral segments scarcely 0.8 – 1.0 cm long, filiform or narrowly linear – subulate; midsegment 0.8 – 0.9 × 0.2 cm, linear, subobtuse. *Spur* 4.5 – 4.6 cm long, curved, white. *Column* 0.5 × 0.3 cm, oblong, rounded, greenish-white. *Pollinia* yellow, ovoid – oblong, caudicle slender. *Capsules* 2.0 – 3.0 cm long, strongly ribbed, beaked (Plate 2.9).

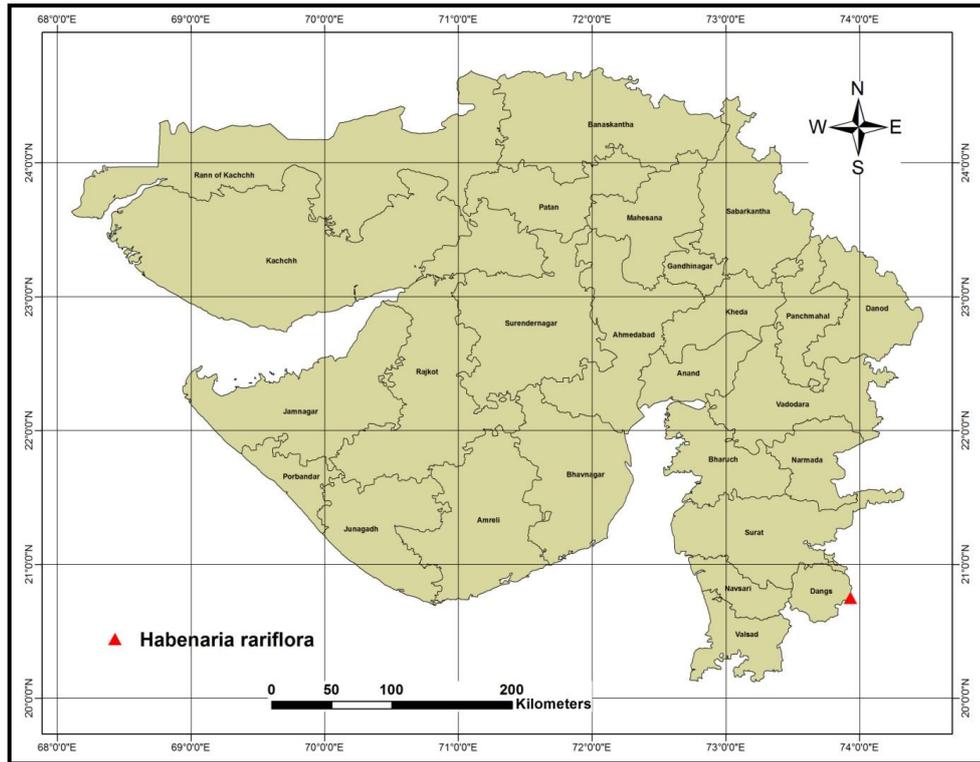
**Flowering & Fruiting:** August – October.

**Habit & Habitat:** Terrestrial or Lithophytic herbs, found on vertical rocks and old walls up to 1000 m a.s.l.

**Specimen Examined:** India, **Gujarat**, Ahwa, Chinchali, 10<sup>th</sup> September 2017, M. R. Bhatt, 0208 (BSI, Jodhpur!).

**Gujarat:** Dangs (3B/C<sub>2</sub>S<sub>1</sub>) (Figure 2.21).

**Global Distribution:** Endemic to Western Ghats of India (Andhra Pradesh, Goa, Maharashtra, Karnataka, Kerala and Tamil Nadu).



**Figure 2.21:** Distribution of *Habenaria rariflora* in Gujarat

**Nervilia** Commers. ex. Gaud. (*nom. cons.*)

- 1. Leaves spread on the ground; scape 2 – 3 flowered.....**N. plicata**
- 1. Leaf raised much above the ground; scape many flowered.....**N. concolor**

**Nervilia concolor** (Blume) Schltr. in Bot. Jahrb. Syst. 45: 404. 1911. *N. aragoana* Gaudich., Voy. Uranie 422, t. 35. 1829; Santapau and Kapadia, Orchids Bombay 134. 1966; Abraham and Vatsala, Introd. Orchids 430, t. 125. 1981; Shah, Fl. Gujarat 2: 659. 1978; Raghavan et al. in Bull. Bot. Surv. India 83. 1981; Bole and Pathak, Fl. Saurashtra 2: 306. 1988; Lakshmi. in Sharma et al., Fl. Maharashtra 2: 48. 1996; Anonymous 149. 1996; Singh et al., Fl. Madhya Pradesh 3: 54. 2001. *Pogonia flabelliformis* Lindl., Gen. Sp. Orchid. Pl. 415. 1840; Hook.f., Fl. Brit. India 6: 121. 1890. *P. carniata* (Roxb.) Lindl. Gen. Sp. Orchid. Pl. 414 1840; T. Cooke, Fl. Pres. Bombay 3: 211. 1958 (Repr.).

*Terrestrial herbs*, up to 30.0 cm high. *Tuber* 1.5 – 2.0 cm in diam., subglobose, white. *Leaf* 9.0 – 12.0 × 8.0 – 11.0 cm, cordate, broadly ovate to almost orbicular, acuminate or apiculate, glabrous, petiolate. *Petiole* 8.0 – 20.0 cm long; generally 2 stolons arise on opposite sides of petiole just above tuber. *Inflorescence* 10.0 – 25.0 cm tall including scape, lax raceme. *Flowers* about 3.0 – 4.0 cm long, drooping, green, bracteate,

pedicellate. *Bracts* ca.  $1.4 \times 0.2$  cm, decurved, linear – lanceolate, subacuminate, glabrous, light green, faintly tinged with purple. *Pedicel* with *Ovary* 0.7 – 8.5 cm long, angularly ridged. *Sepals*  $1.7 - 2.5 \times 0.2 - 0.4$  cm, subequal, oblanceolate, acute or subacute, entire. *Petals*  $1.4 - 2.5 \times 0.2 - 0.5$  cm, similar to sepals, often narrower at base. *Lip* 1.7 – 2.4 cm long, subclawed at base, obovate in outline, 3 – 10 lobed; lateral lobes  $1.0 - 1.4 \times 0.1 - 0.3$  cm, narrowly oblong, acute or obtuse, pale green; midlobe  $0.4 - 0.6 \times 0.5 - 0.7$  cm, obtuse or subacute, irregularly crenulate, crimped with incurved edges, pale yellowish – green; 3 central nerves yellowish – green, minutely hairy. *Spur* minute, sac like. *Column* pale green, 0.7 – 1.0 cm long, dilated above. *Pollinia* two, oblong, pale yellow. *Capsules* spindle shaped,  $1.2 - 1.5 \times 0.5 - 0.6$  cm, ribbed (Plate 2.10).

**Leaves:** July – September.

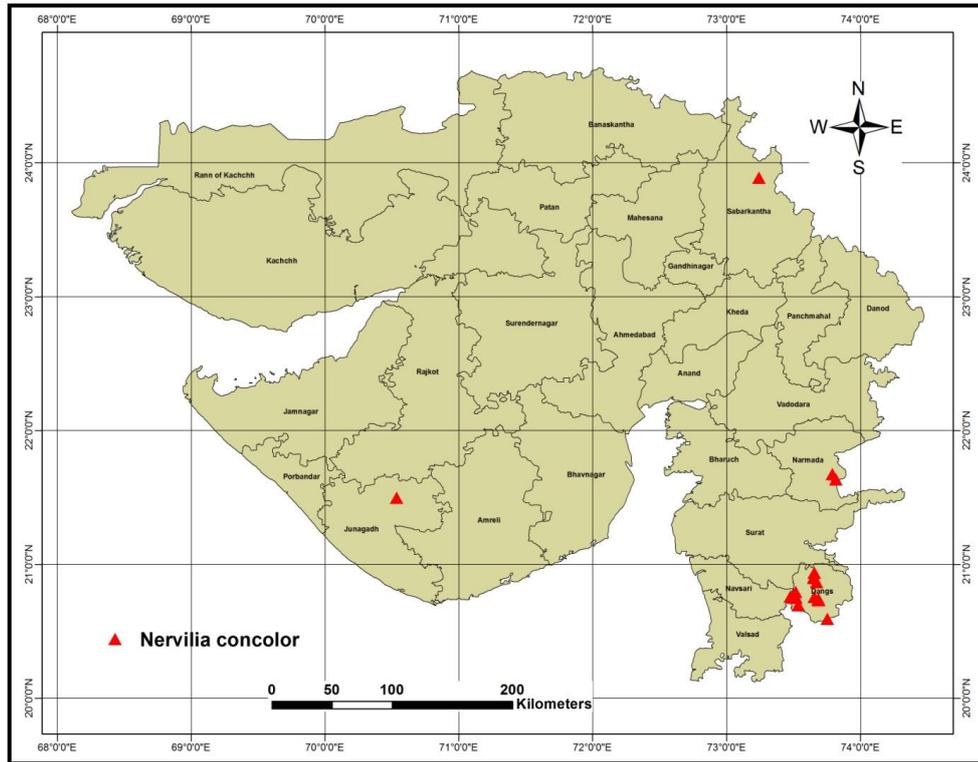
**Flowering & Fruiting:** June – September.

**Habit & Habitat:** Terrestrial herbs, found in groups under the shade of moist and dry deciduous forests up to 1207 m a.s.l.

**Specimens examined:** India, **Gujarat**, Dangs, Ahwa, Devinamal, 2<sup>nd</sup> August 2014, M. R. Bhatt, 33427 (BSI, Jodhpur!); **Goa**, Sukar Village Forest, 5<sup>th</sup> September 1963, K. C. Kanodia, 879211 (BSI, Pune!); **Maharashtra**, RadhaNagari WLS, Kolhapur, 27<sup>th</sup> July 2012, J. S. Jalal, 132767 (BSI Pune!); Sawantwadi, 25<sup>th</sup> July 2012, J. S. Jalal, 133515 (BSI, Pune!).

**Gujarat:** Dangs (3B/C<sub>1b</sub>, 3B/C<sub>2</sub> and 3B/C<sub>2S1</sub>), Junagadh (5A/C<sub>3</sub>), Narmada (3B/C<sub>1b</sub>) and Sabarkantha (5A/C<sub>3</sub>) (Figure 2.22).

**Global Distribution:** India (Andaman and Nicobar Islands, Andhra Pradesh, Assam, Goa, Himachal Pradesh, Jharkhand, Karnataka, Kerala, Maharashtra, Manipur, Odisha, Sikkim, Meghalaya, Nagaland, Rajasthan, Tamil Nadu, Uttarakhand and West Bengal), Australia, Bangladesh, Bhutan, Borneo, China, Japan, Java, Laos, Myanmar, Nepal, NewGuinea, Pacific islands, Philippines, Sumatra, Taiwan, Thailand and Vietnam.



**Figure 2.22:** Distribution of *Nervilia concolor* in Gujarat

*Nervilia plicata* (Andrews) Schltr. in Bot. Jahrb. Syst. 45: 403. 1911; Santapau and Kapadia, Orchids Bombay 137. 1966; Pandey in Shetty and Singh, Fl. Rajasthan 2: 821. 1991; Lakshmi. in Sharma et al., Fl. Maharashtra 2: 50. 1996; Anonymous 149. 1996; Singh et al., Fl. Madhya Pradesh 3: 54. 2001. *N. discolor* (Blume) Schltr. in Bot. Jahrb. Syst. 45: 403. 1911; Shah, Fl. Gujarat 65, 1978; Raghavan et al. in Bull. Bot. Surv. India 84. 1981. *Pogonia plicata* (Andr.) Lindl. Gen. Sp. Orchid. Pl. 415. 1840; Hook.f., Fl. Brit. India 6: 119. 1890; T. Cooke, Fl. Pres. Bombay 3: 211. 1958 (Repr.).

*Terrestrial herbs*, 7.0 – 25.0 cm high. *Tubers* 1.0 – 2.2 cm in diam., globose – oval. *Leaf* 4.0 – 16.0 × 5.0 – 16.0 cm, flat on ground, ovate – cordate, rounded, acute or subacuminate, plicate, petiolate; margins with stiff hairs; upper surface pale green to dark green – purple, hairy all over; lower surface pale green to light mauve-purple with smaller and fewer hairs; petiole 3.0 – 4.0 cm long, arising from one end of tuber and giving rise 2 stolons just below leaf. *Inflorescence* 4.5 – 17.0 cm long including scape, brownish mauve, longitudinally striated. *Flowers* 2.0 – 2.5 cm long, 2 at apex of scape, bracteate, pedicellate. *Bracts* 0.3 – 0.8 × 0.1 – 0.4 cm, ovate – lanceolate, acute, entire or very slightly toothed at apex, glabrous. *Pedicel* with *Ovary* 3.0 – 4.0 cm long, faintly ribbed. *Sepals* and *Petals* spreading, brown – mauve, oblong – lanceolate, acute, entire, glabrous.

*Dorsal sepal* 1.6 – 2.6 × 0.3 – 0.5 cm; *lateral sepals* 1.5 – 2.6 × 0.3 – 0.5 cm. *Petals* 2.3 – 2.4 × 0.3 – 0.4 cm. *Lip* 1.8 – 2.0 × 1.1 cm, obovate – oblong, rose-mauve with deeper lateral veins, midnerve on midlobe much paler or white, shallowly 3 – 10 lobed, lateral lobes very small, entire, obtuse, purple-veined; midlobe oblong – ovate, obtuse, narrowly emarginate, faintly crisped and crenulate. *Spur* small sac like. *Column* 1.0 – 1.2 × 0.4 – 0.5 cm, erect, pale rose-pink. *Pollinia* two, oval, pale yellow. *Capsules* 10 – 16 × 6 – 8 mm, fusiform, ribbed (Plate 2.10).

**Leaves:** June – November.

**Flowering & Fruiting:** June – August.

**Habit & Habitat:** Terrestrial herbs, found in large population under the shade of moist deciduous forests up to 120 – 311 m a.s.l.

**Specimens examined:** India, **Gujarat**, Dangs, Waghai, 1<sup>st</sup> August 2014, M. R. Bhatt, 33455 (BSI, Jodhpur!); **Maharashtra**, Ahmednagar Road, Thane, 16<sup>th</sup> August 2013, J. S. Jalal and S. C. Patil, 66938 (BSI, Pune!); Kiratmal, Nasik, 18<sup>th</sup> July 1967, S. Moorthy, 133521 (BSI, Pune!).

**Gujarat:** Dangs (3B/C<sub>1b</sub>, 3B/C<sub>2</sub> and 3B/C<sub>2</sub>S<sub>1</sub>), Narmada (3B/C<sub>2</sub>), Tapi (3B/C<sub>2</sub> and 3B/C<sub>2</sub>S<sub>1</sub>) and Valsad (3B/C<sub>2</sub>S<sub>1</sub>) (Figure 2.23).

**Global Distribution:** India (Andaman and Nicobar Islands, Arunachal Pradesh, Assam, Himachal Pradesh, Jammu & Kashmir, Karnataka, Kerala, Maharashtra, Manipur, Meghalaya, Mizoram, Odisha, Sikkim, Tamil Nadu, Uttarakhand and West Bengal), Australia, Bangladesh, Bhutan, China, Java, Laos, Malaya, Myanmar, Nepal, New Guinea, Philippines, Sumatra, Taiwan, Thailand and Vietnam.

**Note:** Commonly known as Dukkarkand in the South Gujarat and tubers are used to promote lactation in women.

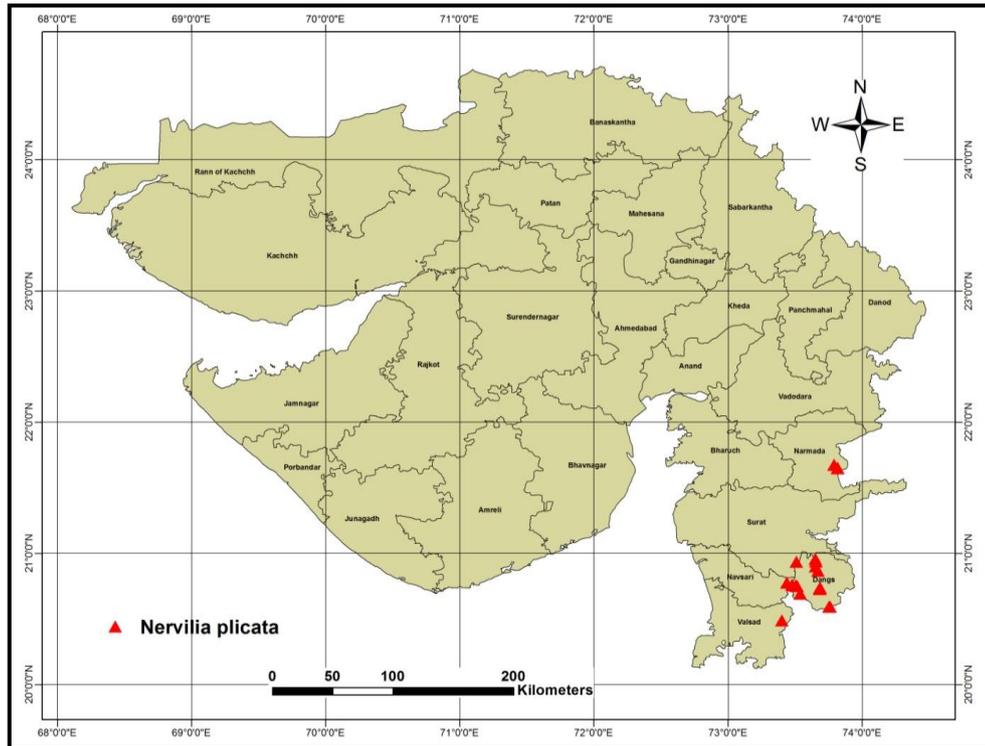


Figure 2.23: Distribution of *Nervilia plicata* in Gujarat

**Oberonia Lindl.**

- 1. Petals and lobes of lip more or less entire .....**O. falconeri**
- 1. Petals and lobes of lip deeply toothed.....**O. mucronata**

**Oberonia falconeri** Hook.f., Hooker's Icon. Pl. 18: t. 1780. 1888; Hook.f., Fl. Brit. India. 5: 678. 1890; T. Cooke, Fl. Pres. Bombay 3: 178. 1958 (Repr.); Santapau and Kapadia, Orchids Bombay 65. t. 11, A-B. 1966; Shah, Fl. Gujarat 2: 660. 1978; Raghavan et al. in Bull. Bot. Surv. India 84. 1981; Lakshmi. in Sharma et al., Fl. Maharashtra 2: 13. 1996; Anonymous 149. 1996; Singh et al., Fl. Madhya Pradesh 3: 57. 2001.

*Epiphytic herbs*, 5.0 – 12.0 cm long. *Leaves* 2.5 – 7.0 × 0.5 – 1.5 cm, 5 – 8 per plant, coriaceous, oblong – lanceolate, subfalcate, acute or subacuminate. *Inflorescence* 5.0 – 12.0 cm long including peduncle, peduncle adnate to uppermost leaf covered by hyaline, irregularly serrulate bracts; raceme erect or curved, laxly many-flowered. *Flowers* ca. 0.2 cm across, spiral to subverticillate, greenish yellow, bracteate, shortly pedicellate. *Bracts* 0.2 – 0.3 × 0.1 cm, hyaline, sheathing, oblong – lanceolate, subulate, irregularly denticulate. *Pedicel* with *Ovary* 0.2 – 0.3 cm long, ridged. *Sepals* ca. 0.2 × 0.1 cm, subequal, yellow, obtuse, entire; *lateral sepals* broadly ovate; *dorsal sepal* oblong – ovate, slightly narrower than lateral ones. *Petals* ca. 0.1 × 0.05 cm, yellow, oblong –

ovate, subfalcate, obtuse, entire, glabrous. *Lip* ca. 0.2 × 0.15 cm, greenish – yellow, spreading, slightly concave, subquadrate, obovate – oblong, tri-lobed; lateral lobes small, shoulder like, rounded; midlobe 0.1 – 0.2 cm long, oblong, faintly wavy on margins, two-lobulate. *Column* yellow, minute, ca. 0.1 cm long, subglobose. *Pollinia* oblong – obovoid. *Capsules* ca. 0.4 × 0.2 cm, obovoid, strongly ribbed, shortly stalked (Plate 2.11).

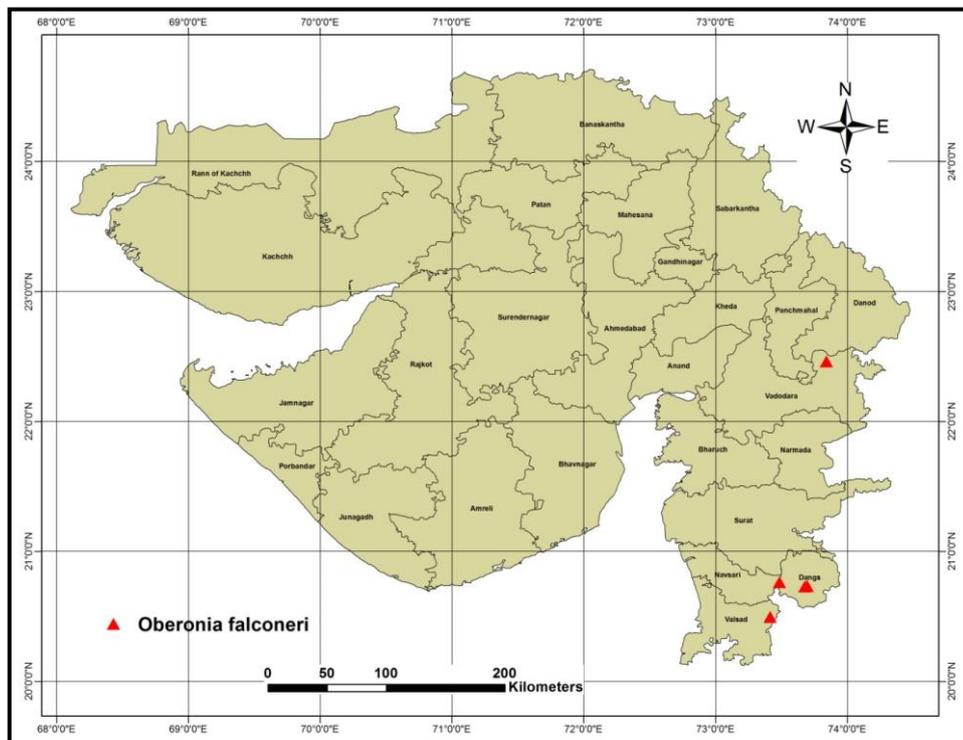
**Flowering & Fruiting:** September – December.

**Habit & Habitat:** Epiphytic herbs, found in the moist deciduous forests up to 350 m a.s.l. The frequent host species observed are *Madhuca indica* J.F.Gmel, *Mitragyna parvifolia* (Roxb.) Korth., *Tectona grandis* L.f., *Terminalia crenulata* Roth, *Wrightia tinctoria* R.Br.

**Specimens examined:** India, **Gujarat**, Dangs, Waghai, 8<sup>th</sup> October 2014, M. R. Bhatt, 33431 (BSI, Jodhpur!); **Maharashtra**, 13<sup>th</sup> April 1968. Kur.lore, 75936 (BSI, Pune!).

**Gujarat:** Dangs (3B/C<sub>1b</sub>, 3B/C<sub>2</sub>), Valsad (3B/C<sub>2</sub>S<sub>1</sub>) (Figure 2.24).

**Global Distribution:** India (Andhra Pradesh, Arunachal Pradesh, Gujarat, Jharkhand, Karnataka, Madhya Pradesh, Maharashtra, Meghalaya, Odisha, Uttarakhand and Sikkim), Bhutan, Laos, Malaysia, Nepal, Thailand and Vietnam.



**Figure 2.24:** Distribution of *Oberonia falconeri* in Gujarat

**Oberonia mucronata** (D.Don) Ormerod & Seidenf., G. Seidenf., Contr. Orchid Fl. Thailand 13: 20. 1997; Bhatt and Nagar in J. Thret. Taxa 8: 8413. 2016. *O. iridifolia* var. *brevifolia* Hook.f., Fl. Brit. India 5: 676. 1890. *O. iridifolia* var. *denticulata* (Wight) Hook. f., Fl. Brit. India 5: 676. 1890; Santapau and Kapadia, Orchids Bombay 58. 1966; Abraham and Vatsala, Introd. Orchids 416. t.117. 1981; Lakshmi. in Sharma et al., Fl. Maharashtra 13. 1996.

*Epiphytic herbs*, about 30.0 cm high. *Leaves* 5 – 7, unequal, distichous, 7.0 – 9.5 × 1.5 – 1.7 cm laterally compressed, fleshy, coriaceous, pale green, laterally compressed, ensiform, oblong – lanceolate, acute. *Scape* 3.0 – 4.0 × 0.3 cm, flattened, two angled, adnate to upper most leaf in young plants. *Inflorescence* ca. 16.0 – 19.0 cm long including peduncle, peduncle flattened, two angled, adnate to upper most leaf in young plants; decurved, densely flowered raceme. *Flowers* ca. 0.2 cm long, pedicellate, bracteate, golden yellow. *Bracts* ca. 0.13 × 0.1 cm, equalling the size of ovary, ovate – oblong, acute or obtuse, irregularly denticulate along margin. *Pedicel* with *Ovary* 0.1 – 0.2 cm long. *Sepals* and *Petals* reflexed and resting on ovary. *Sepals* 0.1 – 0.12 × 0.1 cm, subequal, ovate, acute – mucronate, entire; *Petals* ca. 0.1 × 0.05 cm, ovate – oblong, obtuse with irregularly erose margin, one-nerved. *Lip* ca. 0.5 × 0.5 cm, gland-dotted, quadrate, tri-lobed, lateral lobes oblong, deeply dentate, spreading in flower except for incurved distal end; midlobe two-lobuled, lobules triangular, acute, deeply dentate. *Column* extremely minute, subglobose. *Pollinia* yellow, obovoid. *Capsules* ca. 0.3 × 0.1 cm, ellipsoid with short pedicel (Plate 2.11).

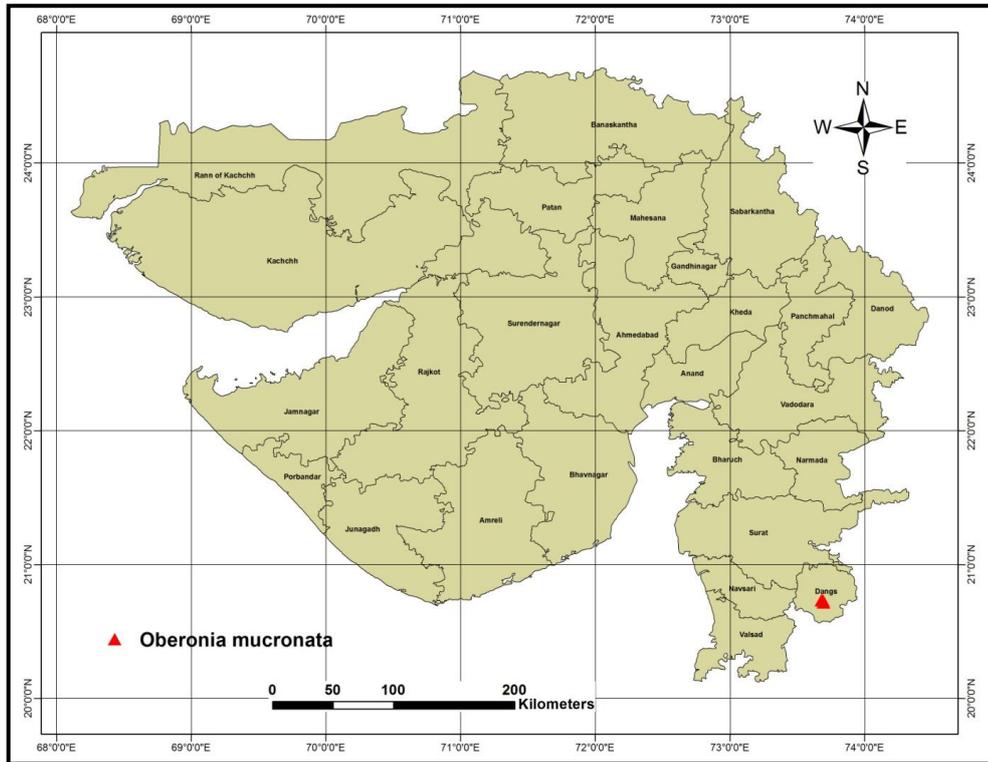
**Flowering & Fruiting:** August – January.

**Habit & Habitat:** Epiphytic herbs, found in the moist deciduous forests up to 700 m a.s.l. The common hosts are *Tectona grandis* L.f., *Terminalia crenulata* Roth, *Wrightia tinctoria* R.Br.

**Specimens examined:** India, **Gujarat**, Dangs, Ahwa, Devinamal, 28<sup>th</sup> October 2014, M. R. Bhatt, 0094 (BSI, Jodhpur!); **Kerala**, 10<sup>th</sup> February 1961, K. M. Subramaniam, 34506 (BSI, Pune!); 16<sup>th</sup> May 1959, M. Y. Ansari, 95870 (BSI Pune!).

**Gujarat:** Dangs (3B/C<sub>1b</sub>) (Figure 2.25).

**Global Distribution:** India (Andaman and Nicobar Islands, Andhra Pradesh, Arunachal Pradesh, Assam, Chhattisgarh, Goa, Karnataka, Kerala, Maharashtra, Manipur, Meghalaya, Mizoram, Nagaland, Odisha, Sikkim, Tamil Nadu and West Bengal), Bhutan, Bangladesh, China, Indonesia, Laos, Malaysia, Myanmar, Nepal, Philippines, Thailand and Vietnam.



**Figure 2.25:** Distribution of *Oberonia mucronata* in Gujarat

**Peristylus Bl. (*nom. cons.*)**

- 1. Spur as long as or longer than sepals, linear, subclavate.....**P. stocksii**
- 1. Spur much shorter than sepals, saccate or globose.....**2**
- 2. Lip shorter than sepals, entire or obscurely tri-lobed.....**P. plantagineus**
- 2. Lip as long as sepals; distinctly tri-fid.....**3**
- 3. Lip tri-fid to middle, spike dense flowered.....**P. constrictus**
- 3. Lip tri-lobed for about one-fourth of length, spike dense or lax flowered.....**P. lawii**

**Peristylus constrictus** (Lindl.) Lindl., Gen. Sp. Orchid. Pl. 300. 1835.

*Habenaria constricta* (Lindl.) Hook.f., Fl. Brit. India 6: 161. 1890.

*Orchis leucantha* Ham. ex Hook.f., Fl. Brit. India 6: 161. 1890; Bhatt et al. in Ind. For. 143, 11: 1140.

*Terrestrial herbs*, 40.0 – 60.0 cm tall. Tubers 4.0 – 5.0 cm long, 1 – 3, ovoid or broadly ellipsoid. *Leaves* 7.0 – 13.5 × 5.0 – 8.5 cm, 4 – 6, clustered at middle of stem, sheathed, fleshy, ovate – elliptic, acute – acuminate. *Inflorescence* up to 25.0 cm long including scape, erect, densely flowered spike. *Flowers* 1.5 – 2.0 cm long, white, sweet scented, spreading, bracteate, sessile. *Bracts* lanceolate, acuminate, sheathing, longer than ovary, concave. *Sepals* subequal, green; *dorsal sepal* 0.7 – 0.8 × 1.0 – 1.1 cm, hooded, concave, ovate, acute, margin on distal half incurved; *lateral sepal* 0.7 – 1.0 × 0.3 cm, spreading, margins involute, linear – oblong, obtuse. *Petals* ca. 11.5 – 14 × 4.5 – 5 cm, larger than sepals, spreading upward, ovate – lanceolate, *Lip* 1.4 – 1.6 cm, white, deeply tri-furcate from about middle, lateral lobes ca. 7.5 × 1.8 cm, linear – lanceolate, acute; midlobe shorter and broader, subacute. *Spur* short, scrotiform, green. *Column* ca. 0.2 cm long, short and globular. *Pollinia* ca. 2.0 cm, pale yellow. *Capsule* 1.2 – 1.4 cm long, ribbed (Plate 2.12).

**Flowering & Fruiting:** July – September.

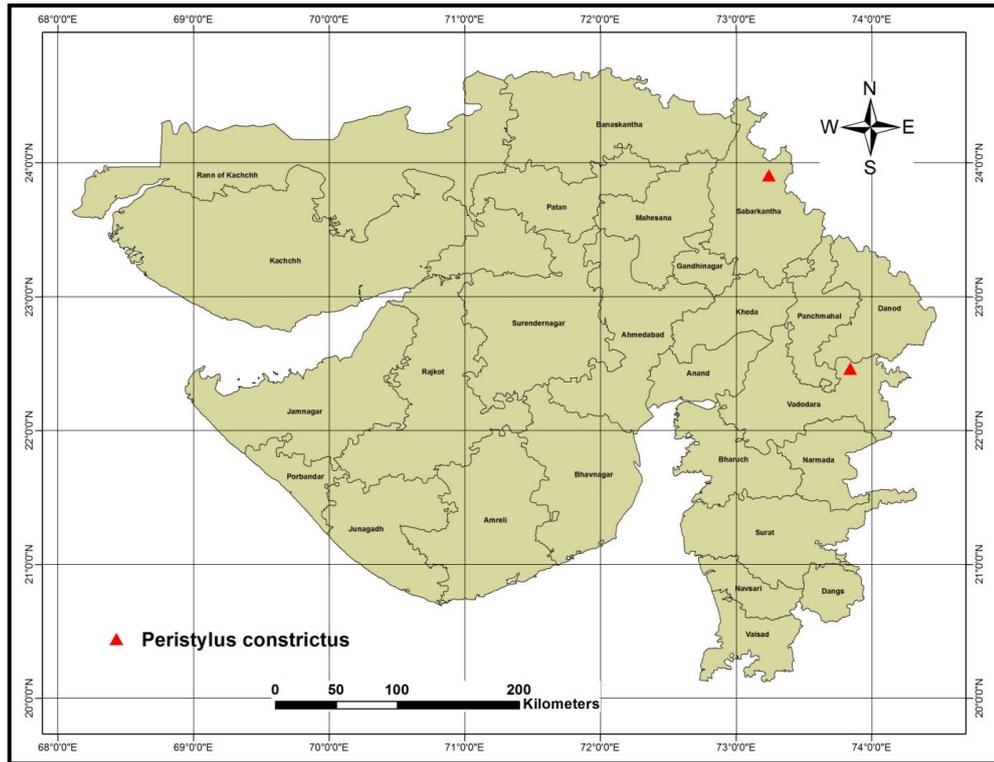
**Habit & Habitat:** Terrestrial herbs, found in the undergrowth of dry deciduous forests up to 397 m a.s.l.

**Specimen examined:** India, **Gujarat**, Chhota Udepur, Sukhi Dam, 27<sup>th</sup> July 2014, M. R. Bhatt, 33416 (BSI Jodhpur!).

**Gujarat:** Sabarkantha (5A/C<sub>3</sub>) and Chhota Udepur (5A/C<sub>3</sub>) (Figure 2.26).

**Global distribution:** India (Arunachal Pradesh, Assam, Bihar, Chhattisgarh, Himachal Pradesh, Jammu and Kashmir, Jharkhand, Madhya Pradesh, Maharashtra, Meghalaya, Nagaland, Odisha, Punjab, Sikkim, Uttarakhand, Uttar Pradesh and West Bengal), Bangladesh, Cambodia, China, Myanmar, Nepal, Philippines, Thailand and Vietnam.

**Notes:** One variant of *Peristylus constrictus* was located from Sabarkantha in which inflorescence is lax raceme, flower small and lip is tri-fid. Leaf shape is lanceolate (Plate 2.12).



**Figure 2.26:** Distribution of *Peristylus constrictus* in Gujarat

**Peristylus lawii** Wight., Icon. Pl. Ind. Orient. 5: t. 1695. 1851; T. Cooke, Fl. Pres. Bombay 3: 216. 1958 (Repr.); Santapau and Kapadia, Orchids Bombay 53. t. 10, C-D. 1966; Abraham and Vatsala, Introd. Orchids 249. t. 41. 1981; Shah, Fl. Gujarat 2: 661. 1978; Raghavan et al. in Bull. Bot. Surv. India 84. 1981; Lakshmi. in Sharma et al., Fl. Maharashtra 2: 56. 1996; Anonymous 149. 1996; Singh et al., Fl. Madhya Pradesh 3: 62. 2001. *Habenaria lawii* (Wight) Hook.f., Fl. Brit. India 6: 162. 1890.

*Terrestrial herbs*, 15.0 – 30.0 cm high. *Tubers* 1.1 – 2.5 × 4.0 – 1.4 cm, 1 – 2, horizontal, ellipsoid, dirty white. *Leaves* ca. 8.0 × 2.1 – 2.5 cm, 3 – 4, clustered about middle of stem, sheathing at base, alternate, oblong – lanceolate, acute, entire. *Inflorescence* ca. 8.0 – 12.0 cm long including peduncle, laxly flowered spike, terete, green. *Flowers* ca. 0.9 – 1.0 cm, minute, sessile, white tinged with greenish-yellow, inodorous, bracteate, pedicellate. *Bracts* ca. 1.0 × 0.4 cm, lanceolate, acuminate, entire, equal to length of ovary. *Pedicel with Ovary* 0.5 – 0.6 cm long. *Sepals* white; *dorsal sepal* ca. 0.3 × 0.2 cm, hooded, concave, ovate – oblong, obtuse, entire. *lateral sepals* spreading, ca. 0.3 × 0.1 cm, oblong, obtuse, entire, glabrous. *Petals* ca. 0.3 × 0.2 cm, concave, incurved, obovate, retuse. *Lip* ca. 0.15 × 0.3 cm, subquadrate tri-lobed about middle, lobes subequal, lateral ones ca. 0.1 cm long, rounded, subacute. *Spur* ca. 0.1 cm in diam. with a circular

depression all round, scrotiform. *Column* ca. 0.1 cm long, greenish-white. *Pollinia* obpyriform. *Capsule* ca. 1.0 × 0.3 cm, fusiform, turgid, ribbed, beaked (Plate 2.13).

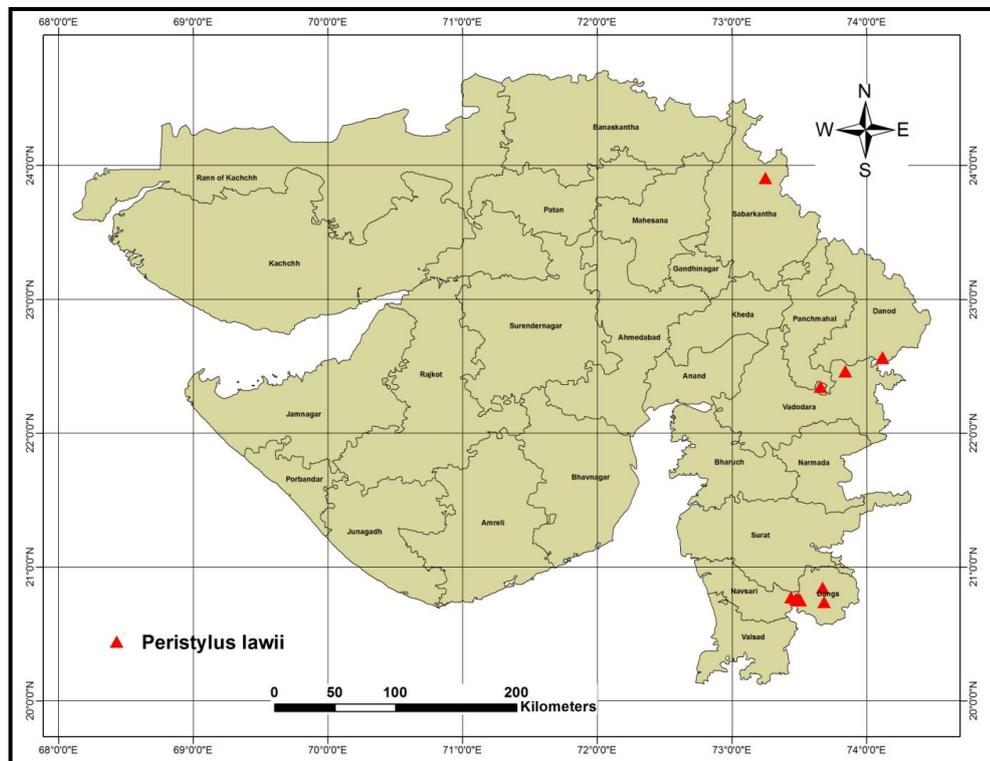
**Flowering & Fruiting:** July – October.

**Habit & Habitat:** Terrestrial herbs, found under the shade of moist and dry deciduous forests up to 246 m a.s.l.

**Specimens examined:** India, **Gujarat**, Chhota Udepur, Sukhi Dam, 29<sup>th</sup> July 2014, M. R. Bhatt, 33415 (BSI, Jodhpur!); **Maharashtra**, Tansa WLS, Thane, 18<sup>th</sup> August 2013, J. S. Jalal, 133326 (BSI, Pune!).

**Distribution in Gujarat:** Chhota Udepur (5A/C<sub>3</sub>), Dahod (5A/C<sub>3</sub>), Dangs (3B/C<sub>1b</sub>, 3B/C<sub>2</sub>), Navsari (3B/C<sub>1b</sub>, 3B/C<sub>2</sub>), Panchmahal (5A/C<sub>3</sub>, 5<sub>2</sub>/S<sub>1</sub>) Sabarkantha (5A/C<sub>3</sub>) (Figure 2.27).

**Global distribution:** India (Bihar, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha, Tamil Nadu, Uttarakhand and West Bengal), Myanmar and Nepal.



**Figure 2.27:** Distribution of *Peristylus lawii* in Gujarat

**Peristylus plantagineus** (Lindl.) Lindl., Gen. Sp. Orchid. Pl. 300. 1835; Cooke, Fl. Pres. Bombay 3: 216. 1958 (Repr.); Santapau and Kapadia, Orchids Bombay 51. t. 10, A-B.

1966; Shah, Fl. Gujarat 2: 661. 1978; Raghavan et al. in Bull. Bot. Surv. India 84. 1981; Lakshmi. in Sharma et al., Fl. Maharashtra 2: 57. 1996; Anonymous 149. 1996; Singh et al., Fl. Madhya Pradesh 3: 63. 2001. *Habenaria wightii* Trimen, Cat. Ceyl. Pl. 91. 1885; Hook.f., Fl. Brit. India 6: 162. 1890.

*Terrestrial herbs*, 17.0 – 88.0 cm tall. *Tubers* ca. 4.0 × 0.8 cm, 1 – 2, oblong – ellipsoid. *Leaves* 9.0 – 23.0 × 4.0 – 10.0 cm, 4 – 8, clustered about middle of stem, sheathing at base, oblong – lanceolate to broadly elliptic, acute, margins yellowish, entire. *Inflorescence* 30.0 – 43.0 cm long including peduncle, spike, densely flowered, pale pinkish – brown. *Flowers* 0.8 – 1.2 cm long, greenish white, inodorous, sessile, bracteate. *Bracts* 0.9 – 1.4 × 0.2 – 0.3 cm, unequal, lower ones much longer than ovary, upper ones smaller, subulate, pale brownish – green. *Sepals* subequal, dirty brown, minutely denticulate, glabrous; *dorsal sepal* 0.2 – 0.45 × 0.23 cm, concave, oblong – ovate; *lateral sepals* 0.25 – 0.5 × 0.15 – 0.25 cm, oblong, margins incurved often overlapping. *Petals* 0.25 – 0.4 × 0.2 – 0.3 cm, subobliquely oblong – elliptic or rarely suborbicular, obtuse, entire, glabrous. *Lip* 0.2 – 0.35 × 0.2 – 0.35 cm, shorter than sepals, broadly ovate – oblong in outline, white, tri-lobed, lobes obtuse, margin undulate. *Spur* 0.1 – 0.2 cm in diam., saccate, globose. *Column* 0.2 cm long, very short, pale green. *Pollinia* 2, bipartite, clavate, caudicles very small with a small, orbicular gland. *Capsules* ca. 1.0 × 0.2 cm, curved at apex, pale brown, ribbed (Plate 2.13).

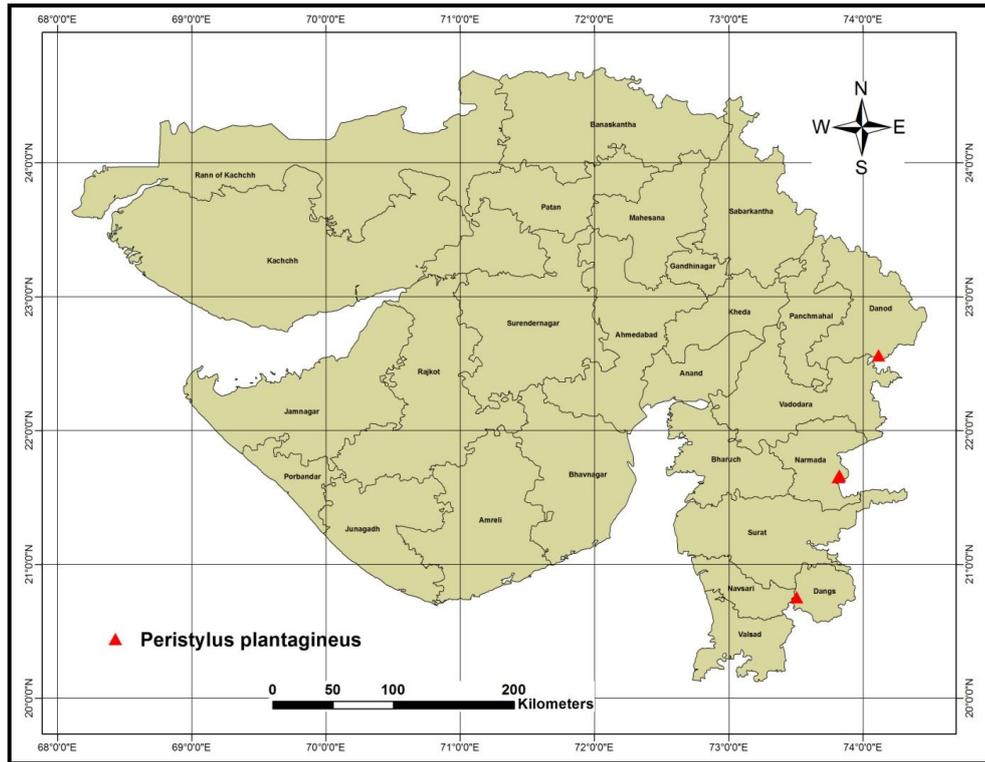
**Flowering & Fruiting:** July – November.

**Habit & Habitat:** Terrestrial herbs, found in the undergrowth of moist-deciduous forests up to 220 m a.s.l.

**Specimens examined:** India, **Gujarat**, Dangs, Waghai, 8<sup>th</sup> October 2014, M. R. Bhatt, 33454 (BSI, Jodhpur!); **Maharashtra**, 25<sup>th</sup> September 1964, B. VenkataReddi, 69616 (BSI, Pune!); Matheran, 26<sup>th</sup> July 1966, S. K. Mudaliar, 76563 (BSI, Pune!); Sawantwadi, 27<sup>th</sup> August 2013, J. S. Jalal, 133697 (BSI, Pune!).

**Global Distribution:** India (Chhattisgarh, Jharkhand, West Bengal, Odisha, Gujarat, Maharashtra, Goa, Karnataka, Kerala and Tamil Nadu), Nepal and Sri Lanka.

**Distribution in Gujarat:** Dangs (3B/C<sub>1b</sub>), Narmada (3B/C<sub>2</sub>) and Panchmahal (5A/C<sub>3</sub>) (Figure 2.28).



**Figure 2.28:** Distribution of *Peristylus plantagineus* in Gujarat

***Peristylus stocksii*** (Hook.f.) Kraenzl., *Orchid. Gen. Sp.* 1: 513. 1898; T. Cooke, *Fl. Pres. Bombay* 3: 215. 1958 (Repr.); Santapau and Kapadia, *Orchids Bombay* 48. t. 9, C-D. 1966; Abraham and Vatsala, *Introd. Orchids* 243. t. 38. 1981; Shah, *Fl. Gujarat* 2: 661. 1978; Raghavan et al. in *Bull. Bot. Surv. India* 84. 1981; Lakshmi. in Sharma, et al., *Fl. Maharashtra* 2: 58. 1996; Anonymous 149. 1996; Singh et al., *Fl. Madhya Pradesh* 3: 65. 2001. *Habenaria stocksii* Hook.f., *Fl. Brit. India* 6: 158. 1890.

*Terrestrial herbs*, 20.0 – 40.0 cm high. *Tubers* 1.7 – 3.0 × 1.2 – 2.0 cm, 1 – 2, oblong or ellipsoidal. *Leaves* 7.0 – 11.5 × 3.0 – 3.5 cm, elliptic – lanceolate, acute or subacuminate, margins wavy, scattered on stem, sheathing at base. *Inflorescence* 9.0 – 24.0 cm long including peduncle, many-flowered subsecund twisted spikes. *Flowers* ca. 0.9 cm, yellowish – green, sessile, bracteate. *Bracts* ca. 1.2 × 0.4 cm, more or less equalling ovary, ovate, acuminate. *Sepals* subequal, green; *dorsal sepal* ca. 0.25 × 0.15 cm, concave, forming a hood over column with petals, elliptic – oblong, mucronate; *lateral sepals* ca. 0.3 × 0.15 cm, spreading, obliquely oblong, obtuse. *Petals* ca. 0.3 × 0.2 cm, green, sub-fleshy, subobliquely ovate – oblong, obtuse, entire. *Lip* ca. 0.3 × 0.4 cm, longer than lateral sepals, tri-lobed, clawed; claw ca. 0.2 cm broad, concave; lateral lobes ca. 0.2 × 0.1 cm, incurved, oblong, obtuse, entire; midlobe ca. 0.4 × 0.1 cm, straight,

oblong, obtuse, entire. *Spur* 0.6 cm long, green, shorter than ovary, inflated downwards. *Column* very small, green, obtuse. *Pollinia* yellowish, clavate, obovate – oblong with short caudicle. *Capsules* 0.8 – 1.0 cm long, green, slightly curved, ribbed (Plate 2.14).

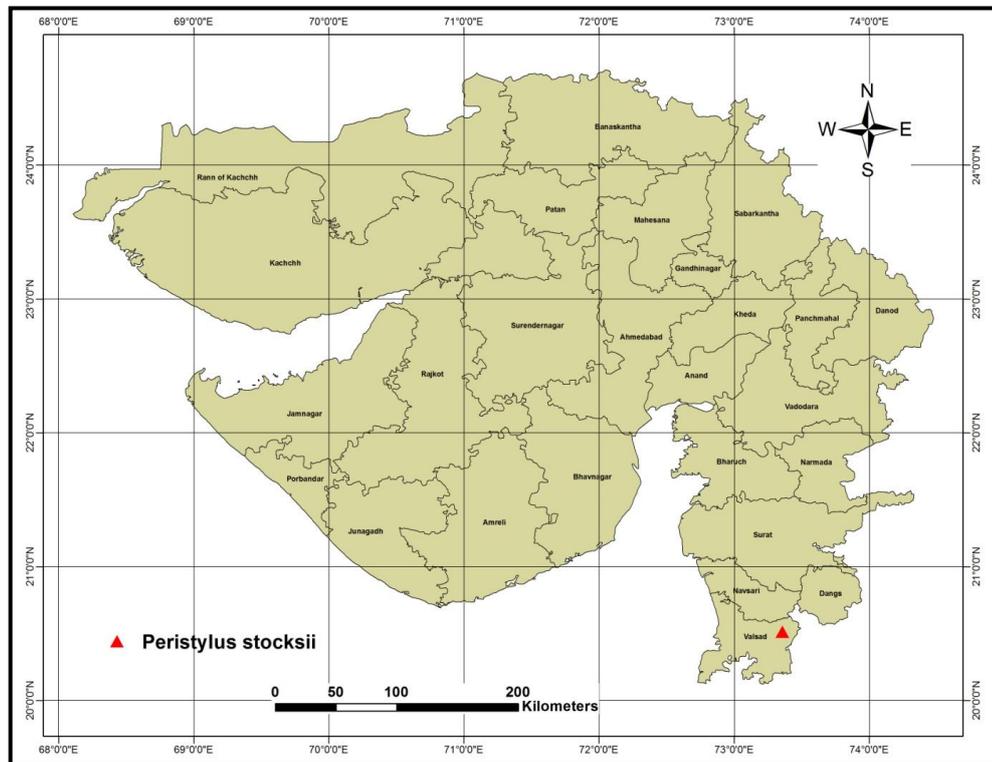
**Flowering & Fruiting:** July – September.

**Habit & Habitat:** Terrestrial herbs, found under the shade of moist deciduous forests up to 457 m a.s.l.

**Specimens examined:** India, **Gujarat**, Valsad, Dharampur, Wilson Hill, 9<sup>th</sup> August 2014, M. R. Bhatt, 33430 (BSI, Jodhpur!); **Karnataka**, 27<sup>th</sup> August 2007, R. K. Singh & P.G. Diwakar, 128330 (BSI, Pune!); **Maharashtra**, 12<sup>th</sup> August 1964, B. Venkata Reddi, 69613 (BSI, Pune!); 2<sup>nd</sup> September 1978, M. Y. Ansari, 102227; Melghat, Amravati, 25<sup>th</sup> July 1978, M. Y. Ansari, 126314 (BSI, Pune!); Near Ambe Plateau, Junnar, Pune, 13<sup>th</sup> August 2013, J. S. Jalal, 133321 (BSI, Pune!).

**Distribution in Gujarat:** Valsad (3B/C<sub>2</sub>S<sub>1</sub>) (Figure 2.29).

**Global Distribution:** Endemic to Western Ghats (Bihar, Goa, Karnataka, Kerala, Madhya Pradesh, Maharashtra and Tamil Nadu).



**Figure 2.29:** Distribution of *Peristylus stocksii* in Gujarat

**Rhynchosyilis Bl.**

**Rhynchosyilis retusa** (L.) Blume, Bijdr. Fl. Ne. Ind. 286. 1825; Hook.f., Fl. Brit. India 6: 32. 1890; T. Cooke, Fl. Pres. Bombay 3: 202. 1958 (Repr.); Santapau and Kapadia, Orchids. Bombay 211. 1966; Abraham and Vatsala, Introd. Orchids 454. t.137. 1981; Lakshmi. in Sharma et al., Fl. Maharashtra 2: 60. 1996; Anonymous 149. 1996; Singh et al., Fl. Madhya Pradesh 3: 69. 2001.

*Epiphytic herbs. Stem* woody, sheathed. *Leaves* 27.0 – 30.0 × 1.52 cm, coriaceous, channelled, with a blunt irregularly sharply-pointed apex. *Inflorescence* 31.0 – 36.0 cm long including peduncle, axillary dense raceme, cylindrical, drooping. *Flowers* 2.0 – 3.0 cm, pale pink with deeper-coloured spots, bracteate, pedicellate. *Bracts* 0.3 – 0.4 × 0.2 cm, persistent, membranous, oblong – lanceolate, acute, entire. *Pedicel with Ovary* 0.8 – 1.2 cm. *Dorsal sepal* ca. 0.8 × 0.6 cm, ovate – oblong, obtuse, entire; *lateral sepals* ca. 0.9 × 0.8 cm obliquely and broadly oblong, acute. *Petals* ca. 0.9 × 0.5 cm, oblong, tapered at apex and base, entire. *Lip* ca. 0.9 cm long, 0.3 – 0.4 cm broad at base, widening upwards to ca. 0.7 cm, curved upwards and forwards, apex emarginate. *Spur* ca. 0.8 × 0.2 cm, laterally compressed, pinkish, oblong and at right angles to ovary. *Column* ca. 0.4 cm long, *Pollinia* 2, yellow coloured. *Capsules* 1.5 – 3.0 × 0.7 – 1.0 cm, obovoid – oblong, winged (Plate 2.14).

**Flowering & Fruiting:** July – September.

**Habit & Habitat:** Epiphytic herbs, found in the moist deciduous forests up to 293 m a.s.l. The frequent host species are *Dalbergia sissoo* DC., *Lannea coromandelica* (Houtt.) Merr., *Mitragyna parvifolia* (Roxb.) Koth., *Tectona grandis* L.f., *Terminalia crenulata* Roth, *Wrightia tinctoria* R.Br. etc.

**Specimens examined:** India, **Gujarat**, Dangs, Waghai, 31<sup>st</sup> July 2014, M. R. Bhatt, 33456 (BSI, Jodhpur!); **Maharashtra**, Thane, 8<sup>th</sup> June 1967, K. V. Billore, 75929 (BSI, Pune!); Phansal WLS, Raigad, 20<sup>th</sup> August 2013, J. S. Jalal, 133267 (BSI, Pune!).

**Distribution in Gujarat:** Dangs (3B/C<sub>2</sub>, 3B/C<sub>2</sub>S<sub>1</sub>), Narmada (3B/C<sub>2</sub>), Navsari (3B/C<sub>2</sub>S<sub>1</sub>) and Valsad (3B/C<sub>2</sub>) (Figure 2.30).

**Global Distribution:** India (Andaman and Nicobar Islands, Arunachal Pradesh, Assam, Bihar, Chhattisgarh, Goa, Haryana, Himachal Pradesh, Jammu and Kashmir, Jharkhand,

Karnataka, Kerala, Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Mizoram, Nagaland, Odisha, Sikkim, Tamil Nadu, Tripura, Uttarakhand and West Bengal), Bangladesh, Bhutan, Borneo, Cambodia, China, Indonesia, Java, Laos, Malaysia, Myanmar, Nepal, Philippines, Sri Lanka, Sumatra, Thailand and Vietnam.

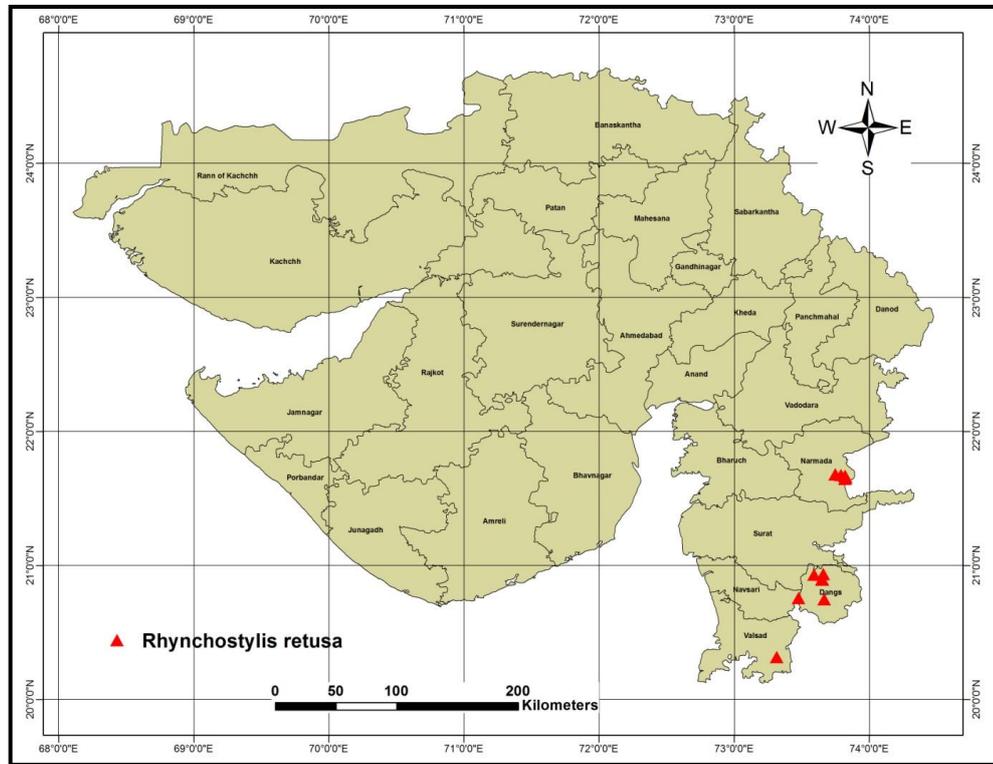


Figure 2.30: Distribution of *Rhynchosyilis retusa* in Gujarat

**Vanda W. Jones ex R. Br.**

- 1. Flowers large, 3 – 5 cm across; sepals and petals tessellated..... **V. tessellata**
- 1. Flowers small, 1.5 – 2 cm across; sepals and petals not tessellated..... **V. testacea**

**Vanda tessellata** (Roxb.) Hook. ex G. Don, Hort. Brit. 372. 1830; Santapau and Kapadia, Orchids Bombay 220. t. 51. 1966; Abraham and Vatsala, Introd. Orchids 438, t. 439. 1981; Shah, Fl. Gujarat 2: 662. 1978; Raghavan et al. in Bull. Bot. Surv. India 84. 1981; Pandey in Shetty and Singh, Fl. Rajasthan 2: 824. 1991; Lakshmi. in Sharma et al., Fl. Maharashtra 2: 13. 1996; Anonymous 149, 1996; Singh et al., Fl. Madhya Pradesh 3: 73. 2001. *V. roxburghii* R.Br., Edw. Bot. Reg. 6: t. 506. 1820; Hook.f., Fl. Brit. India 6: 52. 1890; T. Cooke, Fl. Pres. Bombay 3: 208. 1958 (Repr.).

*Epiphytic herbs. Stem* 1.0 – 1.5 cm thick, woody, sheathed. *Leaves* 15.0 – 27.0 × 1.5 – 2.0 cm, spreading, coriaceous, linear – oblong, entire, apex irregularly toothed.

*Inflorescence* ca. 20.0 cm long including peduncle, axillary, laxly flowered raceme, 2 – 10 flowered, usually longer than leaves, erect or subpendulous. *Flowers* 5.0 cm across, varyingly greenish yellow with brownish hue, mild scented, bracteate, pedicellate. *Bracts* 0.2 cm long, scabrid, broadly triangular ovate, obtuse, persistent. *Pedicel* with *Ovary* 3.0 – 6.0 cm. *Sepals* and *Petals* spreading, leathery, clawed, obovate, obtuse, greenish – yellow and tessellated with brown on inner surface, pure white on outer surface. *Sepals* ca. 2.0 × 1.4 cm, subequal. *Petals* ca. 2.0 × 1.4 cm, clawed. *Lip* ca. 1.5 × 1.0 cm fleshy, three-lobed; lateral lobes white, parallel, obliquely elliptic, subfalcate, acute; midlobe panduriform, thick, fleshy, apex dilated, two lobed, upper surface of midlobe ridged, varying in colour from purplish-blue to red, with white streaks or white with yellow streaks. *Spur* ca. 0.8 cm long, conical, obtuse – pubescent within. *Column* white, with 2 yellow patches on either side. *Pollinia* 2, waxy, yellow, globular. *Capsules* ca. 8.0 × 1.5 cm, oblong, sharply winged (Plate 2.15).

**Flowering & Fruiting:** May – August.

**Habit & Habitat:** Epiphytic herbs, found in the moist and dry deciduous forests up to 529 m a.s.l. The common hosts are *Acacia catechu* (L.f.) Willd., *Butea monosperma* (Lam.) Taub., *Dalbergia sisoo* DC., *Diospyros melanoxylon* Roxb., *Garuga pinnata* Roxb., *Madhuca indica* J.F.Gmel, *Mangifera indica* L., *Schleichera oleosa* (Lour.) Merr., *Tectona grandis* L.f., *Terminalia crenulata* Roth, *Wrightia tinctoria* R.Br.

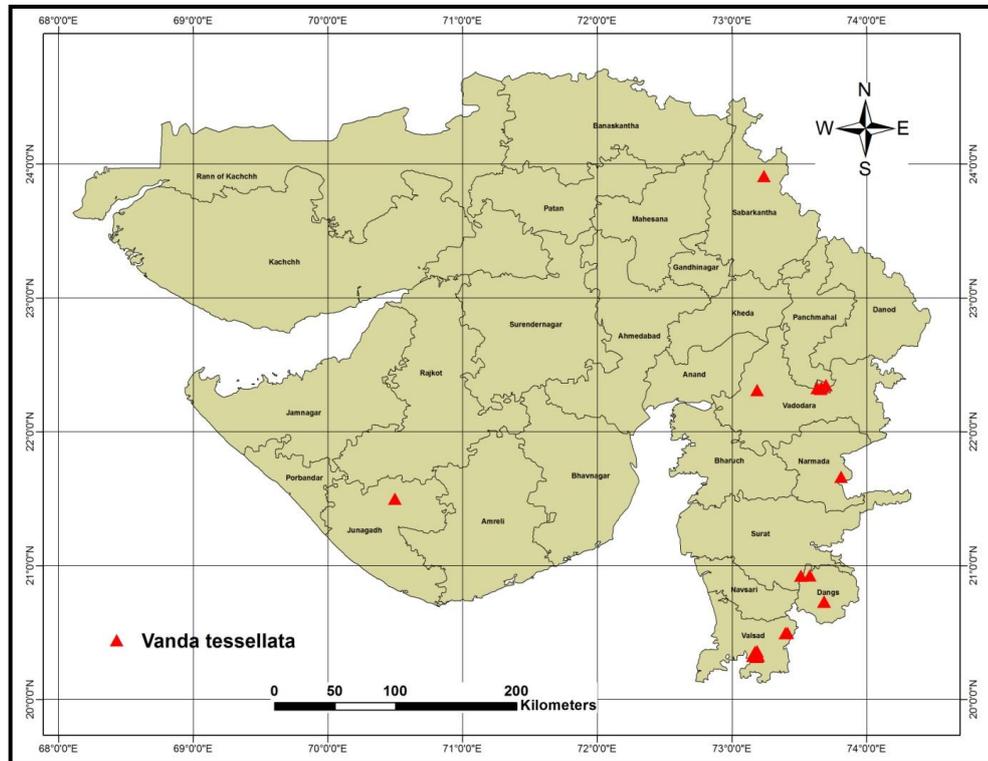
**Specimens examined:** India, **Gujarat**, Dangs, Waghai, 17<sup>th</sup> May 2014, M. R. Bhatt, 33419 (BSI, Jodhpur!); **Maharashtra**, Chanda District, 27<sup>th</sup> April 1969, Seshagiri Rao Rola, 73558 (BSI, Pune!); Khardi Range, 1<sup>st</sup> October 1978, S. Karthikeyan, 109722; Magzira WLS, 7<sup>th</sup> November 2001, D. N. Patil, 129117 (BSI, Pune!).

**Distribution in Gujarat:** Chhota Udepur (5A/C<sub>3</sub>), Dahod (5A/C<sub>3</sub>), Dangs (3b/C<sub>1b</sub>, 3B/C<sub>2</sub>, 3B/C<sub>2</sub>S<sub>1</sub>), Junagadh (5A/C<sub>3</sub>), Narmada (3B/C<sub>2</sub>, 3B/C<sub>2</sub>S<sub>1</sub>), Navsari (3b/C<sub>1b</sub>, 3B/C<sub>2</sub>), Panchmahal (5A/C<sub>3</sub>, 5<sub>2</sub>S<sub>1</sub>), Sabarkantha (5A/C<sub>3</sub>, 5<sub>2</sub>S<sub>1</sub>), Tapi (3B/C<sub>2</sub>, 3B/C<sub>2</sub>S<sub>1</sub>) and Valsad (3B/C<sub>2</sub>, 3B/C<sub>2</sub>S<sub>1</sub>) (Figure 2.31).

**Global Distribution:** India (Andhra Pradesh, Arunachal Pradesh, Assam, Bihar, Chhattisgarh, Goa, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra,

Nagaland, Odisha, Rajasthan, Sikkim, Tripura, Tamil Nadu, Uttarakhand, Uttar Pradesh and West Bengal.), Bangladesh, China, Myanmar, Nepal and Sri Lanka.

**Notes:** Sepals and Petals Greenish yellow to Brownish red tessellated on the upper surface.



**Figure 2.31:** Distribution of *Vanda tessellata* in Gujarat

**Vanda testacea** (Lindl.) Reichb.f., Gard. Chron. n.s., 8: 166. 1877; Santapau and Kapadia, Orchids Bombay 219. 1966; Abraham and Vatsala, Introd. Orchids 436, t. 437. 1981; Shah, Fl. Gujarat 2: 663. 1978; Raghavan et al. in Bull. Bot. Surv. India 84. 1981; Pandey in Shetty and Singh, Fl. Rajasthan 2: 824. 1991; Lakshmi. in Sharma et al., Fl. Maharashtra 2: 63. 1996; Anonymous 149. 1996; Singh et al., Fl. Madhya Pradesh 3: 74. 2001. *V. parviflora* Lindl., Edw. Bot. Reg. 30: 45. 1844; Hook.f., Fl. Brit. India 6: 50. 1890; T. Cooke, Fl. Pres. Bombay 3: 207. 1958 (Repr.).

*Epiphytic herbs.* Stem 1.0 – 1.5 cm thick, sheathed. *Leaves* 6.0 – 15.0 × 1.5 – 2.5 cm, spreading, channelled, coriaceous, linear – oblong, irregularly 2 – 3 toothed at apex. *Inflorescence* ca. 13.0 cm long including peduncle, axillary, laxly flowered raceme, erect. *Flowers* 1.5 – 2.0 cm, pale yellow, bracteate, pedicellate. *Bracts* ca. 0.25 × 0.25 cm, ovate or ovate – oblong, acute, scabrid, brown. *Pedicel* with *Ovary* 1.5 – 2.3 cm long, shallowly

grooved. *Sepals* ca.  $0.6 \times 0.4$  cm, sub equal, obovate – oblong, obtuse; lateral ones slightly broader and subacute. *Petals* ca.  $0.7 - 0.8 \times 0.3$  cm, broadly obovate – oblong, clawed, obtuse, entire. *Lip*  $0.5 \times 0.3$  cm, adnate to foot of column, tri-lobed; lateral lobes ca.  $0.3 \times 0.1$  cm, oblong, obtuse; midlobe ca.  $0.6 \times 0.4$  cm, cuneate – oblong, apex dilated, perfectly semicircular, obtuse, subentire or irregularly crenulate, portion below apex with two blue – lilac caruncled ridges. *Spur* ca. 0.3 cm long, yellow, formed by direct continuation of the lateral lobes of lip. *Column* 0.2 cm long, pale yellow, sparingly purple dotted. *Pollinia* 2, globose with a short caudicle. *Capsules*  $2.0 - 3.5 \times ca. 0.7$  cm, ribbed, fusiform (Plate 2.15).

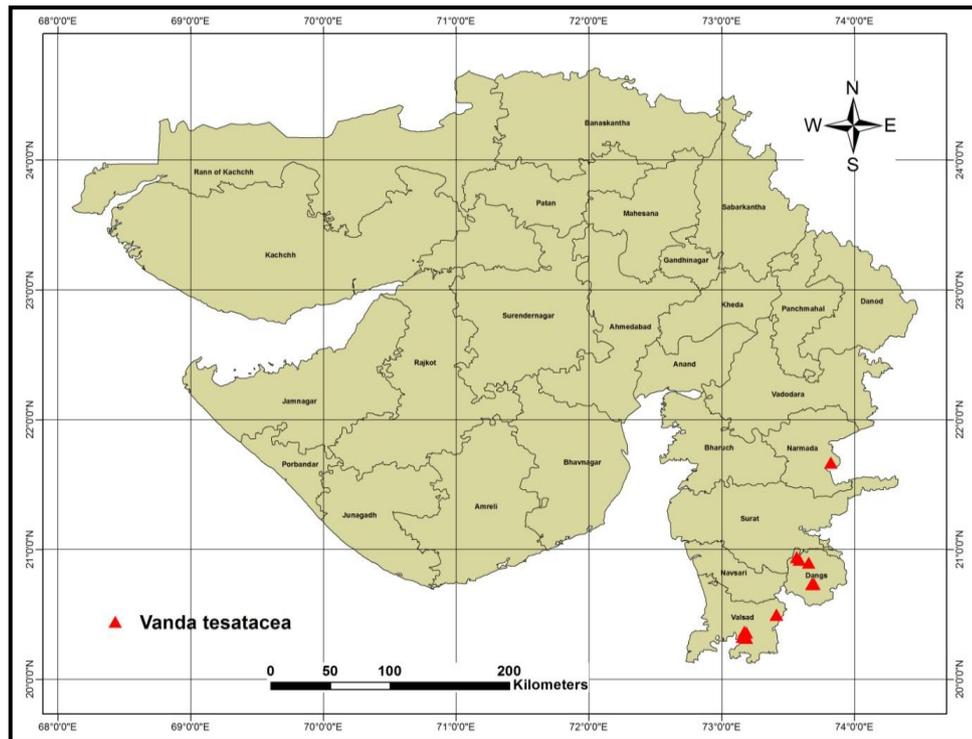
**Flowering & Fruiting:** May – July.

**Habit & Habitat:** Epiphytic herbs, found in the moist and dry deciduous forests up to 526 m a.s.l. The preferable host species are *Madhuca indica* J.F.Gmel, *Mitragyna parviflora* (Roxb.) Korth., *Tectona grandis* L.f., *Terminalia crenulata* Roth, *T. bellirica* (Gaertn.) Roxb., *Wrightia tinctoria* R.Br. etc.

**Specimens examined:** India, **Gujarat**, Dangs, Ahwa, Devinamal, 11<sup>th</sup> May 2014, M. R. Bhatt, 33418 (BSI, Jodhpur!); **Maharashtra**, Khardi Range, 1<sup>st</sup> June 1968, K. V. Billore, 75925 (BSI, Pune!); Thane, 17<sup>th</sup> August 2013, J. S. Jalal, 133603 (BSI, Pune!).

**Distribution in Gujarat:** Dangs (3b/C<sub>1b</sub>, 3B/C<sub>2</sub>) Valsad (3b/C<sub>1b</sub>, 3B/C<sub>2</sub>) and Narmada (3b/C<sub>1b</sub>, 3B/C<sub>2</sub>) (Figure 2.32).

**Global Distribution:** India (Arunachal Pradesh, Assam, Chhattisgarh, Goa, Himachal Pradesh, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Manipur, Mizoram, Nagaland, Odisha, Rajasthan, Sikkim, Tamil Nadu, Uttarakhand, Uttar Pradesh and West Bengal), Bhutan, Myanmar, Nepal, Sri Lanka and Thailand.



**Figure 2.32:** Distribution of *Vanda testacea* in Gujarat

#### ***Zeuxine* Lindl.**

***Zeuxine strateumatica* (L.) Schltr.** in Bot. Jahrb. Syst. 45: 394. 1911; Santapau and Kapadia, Orchids Bombay 167. t. 38. 1966; Shah, Fl. Gujarat 2: 663. 1978; Raghavan et al. in Bull. Bot. Surv. India 84. 1981; Pandey in Shetty and Singh, Fl. Rajasthan 2: 825. 1991; Lakshmi. in Sharma et al., Fl. Maharashtra 2: 64. 1996; Anonymous 149. 1996; Singh et al., Fl. Madhya Pradesh 3: 74. 2001. *Z. sulcata* (Roxb.) Lindl., Royle, Coll. Bot. 18. 1826; Hook.f., Fl. Brit. India 6: 106. 1890; T. Cooke, Fl. Pres. Bombay 3: 213. 1958 (Repr.).

*Terrestrial herbs*, 7.0 – 15.0 cm tall from an underground rhizome which is covered over by a fine network of thin hair-like roots. *Leaves* 4.5 – 5.0 × ca. 0.4 cm, several, alternate, pentastichously arranged all along stem, pale olive-green – yellowish, linear – lanceolate, acute, entire. *Inflorescence* 5.0 – 7.0 cm, secund or subsecund spikes, erect or slightly decurved. *Flowers* ca. 1.3 cm long, sessile, bracteate. *Bracts* 1.0 – 1.3 × ca. 0.4 cm, longer than ovary, ovate – lanceolate, acute, entire, glabrous, greenish – white tinged with pale pink. *Sepals* unequal, white, obtuse, entire; *dorsal sepal* 0.7 × 0.3 cm, ovate – oblong, concave; *lateral sepals* ca. 0.6 × 0.3 cm, subobliquely linear – oblong. *Petals* ca. 0.6 × 0.2 cm, white, obliquely oblong – elliptic, obtuse, entire, glabrous. *Lip* ca. 0.5 × 0.2 cm, minutely glandular-papillate, slightly saccate at base, narrowly panduriform, obtuse or

sub emarginate; colour of lip pale purple at base, yellow from a little above middle. *Column* very short. *Pollinia* 2, yellow, obpyriform, sessile. *Capsules* broadly ovoid, beakless, strongly ribbed (Plate 2.16).

**Flowering:** January – February.

**Habit & Habitat:** Terrestrial herbs, commonly found in moist, swampy ground, often in running water, among short grasses up to 424 m a.s.l.

**Distribution in Gujarat:** Dangs (3b/C<sub>1b</sub>, 3B/C<sub>2</sub>) and Narmada (3b/C<sub>1b</sub>, 3B/C<sub>2</sub>) (Figure 2.33).

**Specimen examined:** India, **Gujarat**, Narmada, Saghai range, 22<sup>nd</sup> February 2015, M. R. Bhatt, 0103 (BSI, Jodhpur!).

**Global Distribution:** India (Arunachal Pradesh, Assam, Bihar, Haryana, Himachal Pradesh, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Mizoram, Nagaland, Odisha, Punjab, Rajasthan Sikkim, Tamil Nadu, Tripura, Uttarakhand and West Bengal), Afghanistan, Bangladesh, Borneo, Cambodia, China, Iran, Japan, Java, Laos, Malaya, Myanmar, Nepal, New Guinea, Pakistan, Saudi Arabia, Sri Lanka, Tadzhikistan, Thailand, U.S.A., Uzbekistan and Vietnam.

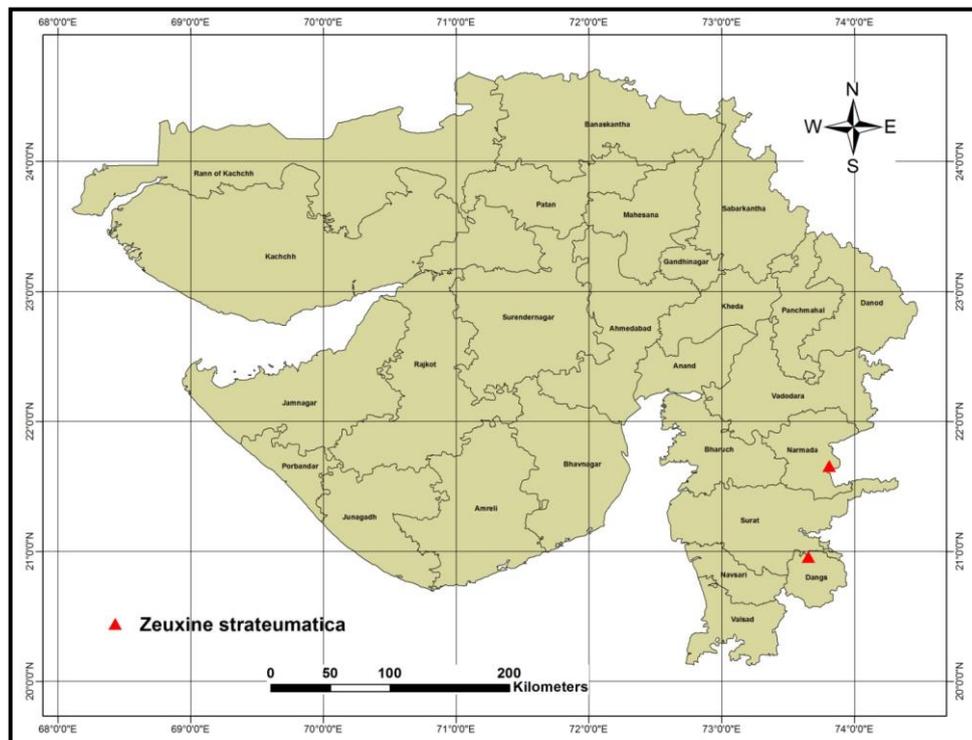
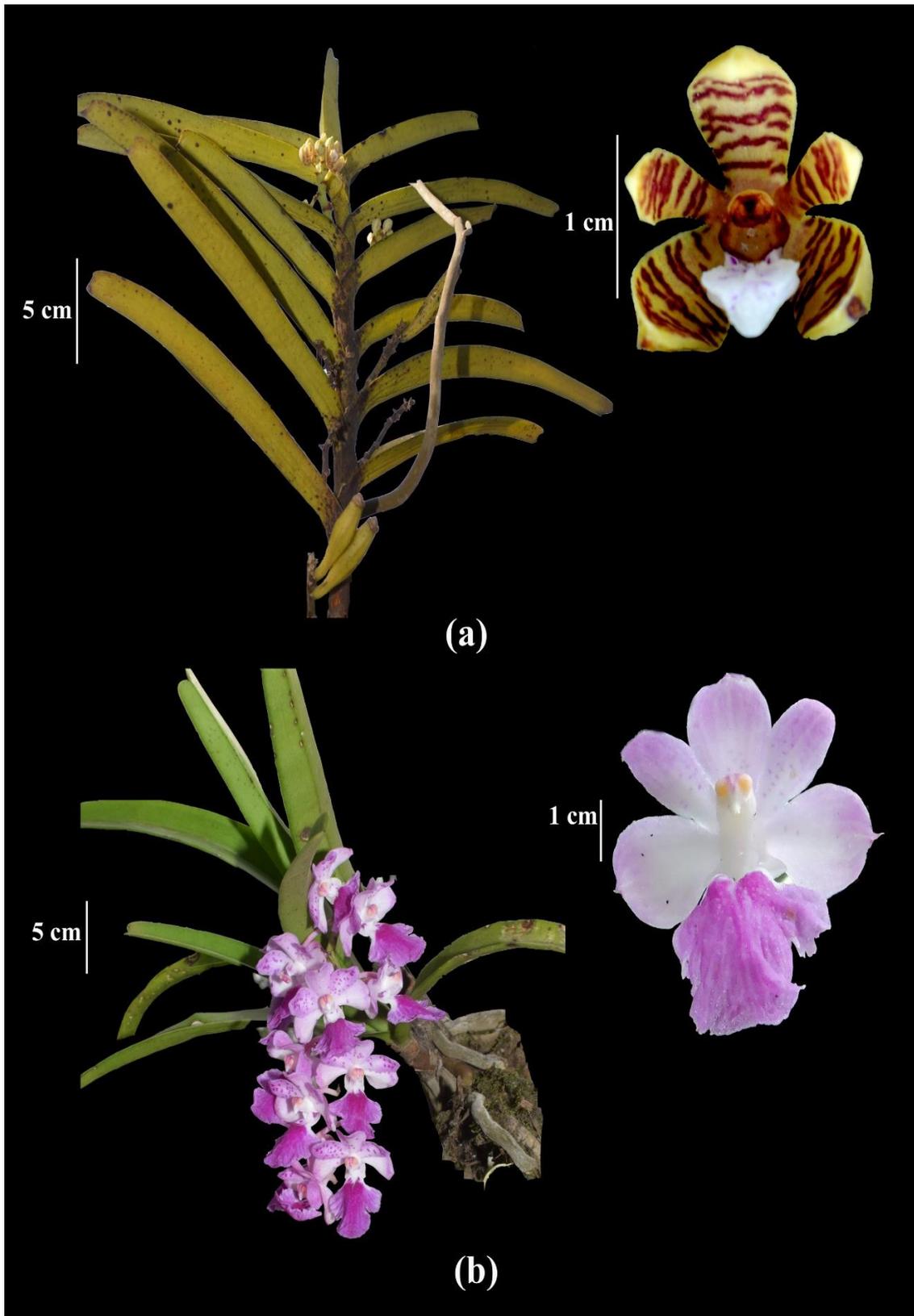


Figure 2.33: Distribution of *Zeuxine strateumatica* in Gujarat



**Plate 2.1:** (a) *Acampe praemorsa*; (b) *Aerides maculosa*

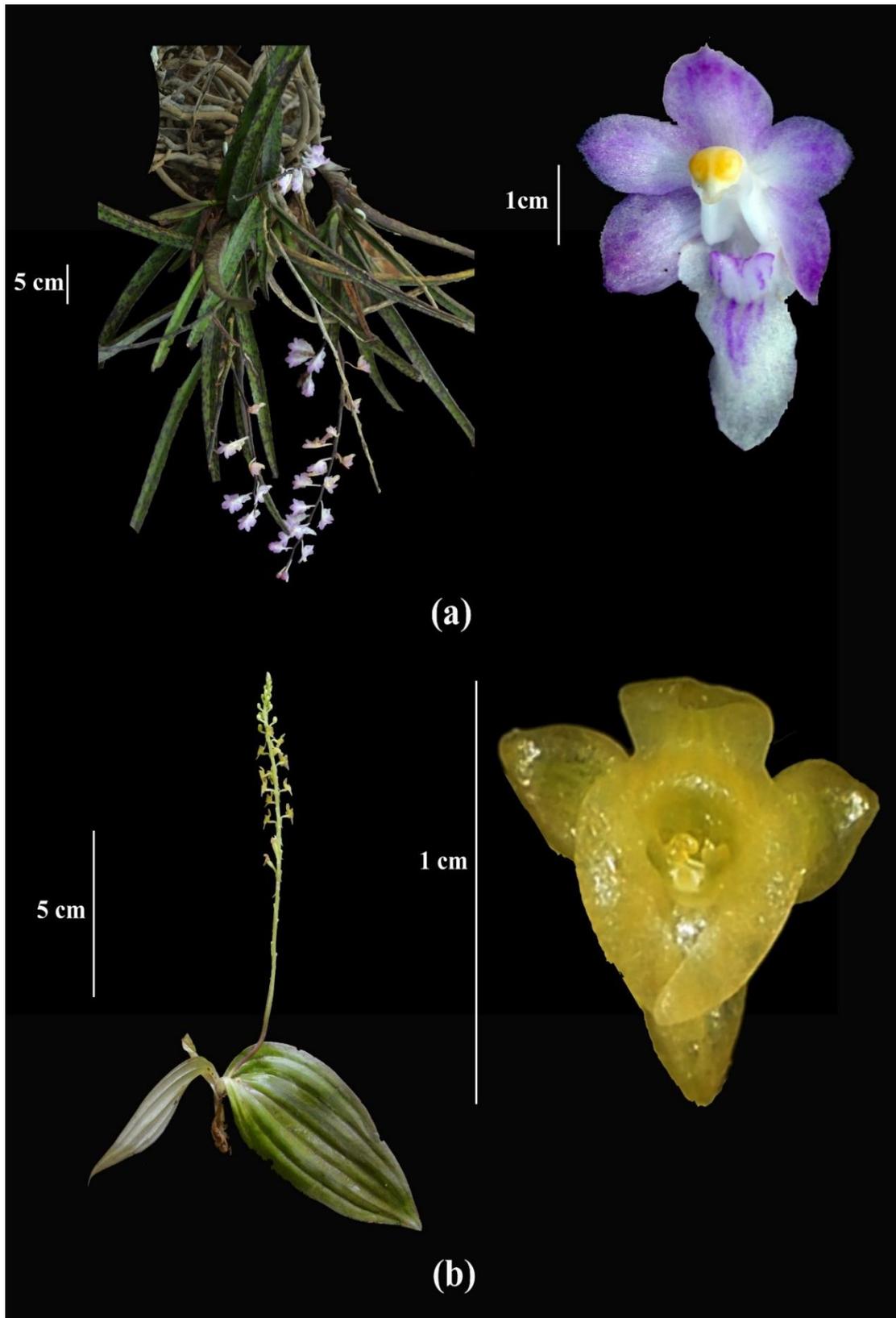


Plate 2.2: (a) *Aerides ringens*; (b) *Crepidium mackinnonii*

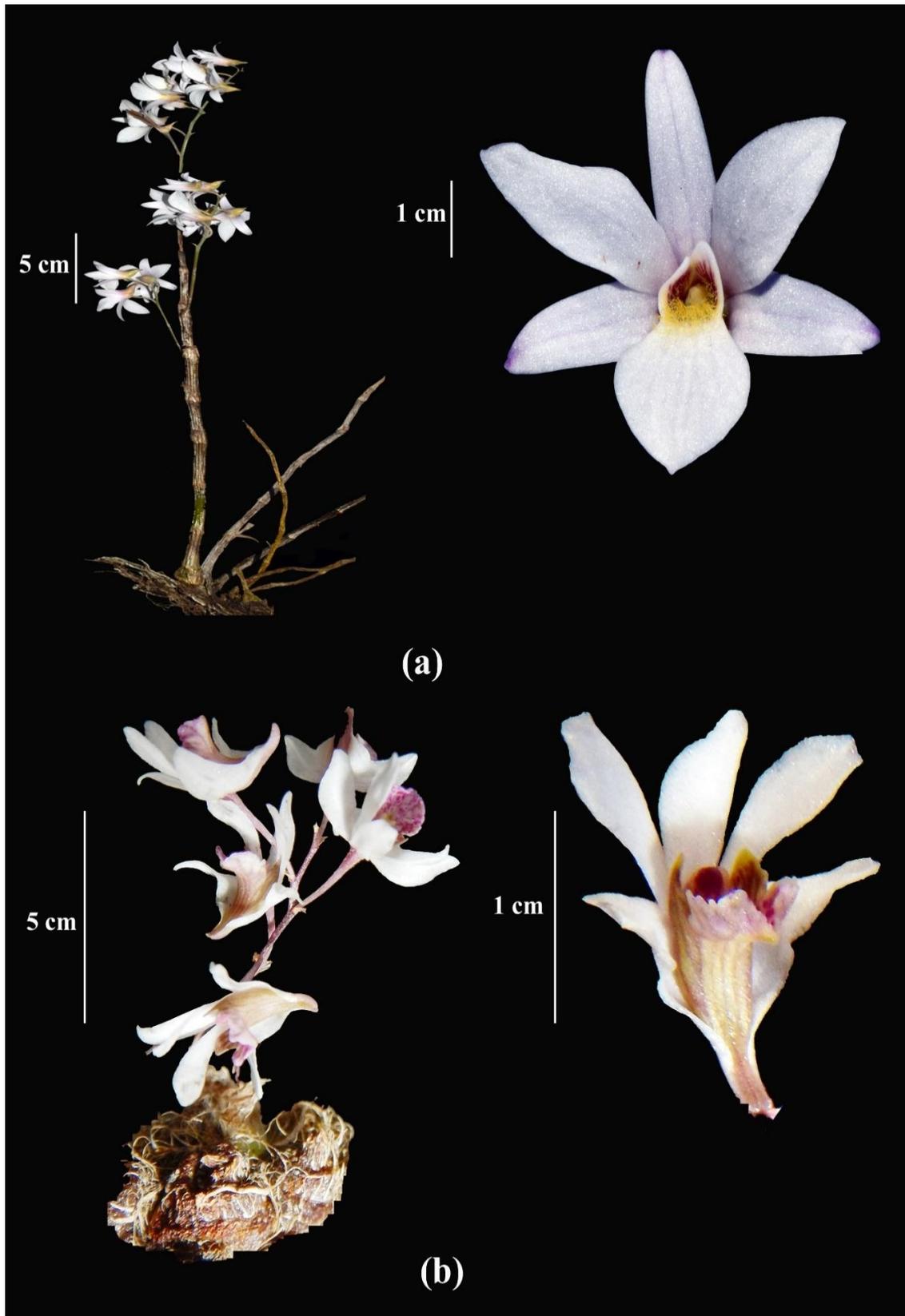
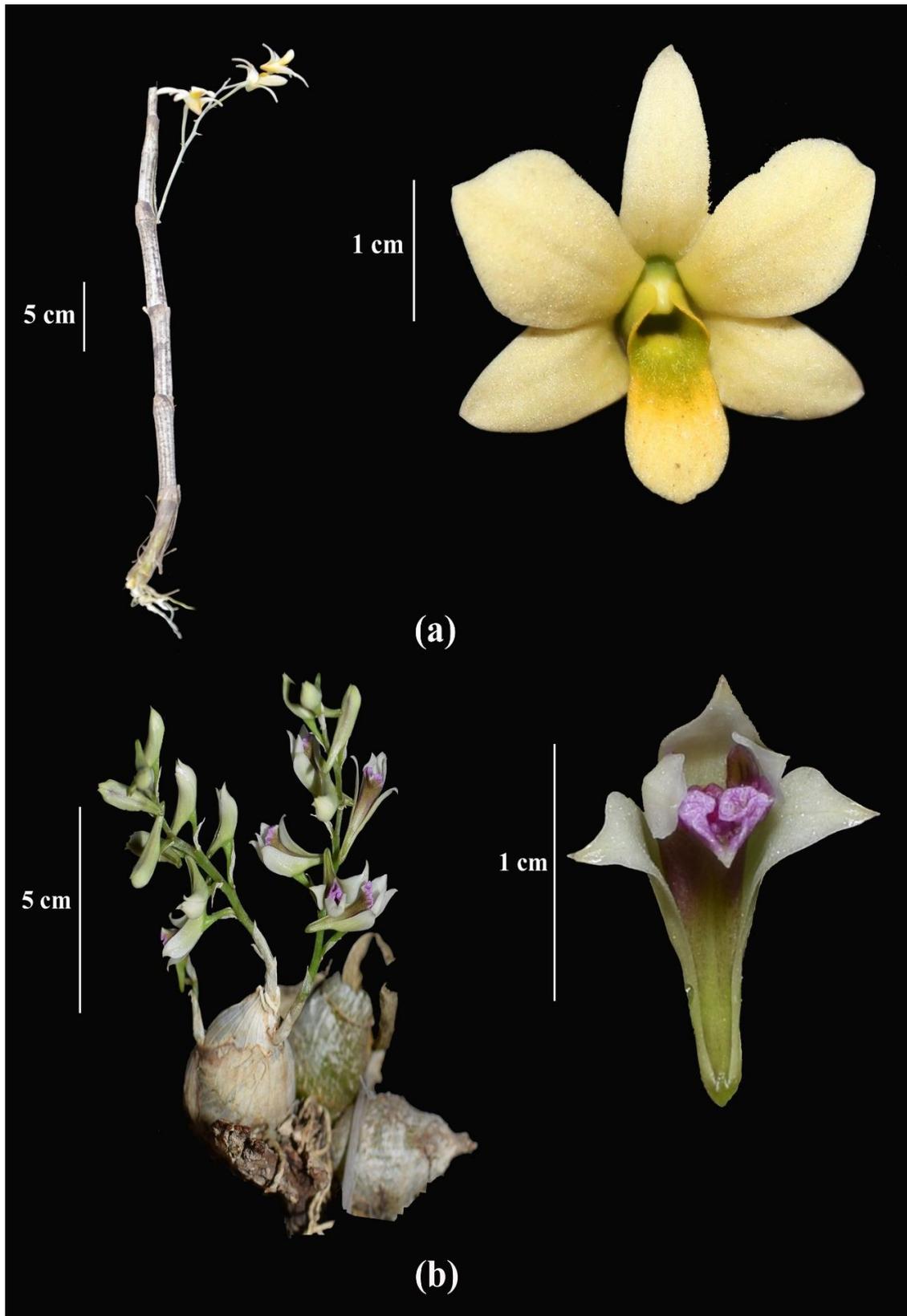
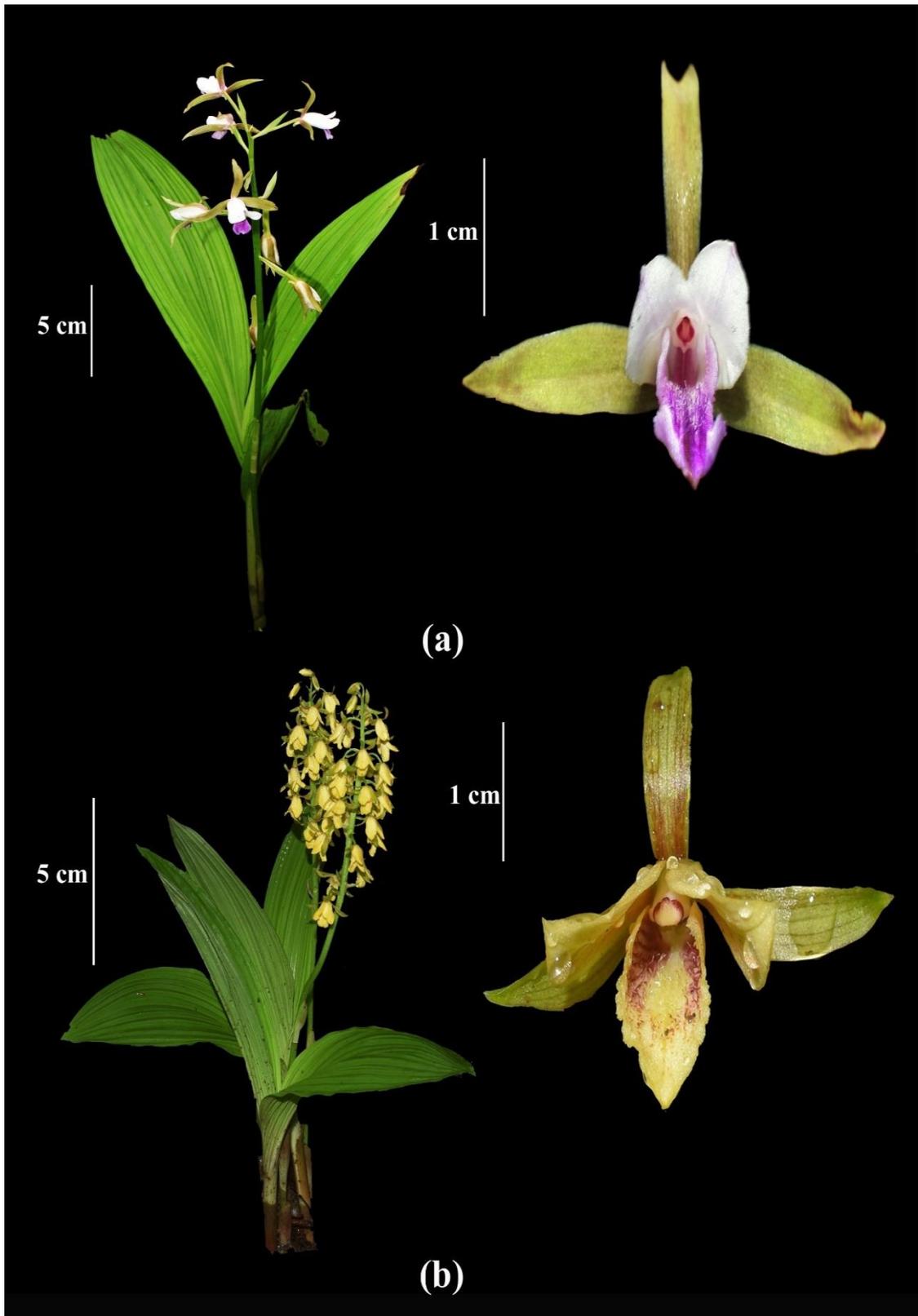


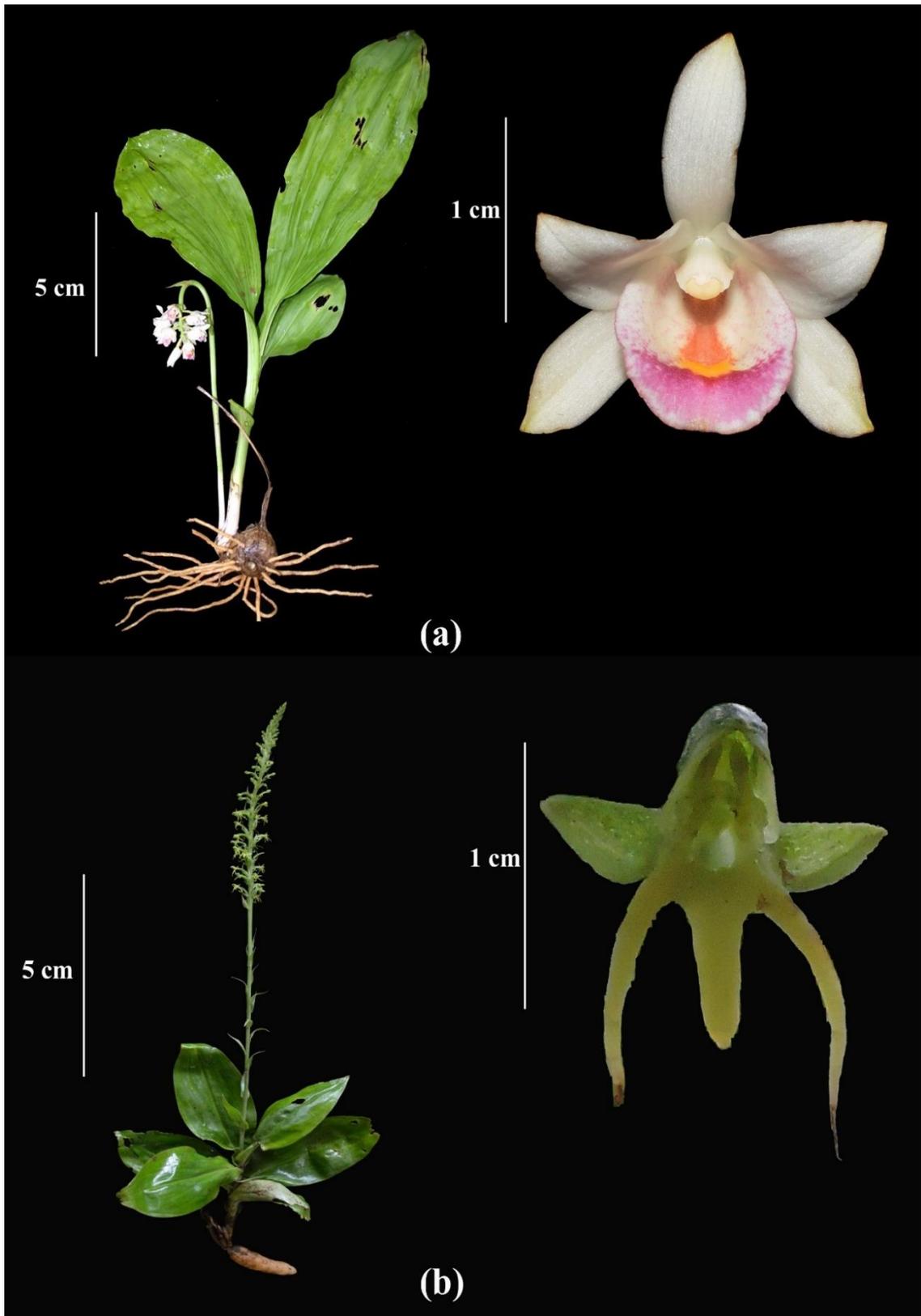
Plate 2.3: (a) *Dendrobium barbatulum*; (b) *Dendrobium microbulbon*



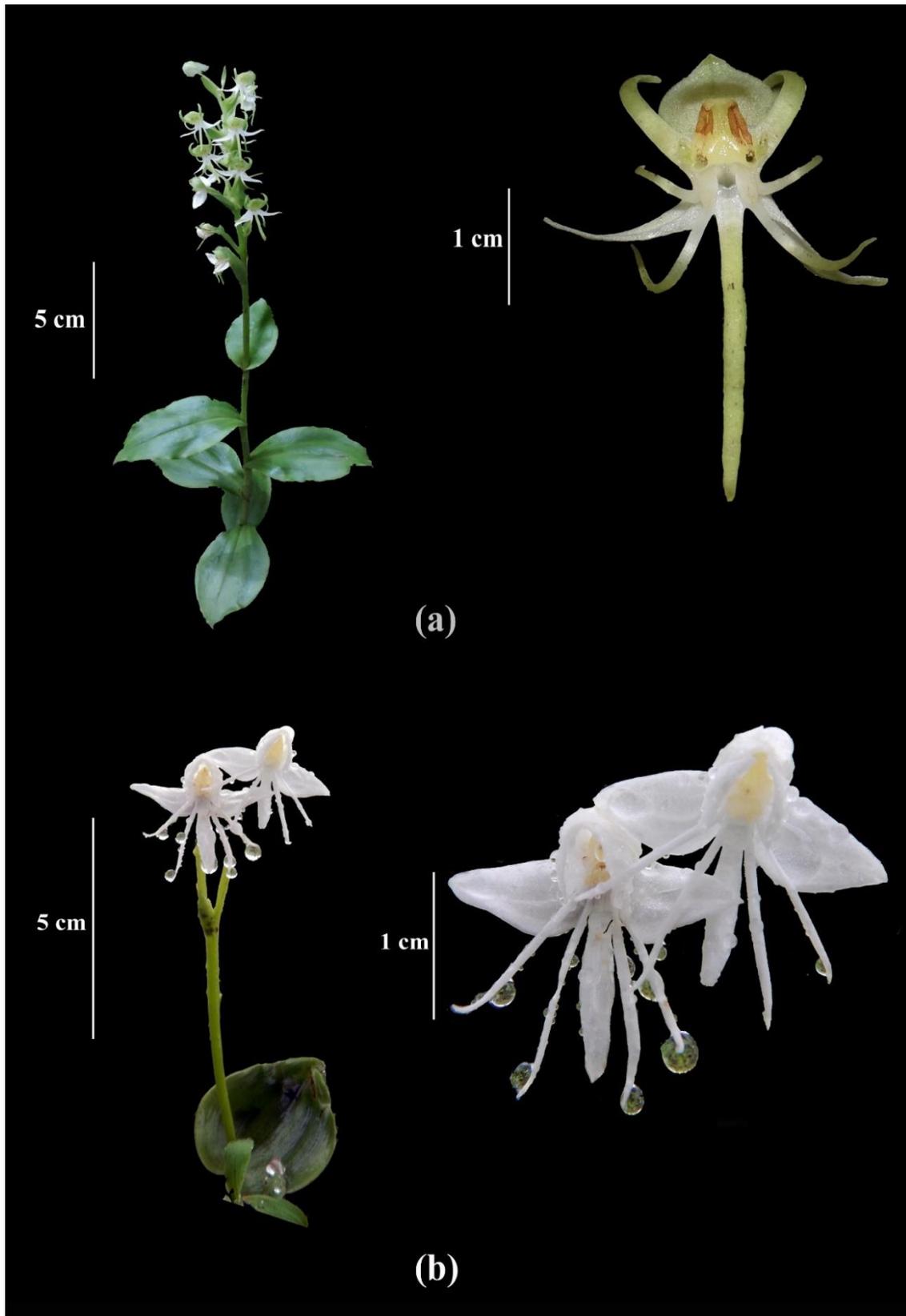
**Plate 2.4:** (a) *Dendrobium ovatum*; (b) *Dendrobium peguanum*



**Plate 2.5:** (a) *Eulophia herbacea*; (b) *Eulophia ochreatea*



**Plate 2.6:** (a) *Geodorum laxiflorum*; (b) *Habenaria furcifera*



**Plate 2.7:** (a) *Habenaria gibsonii*; (b) *Habenaria grandifloriformis*

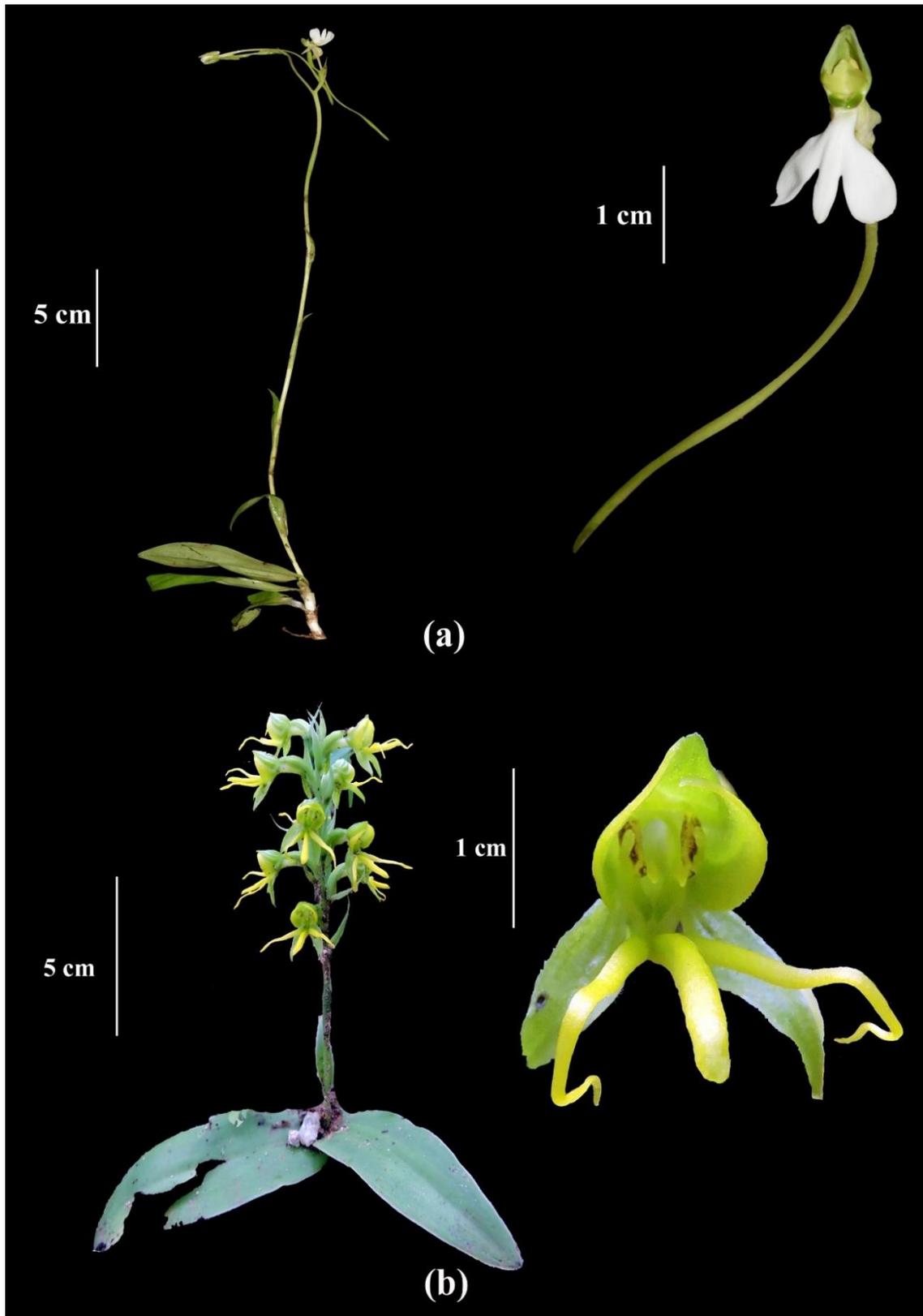


Plate 2.8: (a) *Habenaria longicorniculata*; (b) *Habenaria marginata*

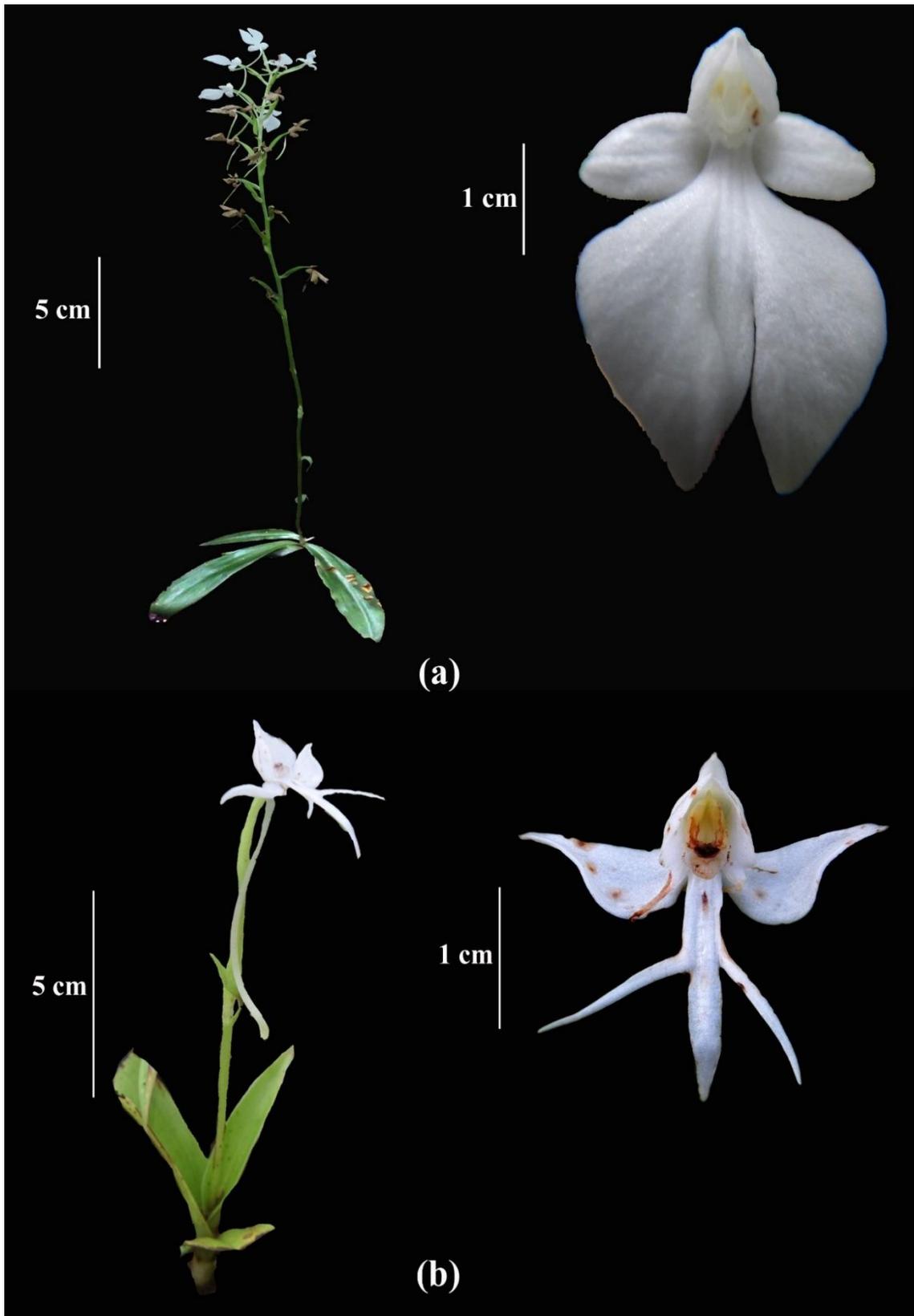
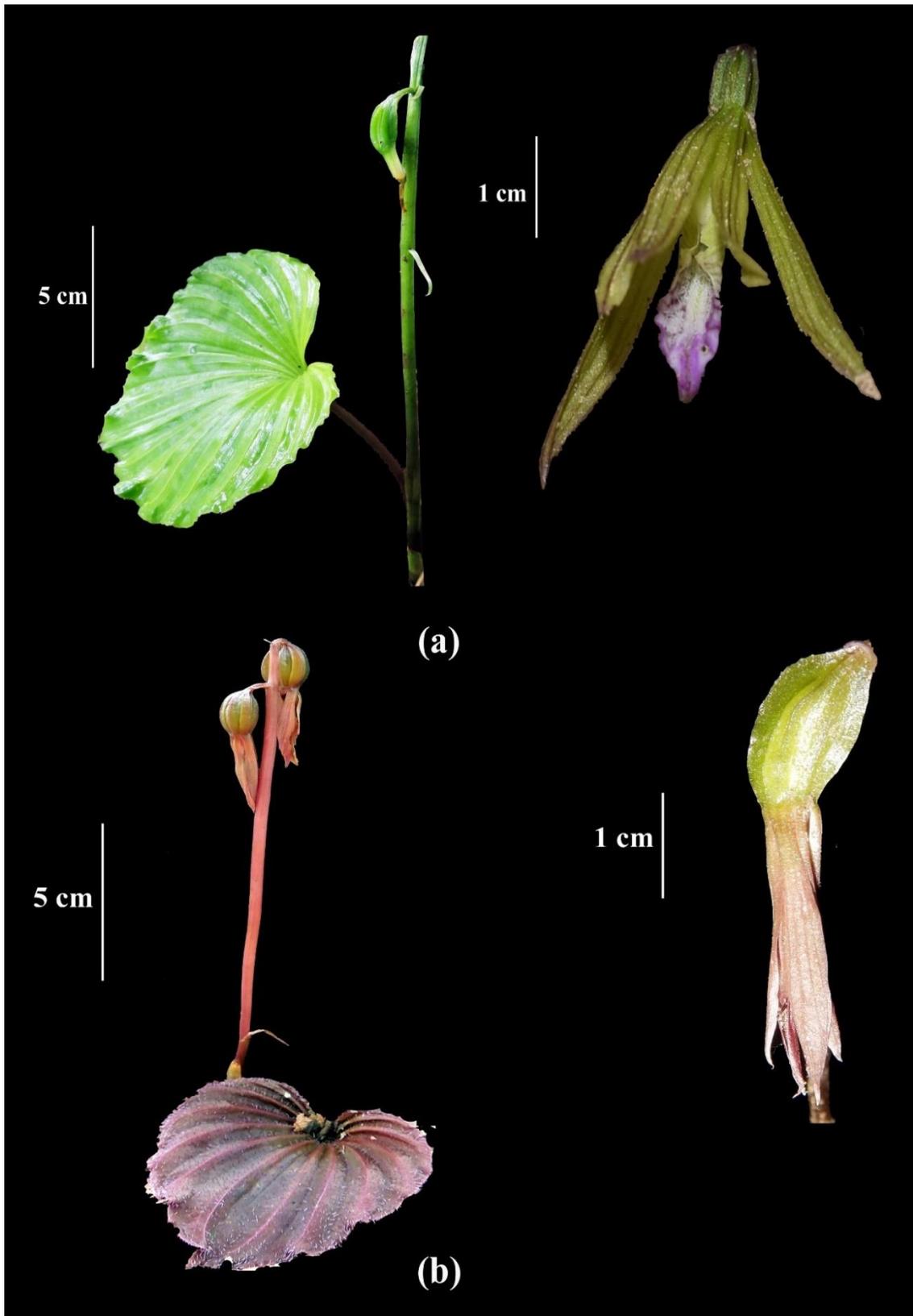


Plate 2.9: (a) *Habenaria plantaginea*; (b) *Habenaria rariflora*



**Plate 2.10:** (a) *Nervilia concolor*; (b) *Nervilia plicata*

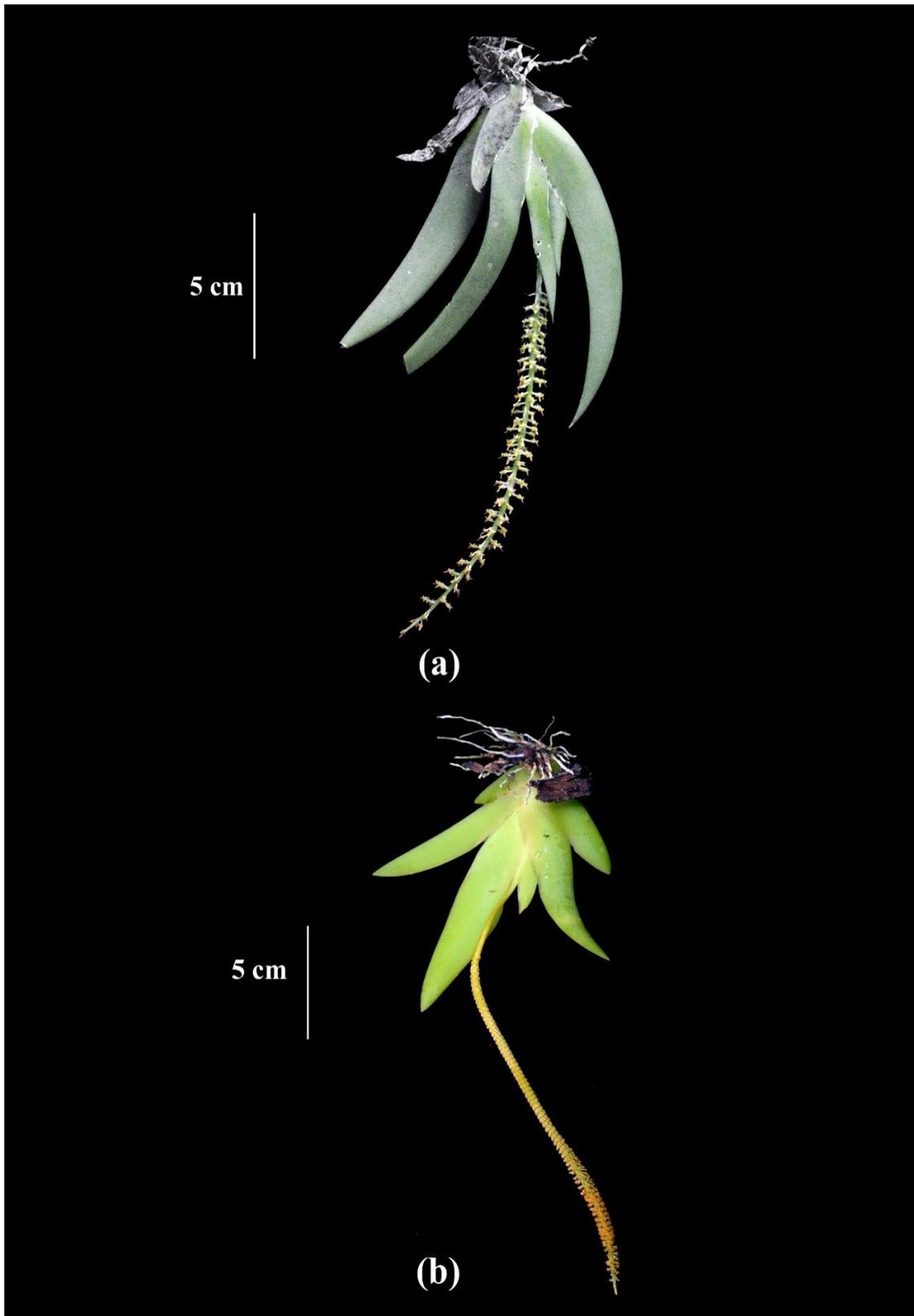


Plate 2.11: (a) *Oberonia falconeri*; (b) *Oberonia mucronata*

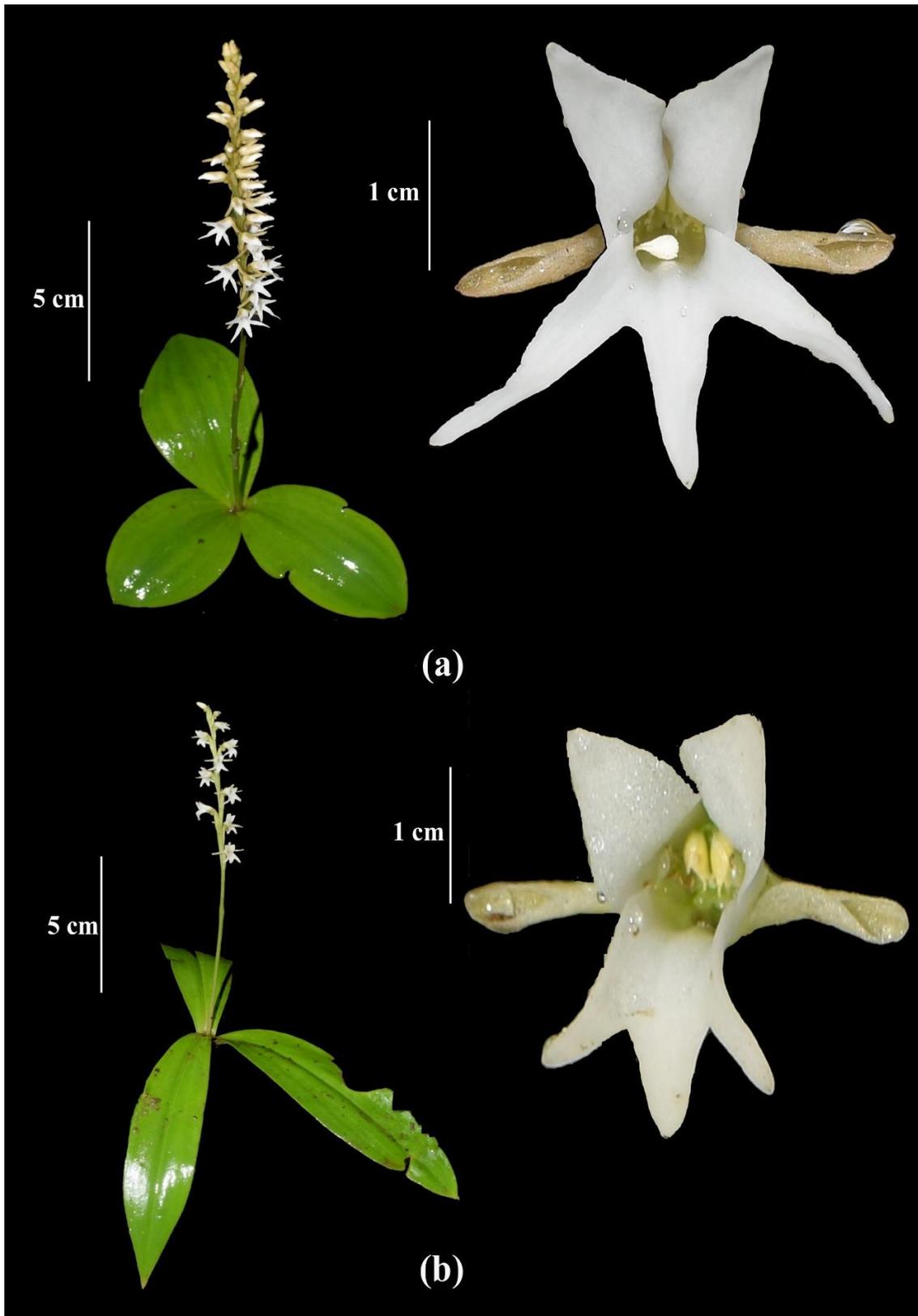


Plate 2.12: (a) *Peristylus constrictus*; (b) *Peristylus constrictus* (variant)

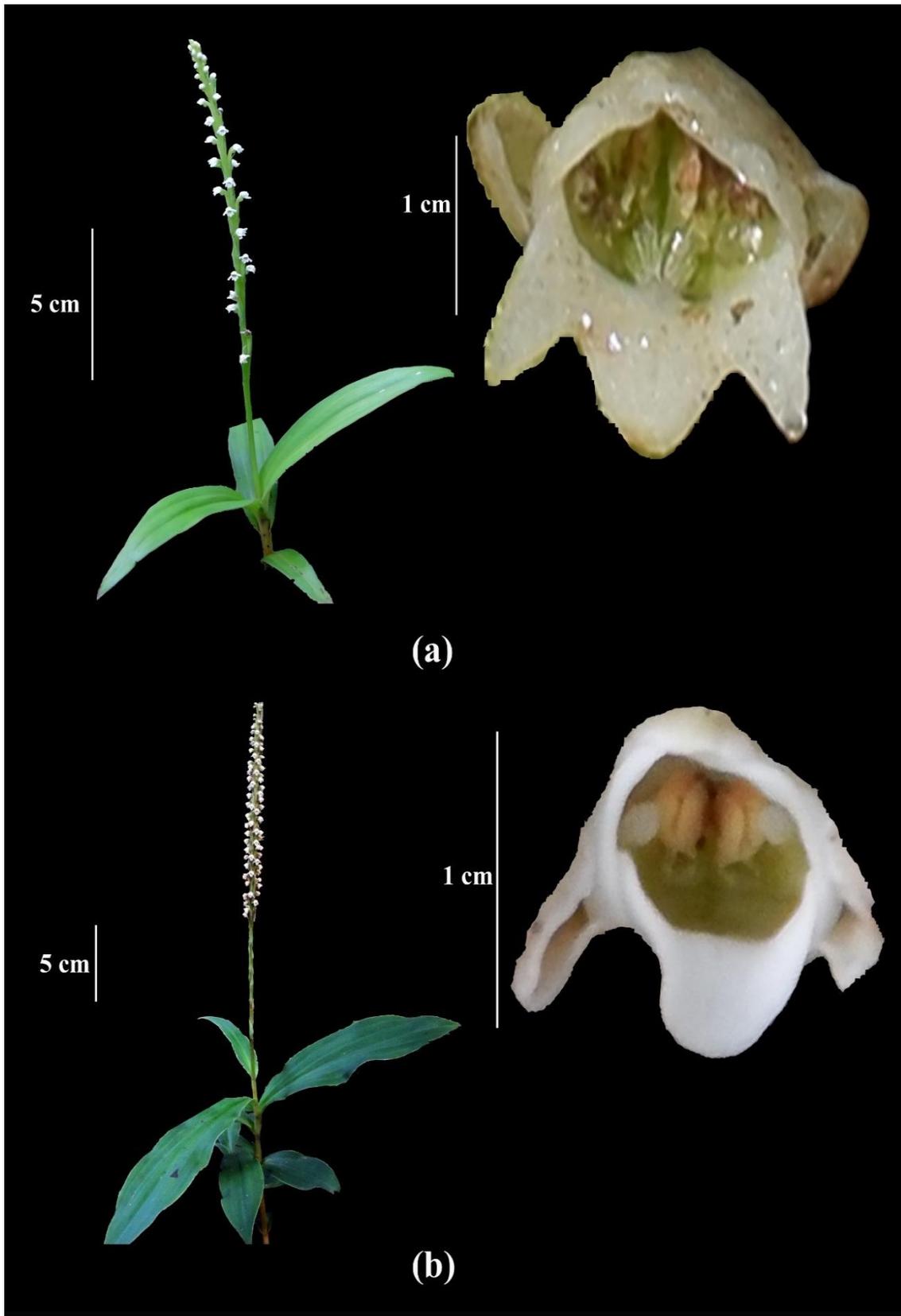
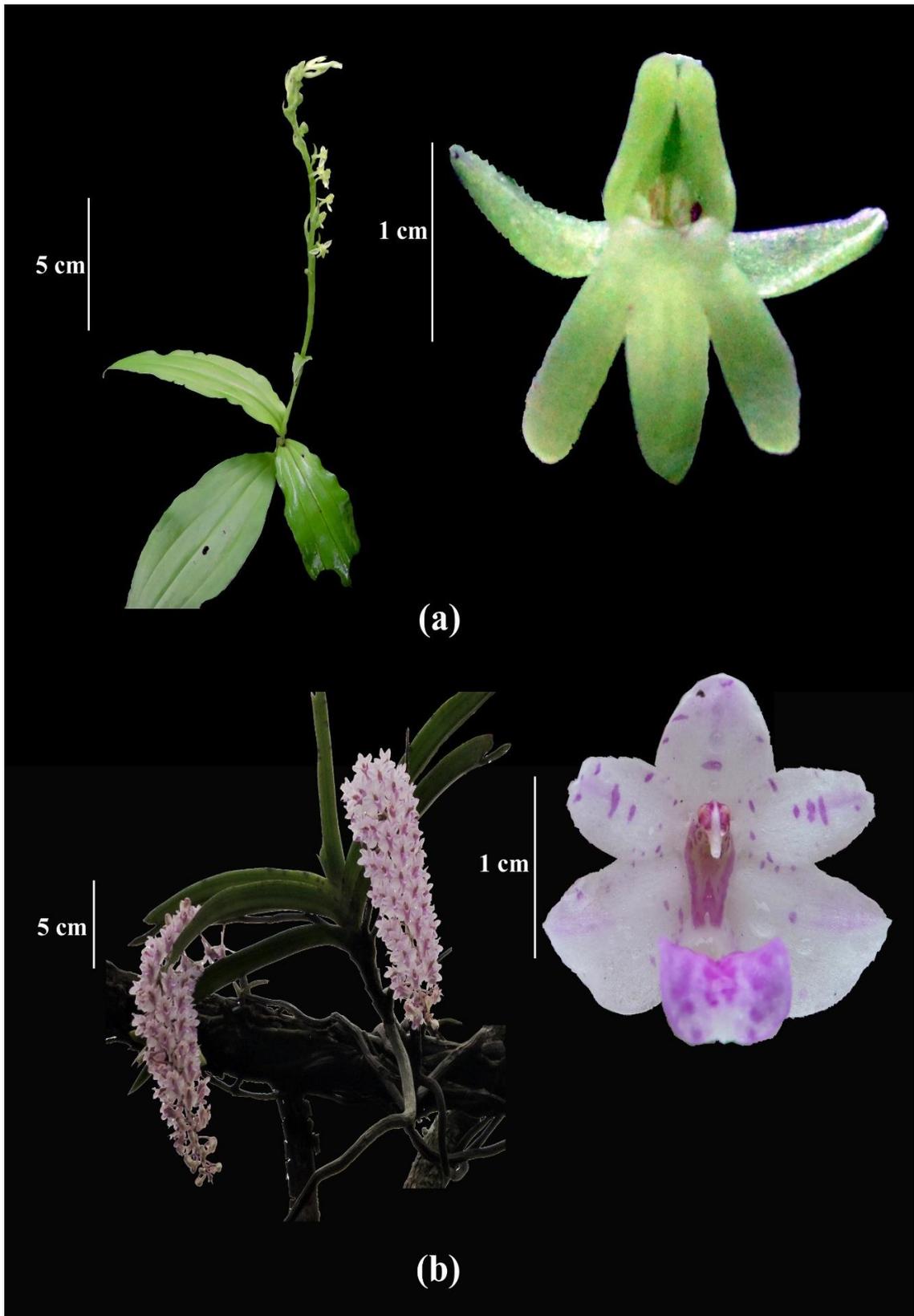


Plate 2.13: (a) *Peristylus lawii*; (b) *Peristylus plantagineus*



**Plate 2.14:** (a) *Peristylus stocksii*; (b) *Rhynchosstylis retusa*

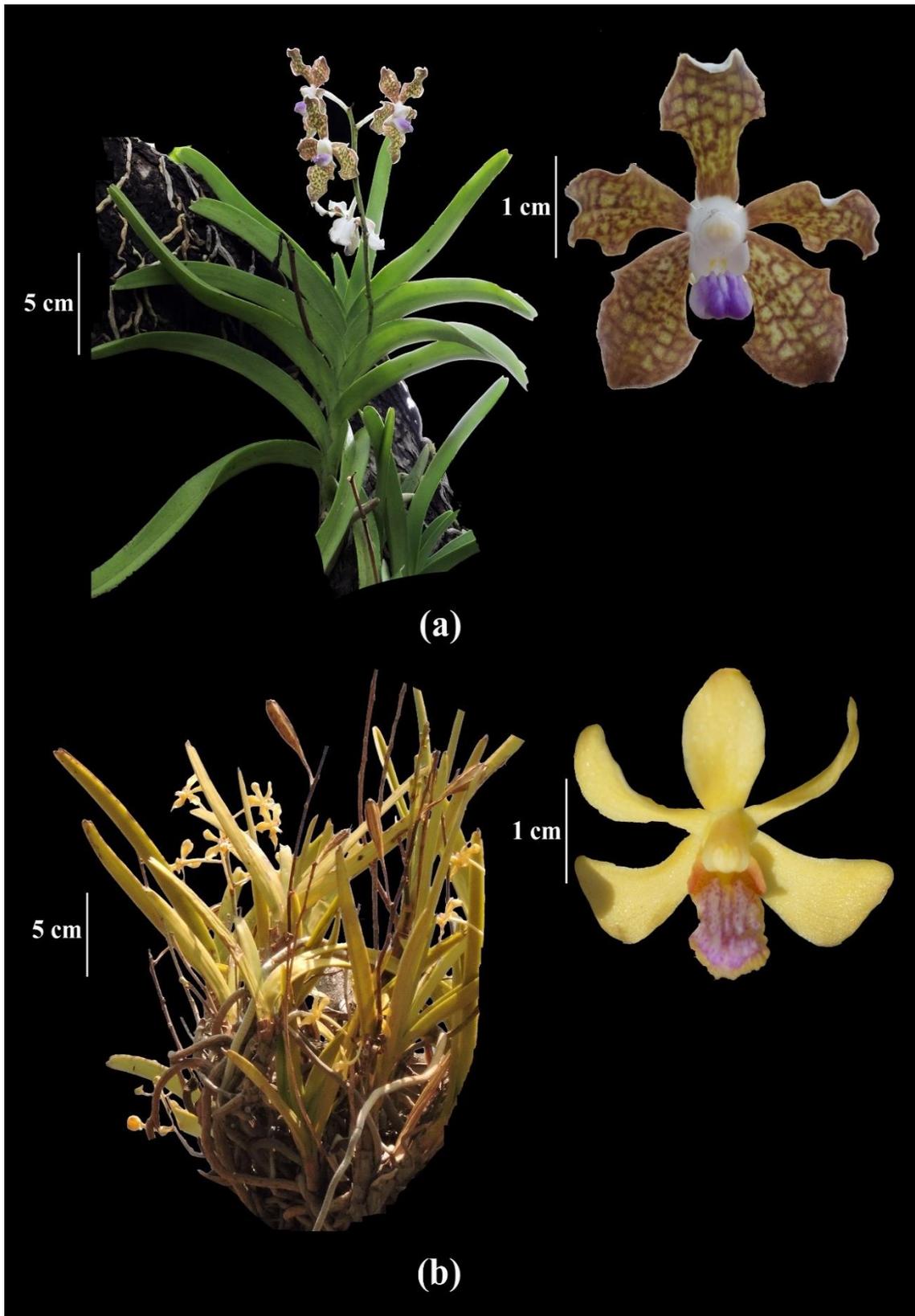
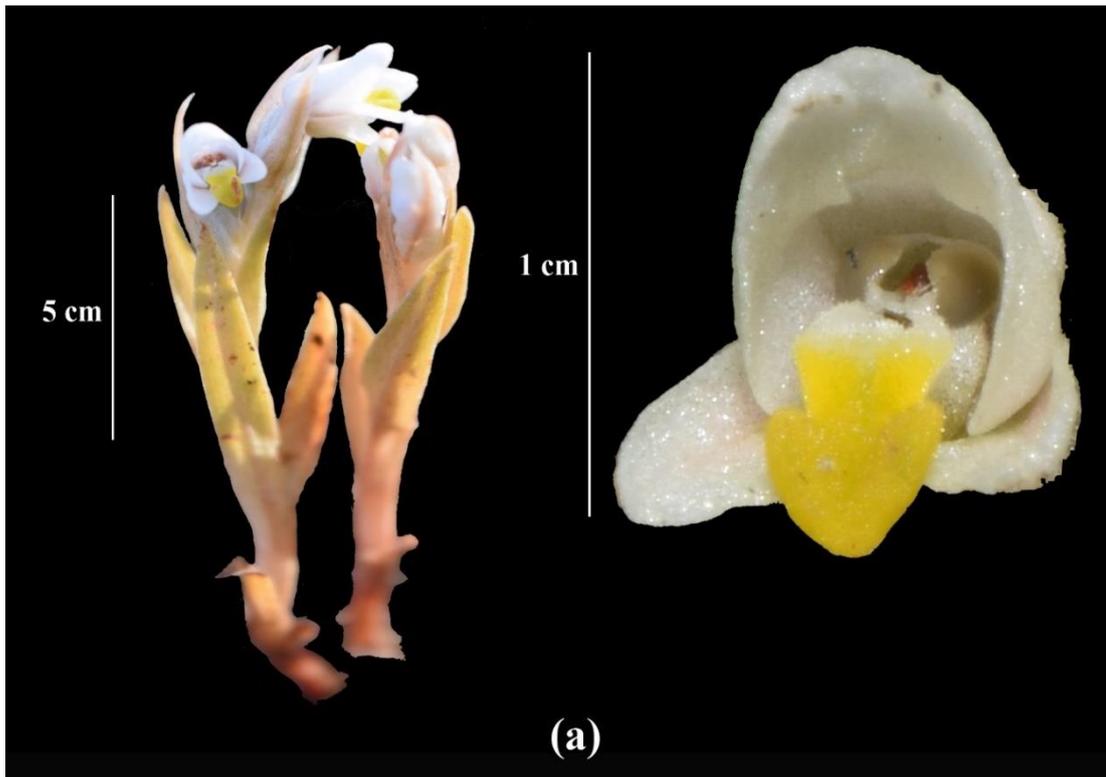


Plate 2.15: (a) *Vanda tessellata*; (b) *Vanda testacea*



**Plate 2.16: (a)** *Zeuxine strateumatica*

### 2.4.3. Host tree Preference

Epiphytic orchids are highly vulnerable to anthropogenic influences and also have to depend on some host species for their growth. Host position and type (Flores-Palacios and García-Franco, 2006; Hirata et al., 2009; Timsina et al., 2016), as well as the growth of epiphytic species, are influenced by different environmental factors such as annual precipitation, light intensity, humidity (Wolf et al., 2003; Werner and Gradstein, 2009), climatic conditions (Callaway et al., 2002; Adhikari et al., 2012b; Adhikari et al., 2016), host tree size (Wolf, 2005; Flores-Palacios and García-Franco, 2006; Adhikari et al., 2012b), bark roughness (Callaway et al., 2002; Adhikari et al., 2012a; Adhikari et al., 2012b; Timsina et al., 2016) and bark pH (Adhikari et al., 2015).

In the present study, a total of 12 species of epiphytic orchids were recorded on 24 host tree species. The detail of host trees with their bark characteristics is mentioned in Table 2.5. Out of 24 host species, three species namely *Madhuca indica*, *Terminalia crenulata* and *Tectona grandis* are the most preferred hosts by the number epiphytic species. These three preferred hosts have smooth or rough bark with longitudinal fissures.

Host trees with rough bark are more frequently colonized by epiphytes (Table 2.5) as reported by Callaway et al. (2002) and Adhikari et al. (2012a). The main reason for higher epiphytic diversity on rough bark is that it retains moisture for longer period of time and seedling recruitment is better as seeds anchors more easily in the fissures of rough bark than on smooth bark (Zimmerman and Olmsted, 1992; Adhikari and Fischer, 2011). The orchids are more abundant on tall trees (Kromer et al., 2007) because they are more exposed to light. Likewise, compared to dry deciduous forest (5 species) the diversity of orchids in moist deciduous forest is more (12 species) because the humidity in moist deciduous forests is throughout year due to which it became a suitable habitat for epiphytic species (Timsina et al., 2016). *Terminalia crenulata* and *Tectona grandis* hosted similar orchid communities while *Madhuca indica* and *Mangifera indica* exhibited similar orchid communities.

**Table 2.5:** Host Specificity of Epiphytes

Host species	Bark type	Orchid species												
		1	2	3	4	5	6	7	8	9	10	11	12	
<i>Acacia catechu</i>	Rough, longitudinally fissured, exfoliating flakes													
<i>Acacia chundra</i>	Rough, longitudinally fissured, exfoliating flakes													
<i>Bombax insigne</i>	Rough, with shallow longitudinal fissures, prickled													
<i>Bridelia retusa</i>	Rough with stout conical spines													
<i>Butea monosperma</i>	Rough and fibrous along with reddish exudates													
<i>Casuarina equisetifolia</i>	Rough, furrowed and flaking													
<i>Erythrina stricta</i>	Rough, corky, deeply furrowed													
<i>Dalbergia sissoo</i>	Rough along with longitudinal furrows													
<i>Diospyros melanoxylon</i>	Rough, exfoliating in rectangular scales													
<i>Garuga pinnata</i>	Rough, shallow longitudinal furrows, exfoliating													

Host species	Bark type	Orchid species												
		1	2	3	4	5	6	7	8	9	10	11	12	
<i>Heterophragma quadriloculare</i>	Rough, exfoliating in small angular scales		Blue		Blue									
<i>Lanea coromandelica</i>	Smooth with shallow longitudinal fissures and cracks										Blue			
<i>Madhuca indica</i>	Smooth with shallow longitudinal fissures	Green	Green	Green					Red			Green		
<i>Mangifera indica</i>	Rough, furrowed with many thin fissures	Green										Blue	Blue	
<i>Meyna laxiflora</i>	Smooth				Red									
<i>Mitragyna parvifolia</i>	Smooth, exfoliating leaving shallow depressions				Red	Red		Red	Red		Red		Red	
<i>Peltophorum pterocarpum</i>	Smooth				Red	Blue								
<i>Schleichera oleosa</i>	Smooth and round irregular flakes												Red	
<i>Syzigium cumini</i>	Rough, cracked, flaking				Red	Red								
<i>Tamarindus indica</i>	Rough, fissured	Blue	Red											
<i>Tectona grandis</i>	Shallow longitudinal fissures, exfoliating	Red	Green		Blue	Green		Green	Green	Green	Red	Blue	Green	
<i>Terminalia crenulata</i>	Rough with deep longitudinal fissures, exfoliating		Blue		Green	Green		Green	Green	Blue	Blue	Blue	Blue	
<i>Trewia polycarpa</i>	Smooth to rugose, often peeling in thin plates					Red								
<i>Wrightia tinctoria</i>	Smooth, scaly		Red			Red		Red	Red	Green	Red	Blue	Green	

**Green: Commonly (found > 30 times); Blue: Occasionally (found < 30 ≥ 5 times); Red: Rarely (< 5 times)**

**1.** *Acampe praemorsa*; **2.** *Aerides maculosa*; **3.** *A. ringens*; **4.** *Dendrobium barbatulum*; **5.** *D. microbulbon*; **6.** *D. ovatum*; **7.** *D. peguanum*; **8.** *Oberonia falconeri*; **9.** *O. mucronata*; **10.** *Rhynchostylis retusa*; **11.** *Vanda tessellata*; **12.** *V. testacea*

#### 2.4.4. Not located and misinterpreted species

Shah (1978) provided inadequate data about the distribution and status of orchids in the flora of Gujarat. During the present survey 10 species namely *Aerides crispum*, *Conchidium filiforme*, *Eulophia dabia* (syn. *E. ramentacea*), *E. spectabilis*, *Geodorum densiflorum*, *Habenaria commelinifolia*, *H. digitata*, *Oberonia brunoniana*, *Pecteilis susannae* and *Peristylus goodyeroides* could not be located.

*C. filiforme*, an epiphytic species was reported by Reddy (1987) on dead tree of *Mangifera indica* in association with *V. tessellata* from Dharampur, Valsad. Since 1987 there are no scientific evidences available on the occurrence of this species. *H. commelinifolia* and *P. susannae* was reported from Parnera hills, Valsad (Vora, 1980) and Waghai taluka, Dangs (Shah, 1978) respectively. Both the sites and surrounding areas with suitable habitat were visited during their flowering period but they could not be relocated. Similarly *E. dabia*, *H. digitata* and *O. brunoniana* were reported by Raghavan et al. (1981) in the checklist of plants of Gujarat. *P. goodyeroides* was reported by Thaker (1974) from Chhota Udepur district. As per the review, the species is mainly distributed in Northeast and Western Ghats while the reported site comes under the Semi-arid region. The occurrence of this species in Gujarat is uncertain. *A. crispum* was reported by Bedi (1968) from Ratanmahal WLS, Panchmahal. Later, the same species was recorded by Thaker et al. (1974) from Luni region of Chhota Udepur, Patel (1971) and Vora (1980) from Bulsar and Tadvi (2013) from Dangs. The above described species could not be relocated even though the study area was extensively explored. There is a possibility that the species either have been misinterpreted or lost their natural habitat due to anthropogenic pressure.

Tadvi (2013) has also collected a species of *Geodorum* from Dangs and identified it as *G. densiflorum* (Lam.) Schltr. During survey the same species was recollected from the same locality and after critical observation it was identified as *G. laxiflorum* Griff. *G. laxiflorum* is distinctly recognized from *G. densiflorum* by its short and decurved inflorescence (Annexure 4).

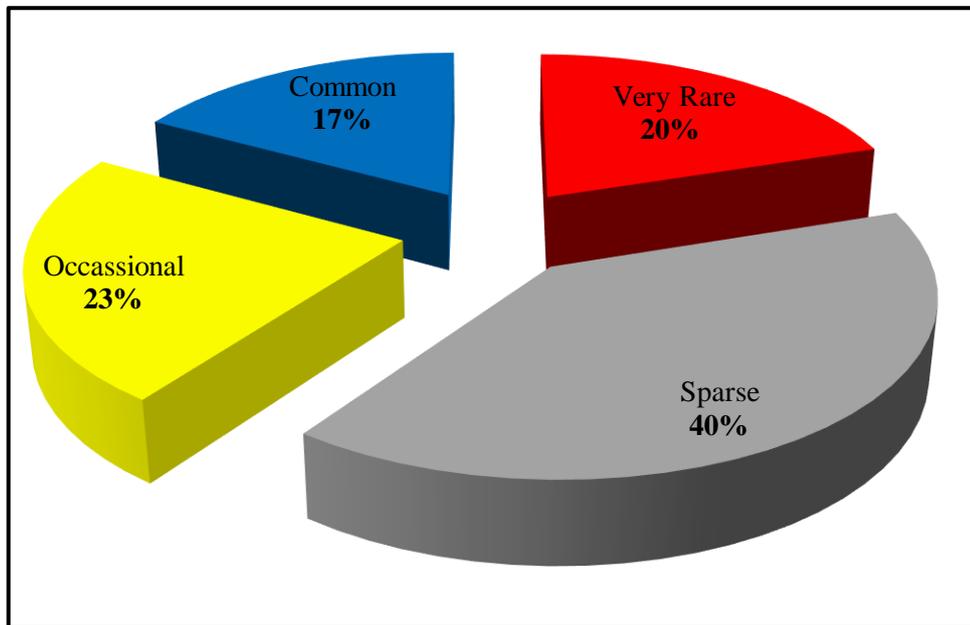
#### 2.4.5. New Records

In the current survey five species of orchids were reported as new addition to the state. The five newly reported species were *Aerides ringens* Fischer (Bhatt and Nagar,

2014) (Annexure 2), *Habenaria rariflora* A. Rich., *Geodorum laxiflorum* Griff. (Bhatt et al., 2015) (Annexure 4), *Oberonia mucronata* (D.Don) Ormerod & Seidenf. (Bhatt and Nagar, 2016) (Annexure 5) and *Peristylus constrictus* (Lindl.) Lindl. (Bhatt et al., 2016) (Annexure 7).

#### 2.4.6. Status of Orchids

To analyze the status of orchids across various biogeographical zones is ecologically a complex matter. The flowering pattern of orchids varies in different sites and is of very short duration. Therefore, it is very difficult to visit all the sites at the same time period. In addition, the morphological similarity of the terrestrial orchids in vegetative phase makes it difficult to distinguish. Although, the successive efforts have been made to study the distribution pattern of orchids from every possible location of the targeted study area. The study reveals that 20% of orchid species are very rare, 40% are sparse, 23% are occasional and 17% are common in Gujarat (Figure 2.34). The detail of species with their rarity status is given in Table 2.6.



**Figure 2.34:** Status Representation of Orchids (n=30 species)

Some of the orchids namely *Aerides ringens*, *Habenaria longicorniculata*, *H. plantaginea*, *H. rariflora*, *Oberonia falconeri*, *O. mucronata*, *Peristylus constrictus* and *P. stocksii* have restricted distribution (located from one or two site). The species with restricted distribution are more prone to extinction, as slight change in their habitat may lead to their extinction regionally. Anthropogenic threatening is the prime factor for

reduction in species distribution and abundance (Cribb et al., 2003; Koopwitz et al., 2003). Other main threats noticed during the study are over grazing, cutting of side branch of the tree, land clearing for agricultural practices, land slide, habitat fragmentation and destruction.

#### 2.4.7. *Ex-Situ* Conservation

Humans exploited natural resources for their benefit from centuries. The constant rise in demand for the large land area, agriculture as well as timbers leads to the destruction of many forests. The extensive devastation of forests leads to extinction of number of species and many of them are becoming endangered. The populations of orchid are gradually disappearing from the forests either due to deforestation, annexation of land area, over collection by the amateurs and professional orchidists. Furthermore, the ravaging of forests for excessive demands of timber, particularly 'teak' in Gujarat has destroyed the substantial number of epiphytic orchids growing on the trees as well as the terrestrial orchids. As the economical and medicinal values of orchids are very high, the conservation of orchids is indispensable from the scientific point of view.

In the present study, an Orchidarium was constructed in the Arboretum of the Maharaja Sayajirao University of Baroda, Vadodara (Plate 2.17 and 2.18) and Waghai Botanical Garden, Dangs (Plate 2.19). The foremost goal for the establishment of the Orchidarium was to represent the diversity of Orchidaceae in Gujarat region. It was established for conservation, public education and also to create awareness among the people.

Out of 30 species located during the survey, a total of 24 species were successfully conserved at both the sites of which 10 were epiphytic and 14 were terrestrial (Table 2.6). The rare species of orchids were not collected for the conservation and allowed to grow in their natural habitat without any disturbance. It is the first dedicated effort of orchid *ex-situ* conservation in Gujarat.

**Table 2.6:** List of Orchids of Gujarat with their threat status and Conservation

SN	Orchid Name	Habit	Status	MG	WG
1.	<i>Acampe praemorsa</i>	E	O	+	+
2.	<i>Aerides maculosa</i> (Endemic)	E	S	+	+
3.	<i>A. ringens</i>	E	R	-	-

SN	Orchid Name	Habit	Status	MG	WG
4.	<i>Crepidium mackinnonii</i>	T	S	-	+
5.	<i>Dendrobium barbatulum</i> (Endemic)	E	S	+	+
6.	<i>D. microbulbon</i> (Endemic)	E	S	+	+
7.	<i>D. ovatum</i> (Endemic)	E	R	-	-
8.	<i>D. peguanum</i>	E	S	-	+
9.	<i>Eulophia herbacea</i>	T	S	+	-
10.	<i>E. ochreatea</i> (Endemic)	T	S	+	+
11.	<i>Geodorum laxiflorum</i> (Endemic)	T	R	+	+
12.	<i>Habenaria furcifera</i>	T	O	+	+
13.	<i>H. gibsonii</i> (Endemic)	T	S	+	+
14.	<i>H. grandifloriformis</i> (Endemic)	T	S	+	+
15.	<i>H. longicorniculata</i>	T	R	-	-
16.	<i>H. marginata</i>	T	O	+	+
17.	<i>H. plantaginea</i>	T	S	-	+
18.	<i>H. rariflora</i> (Endemic)	T	R	-	-
19.	<i>Nervilia concolor</i>	T	C	+	+
20.	<i>N. plicata</i>	T	C	+	+
21.	<i>Oberonia falconeri</i>	E	O	+	-
22.	<i>O. mucronata</i>	E	O	+	+
23.	<i>Peristylus constrictus</i>	T	S	+	-
24.	<i>P. lawii</i>	T	O	+	+
25.	<i>P. plantagineus</i>	T	S	+	+
26.	<i>P. stocksii</i> (Endemic)	T	R	-	-
27.	<i>Rhynchostylis retusa</i>	E	C	+	+
28.	<i>Vanda tessellata</i>	E	C	+	+
29.	<i>V. testacea</i>	E	O	+	+
30.	<i>Zeuxine strateumatica</i>	T	C	-	-

**E** - Epiphytic; **T** - Terrestrial; **R** - Rare; **S** - Sparse; **O** - Occasional; **C** - Common

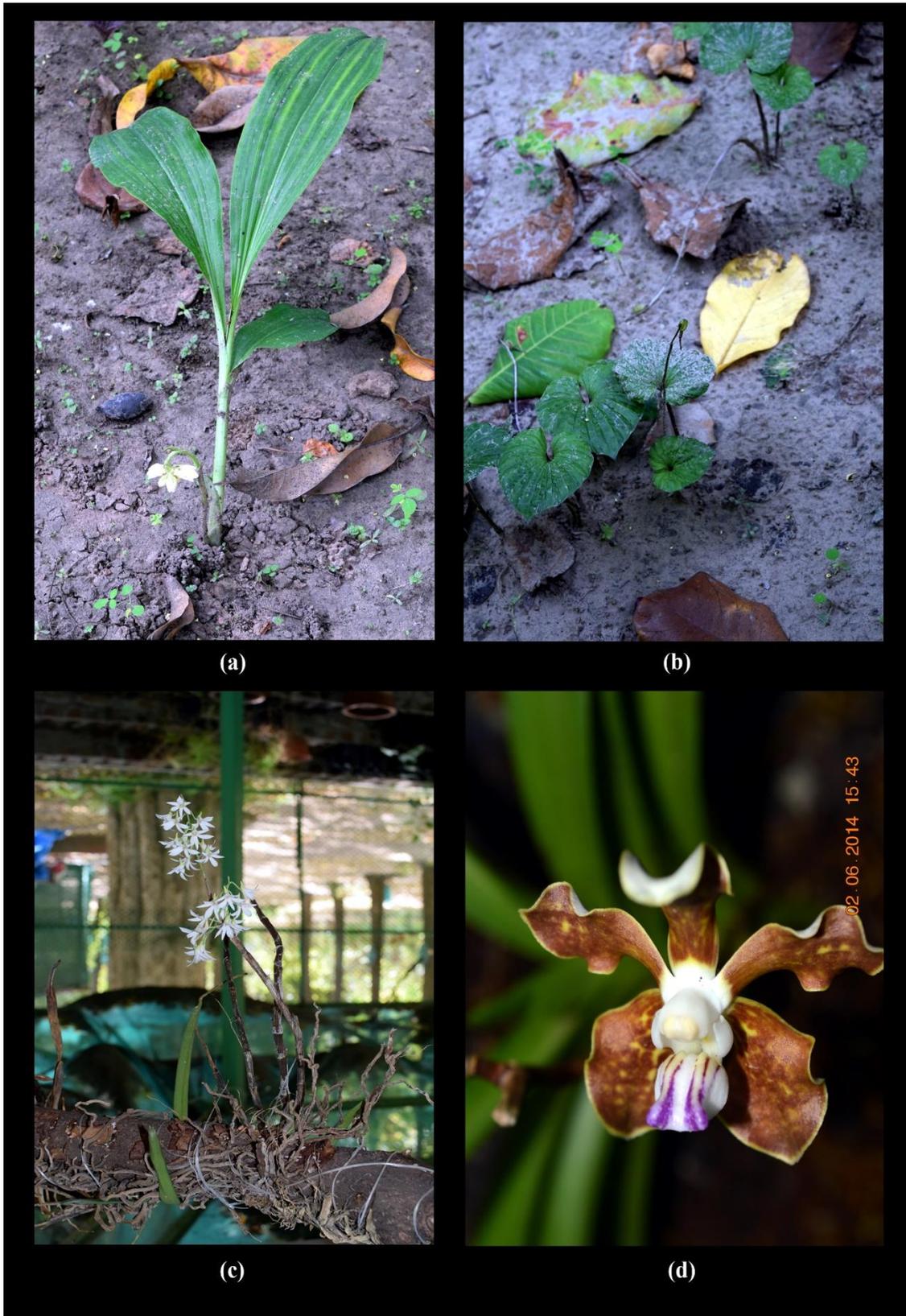
**MG** -Species maintained in Arboretum, The Maharaja Sayajirao University of Baroda;

**WG** - Species maintained in Waghai Botanical Garden, Dangs

‘+’ Collected and conserved; ‘-’ not conserved



**Plate 2.17:** Conservation of Orchids at Arboretum of The M. S. University of Baroda  
**(a)** Terrestrial Orchids **(a1)** *N. plicata*, **(a2)** *E. ochreatea*, **(a3)** *G. laxiflorum*, **(a4)** *H. marginata*;  
**(b)** Epiphytic Orchids **(b1)** *A. praemorsa*, **(b2)** *V. testacea*, **(b3)** *A. maculosa*,  
**(b4)** *R. retusa*, **(b5)** *V. tessellata*



**Plate 2.18:** Conservation of Orchids at Arboretum of The M. S. University Baroda (a) Flowering in *Geodorum laxiflorum*; (b) Fruiting in *Nervilia concolor*; (c) Flowering in *Dendrobium barbatulum*; (d) Flowering in *Vanda tessellata*



**Plate 2.19:** Conservation of Orchids at Waghai Botanical Garden, Dangs (a) Terrestrial Orchids (a1) *C. mackinnonii*, (a2) *N. concolor*, (a3) *N. plicata*, (a4) *E. ochreatea*, (a5) *G. laxiflorum*, (a6) *H. furcifera*, (a7) *H. gibsonii*, (a8) *H. marginata*, (a9) *H. grandifloriformis*, (a10) *H. plantagineus*, (a11) *P. lawii*, (a12) *P. plantagineus*; (b) Epiphytic Orchid

## 2.5. CONCLUSION

This chapter provides the detail information about the diversity of orchids in various biogeographical regions of Gujarat. During the present investigation 30 species of the orchids were located, out of 35 species which were reported in literature. Out of 30 species, five were reported as new distributional records for the state. The remaining 10 species of orchids, which were reported by earlier workers could not be located. This shows that either they are extremely rare or locally extinct due to habitat alternation and anthropogenic threats. Among the 30 species reported during present work, 10 are endemic to India. From the study of rarity status, it was concluded that almost all the species located are regionally threatened. Hence, the efforts of *ex-situ* conservation were made at the Arboretum of the Maharaja Sayajirao University of Baroda, Vadodara and Waghai Botanical Garden, Dangs. A total of 24 species of orchids were successfully conserved at both the sites. The *in-situ* conservation of orchids is very crucial for their flourishing in natural habitat. Host-tree relationships are very important for the epiphytic species, so the preferred host tree species are need to be conserved for the growth of epiphytic orchids.

## 2.6. REFERENCES

- Abraham, A., Vatsala, 1981. Introduction to Orchids: With Illustrations and Descriptions of 150 South Indian Orchids. Tropical Botanic Garden and Research Institute, 1 – 32.
- Adhikari Y.P., Fischer A., 2011. Distribution pattern of the epiphytic orchid *Rhynchostylis retusa* under strong human influence in Kathmandu valley, Nepal. *Botanica Orientalis: J. Plant Sci.* 8, 90 – 99. doi:10.3126/botor.v8i0.5956
- Adhikari Y.P., Fischer A., Pauleit S., 2015. Sustainable conservation perspectives for epiphytic orchids in the central Himalayas, Nepal. *Appl. Ecol. Environ. Res.* 13, 753 – 767. doi:10.15666/aeer/1303\_753767
- Adhikari, Y.P., Fischer, A., Fischer H.S., 2012a. Micro-site conditions of epiphytic orchids in a human impact gradient in Kathmandu valley, Nepal. *J. Mt. Sci.* 9, 331 – 342. doi:10.1007/s11629-009-2262-1
- Adhikari, Y.P., Fischer, H.S., Fischer, A., 2012b. Host tree utilization by epiphytic orchids in different land-use intensities in Kathmandu valley, Nepal. *Plant Ecol.* 213, 1393 – 1412. doi:10.1007/s11258-012-0099-0
- Ahmedullah, M., Nayar, M.P., 1986. Endemic Plants of the Indian Region, Flora of India. Botanical Survey of India Volume I, 143 – 153.
- Aitchison, J.E.T., 1869. A Catalogue of the Plants of the Punjab and Sindh: To which are Added Some Others That, from Their Present Geographical Proximity, May be Found Hereafter to Occur in the Punjab. Taylor & Francis, 147.
- Alappatt, J.P., 2016. Additions to the orchid flora of Andaman and Nicobar Islands, India. *Rheedea* 26, 165 – 170.
- Anderson, L., 1968. Methods of Native Orchid Conservation. *Am. Orch. Soc. Bull.* 37, 293 – 305.
- Anonymous, 1996. The Biological Diversity of Gujarat: Current Knowledge. Gujarat Ecology Commission, Vadodara, 1 – 350.
- Anonymous, 2002. Conservation of Rare and Endangered Biodiversity of Gujarat

- (CREB). Gujarat Ecology Commission, Vadodara, 1 – 428.
- Ansari, R., Balakrishnan, N.P., 1990. A Revision of the Indian Species of *Oberonia* (Orchidaceae), Orchid monographs. Rijksherbarium/Hortus Botanicus, 1 – 82.
- Arora, R.K., Wadhwa, B.M., Raizada, M.B., 1981. The Botany of South Kanara District, Indian Journal of forestry: Additional series. Bishen Singh Mahendra Pal Singh Publisher, 1 – 64.
- Atkinson, E.T., 1882. The Himalayan Gazetteer, or, The Himalayan Districts of the North Western Province of India. Low Price Publications, 1000 – 1064.
- Bakshi, D.N.G., 1984. Flora of Murshidabad District, West Bengal, India. Scientific Publishers, 310 – 313.
- Banerjee, M.L., Thapa, B.B., 1978. Orchids of Nepal. New Delhi, India, 1 – 12.
- Barua, I.C., 2001. Orchid Flora of Kamrup District, Assam: With Illustrations. Bishen Singh Mahendra Pal Singh, 1 – 10.
- Baruah, B.N., 1978. Studies on Systematics of Orchids in The Brahmaputra Valley, Assam. University of Guwahati, Assam, Ph.D. Thesis.
- Baruah, B.N., Boissya, C.L., 1978. *Vanda terea* & *Dendrobium acinaciforme* - Two orchids of Assam. Ann. Orch. Soc. Bull. 47, 416 – 417.
- Bedi, S.J., 1968. Floristic Study of Ratan Mahal and Surrounding hills. The Maharaja Sayajirao University of Baroda, Vadodara, Gujarat, Ph.D. Thesis.
- Bedi, S.J., 1973. Studies on the Flora and Vegetation of Ratanmahal Hills, Gujarat State, India. Bull. Natl. Sci. Acad. 45, 1 – 9.
- Bhatt, M.P., 1987. Contribution to the flora of Navsari area with special reference to Ethnobotany. South Gujarat University, Surat, Gujarat, Ph.D. Thesis.
- Bhatt, M.R., Jalal, J.S., Nagar, P.S., 2015. Extended distribution of *Geodorum laxiflorum* (Orchidaceae) in Gujarat, India. Richardiana 333 – 341.
- Bhatt, M.R., Nagar, P.S., 2014. *Aerides ringens* (Lindl.) C.E.C. Fisch: A new addition to the orchid flora of Gujarat, India. J. Orchid Soc. India 28, 115 – 117.

- Bhatt, M.R., Nagar, P.S., 2016. *Oberonia mucronata* (D. Don) Ormerod & Seidenf. (Orchidaceae), new addition to the flora of Gujarat, India. J. Threat. Taxa 8, 8412 – 8414. <https://doi.org/10.11609/JoTT.17apr15.7047-7088>
- Bhatt, M.R., Nagar, P.S., Singh, A.P., 2016. *Peristylus constrictus* (Orchidaceae) - A new addition for Gujarat, India. Indian For. 143, 1140 – 1141.
- Bhatt, R.G., 1975. A contribution to the Floristics and Phytosociology of the Panchmahal Districts in Gujarat. Sadar Patel University, Vallabh Vidyanagar, Gujarat, Ph.D. Thesis.
- Bhatt, R.P., 1971. Studies on the flora and vegetation Khedbrahma region of Khedbrahma region in North Gujarat with a note on the chromosome number and karyotype of some taxa therein. The Maharaja Sayajirao University of Baroda, Vadodara, Gujarat, Ph.D. Thesis.
- Bhattacharjee, B., 2009. Studies on Diversity of Orchid Flora in Southern Assam and Their Conservation. Assam University, Silchar, Assam, Ph.D. Thesis.
- Blatter, E., 1928. A list of orchids with some new species from High Wavy Mountain (Madurai District). J. Bombay Nat. Hist. Soc. 32, 518 – 523.
- Blatter, E., McCann, C., 1931. Revision of the flora of the Bombay Presidency (Orchidaceae). J. Bombay. Nat. Hist. Soc. 35, 252 – 275.
- Bole, P.V., Pathak, U.M., 1988. Flora of Saurashtra. Botanical Survey of India, Howrah, Kolkata, 137 – 154.
- Bose, T.K., Bhattacharjee, S.K., 1980. Orchids of India. Naya Prokash, Calcutta, 1 – 50.
- Brühl, P., 1926. A Guide to the Orchids of Sikkim: Being a Guide to the Identification of those Species of Orchids Found Between the Terai and the Northern Frontier of Independent Sikkim Including the Chumbi Valley and British Bhutan. Bishen Singh Mahendra Pal Singh Publisher, 1 – 13.
- Callaway R.M., Reinhart K.O., Moore G.W., 2002. Epiphyte host preferences and host traits: mechanisms for species-specific interactions. Oecologia 132, 221 – 230. doi:10.1007/s00442-002-0943-3

- Champion, H.G., Seth, S.K., 1968. A revised survey of the forest types of India. Natraj Publisher, Dehradun, New Delhi, India, 1 – 34.
- Chatterjee, D., 1939. Studies on the endemic flora of India and Burma. J. Asiat. Soc. Bengal 5, 19 – 67.
- Chatterjee, D., 1962. Floristic patterns of Indian vegetation. Proc. Summer School of Botany, Darjeeling, New Delhi, India, 32 – 42.
- Chavan, A.R., Bedi, S.J., Sabnis, S.D., 1961. Contribution to the flora of Devgad hills, Devgad Bariya. J. Maharaja Sayajirao Univ. Baroda 10, 43 – 57.
- Chavan, A.R., Oza, G.M., 1966. Flora of Pavagadh (Gujarat State, India). Department of Botany, Faculty of Science, The Maharaja Sayajirao University of Baroda, Vadodara, Gujarat, Ph.D. Thesis.
- Chawngthantluanga, 1996. Orchids of Mizoram Volume 1. Department of Environment & Forests, Govt. of Mizoram 1 – 29.
- Chowdhery, H.J., 1998. Orchid Flora of Arunachal Pradesh. Bishen Singh Mahendra Pal Singh Publisher, 1 – 51.
- Chowdhury, H.J., Pal, G.D., 1997. Orchidaceae of Arunachal Pradesh, A check list (Higher Plants of Indian Subcontinent), Volume 7. Bishen Singh Mahendra Pal Singh Publisher, 1 – 198.
- Chowdhury, S., 1987. Some Rare and imperfectly known species of Orchids of Assam-II. J. Assam Sci. Soc. 30, 22 – 32.
- Chowdhury, S., Baruah, S.N., Baruah, H.K., 1971. Some rare and imperfectly known species of orchids of Assam - I. J. Assam. Sci. Soc. 14, 129 – 135.
- Clarke, C.B., 1898. Sub-areas of British India, Illustrated by the detailed distribution of Cyperaceae in that Empire. J. Linn. Soc. 34, 1 – 136.
- Collett, H., Hemsley, W.B., 1902. Flora simlensis: a handbook of the flowering plants of Simla and the neighbourhood. Thacker, Spink & Co, 489 – 508.
- Contracter, G.J., 1986. A contribution to the Floristic, Phytosociology and Ethnobotany of Vapi and Umergaon areas in South Gujarat. Sardar Patel University, Vallabh

- Vidyanagar, Gujarat, Ph.D. Thesis.
- Cooke, T., 1958. The Flora of the Presidency of Bombay. Botanical Survey of India, 186 – 222.
- Cribb, P.J., Kell, S.P., Dixon, K.W., Barrett, R.L., 2003. Orchid conservation: a global perspective. In. Orchid Conservation: (Eds.) Natural History Pub., Kota Kinabalu, Sabah, 1 – 4.
- Dangat, B.T., 2015. Studies on Systematics of the Genus *Habenaria* Willd. (Orchidaceae) in Western Ghats. Shivaji University, Kolhapur, Maharashtra, Ph.D. Thesis.
- Das, S.J., Jain, S.K., 1980. Fascicles of Flora of India. Volume 5: Orchidaceae: Genus *Coelogyne*. Botanical Survey of India, Howrah, Calcutta, India, 1 – 33.
- De, L.C., Medhi, R.P., 2014. Diversity and Conservation of Rare and Endemic Orchids of North East India - A Review. Indian J. Hill Farming 27, 138 – 153.
- Deb, C.R., Imchen, T., 2008. Orchid diversity of Nagaland. Scichem Publishing House, 1 – 56.
- Deb, D.B., 1983. Records of the Botanical Survey of India. Volume XXIII: Flora of Tripura state. Botanical Survey of India, Howrah, Calcutta, India, 486 – 547.
- Desai, M.J., 1976. A Contribution to the Flora of Bansda Forest. Sardar Patel University, Vallabh Vidyanagar, Gujarat, Ph.D. Thesis.
- Desai, P.R., 2013. Studies on Floristic Diversity, Ethnobotany and Resources Survey in Jessore Wildlife Sanctuary of Banaskantha District, Gujarat. Hemchandracharya North Gujarat University, Patan, Gujarat, Ph.D. Thesis.
- Dhar, U., Kachroo, P., 1983. Alpine flora of Kashmir Himalaya. Scientific Publishers, 1 – 280.
- Dressler, R.L., 1981. The orchids: natural history and classification. Harvard University Press, 22 – 100.
- Drury, H., 1864. Hand-book of Indian Flora: Being a Guide to All the Flowering Plants Hitherto Described as Indigenous to the Continent of India. Trabancore Sircar

- Press, 1 – 605.
- Duthie, J.F., 1906. The orchids of north-western Himalaya. *Ann. R. Bot. Gard. Calcutta* 9, 81 – 211.
- Faden, R.B., Dahlgren, R.M.T., Jacobsen, N., Clifford, H.T., Jakobsen, K., Yeo, P.F., Jensen, S.R., Nielsen, B.J., Rasmussen, F.N., 1985. *The Families of the Monocotyledons: Structure, Evolution, and Taxonomy*. Springer Berlin Heidelberg, 1 – 106.
- Fischer, C.E.C., 1921. Survey of Flora of Anamalai Hills. Volume IX. Botanical Survey of India, Howrah, Calcutta, India, 1 – 218.
- Fischer, C.E.C., 1928. Orchidaceae, in: *Flora of the Presidency of Madras* (Gamble, J S), *Flora of the Presidency of Madras*. West, Newman and Adlard, 199 – 202.
- Flores-Palacios A., García-Franco J.G., 2006. The relationship between tree size and epiphyte species richness: testing four different hypotheses. *J. Biogeogr.* 33, 323 – 330. doi:10.1111/j.1365-2699.2005.01382.x
- FSI, 2009. *India State of Forest Report 2009*. (Ministry of Environment and Forests, Government of India). Dehradun, India, 82 – 85.
- Fyson, P.F., 1915. *The flora of the Nilgiri and Pulney hill-tops*, Volume 1. Government Press, Madras, 109 – 113.
- Gammie, G.A., 1886. The Orchids of the Bombay Presidency, in: *The J. Bombay Nat. Hist. Soc.* Volume I. 16, 429 – 433, 562 – 569; 17, 31 – 37, 940 – 942; 18, 88 – 90.
- Ghose, B.N., 1978. *Beautiful Indian Orchids and how to grow them*. G. Ghose Publishing Press, 1 – 200.
- Gogoi, K., 2015. Orchids in Assam, India : The Genus *Paphiopedilum* Pfitzer Taxonomic studies Enumeration of Species. *MIOS J.* 16, 2 – 7.
- Govaerts, R., Dransfield, J., Zona, S., Hodel, D.R., Henderson, A., 2017. WCSP (2017). *World Checklist of Selected Plant Families*. R. Bot. Gard. URL <http://wmsp.science.kew.org>
- Griffith, W., 1851. *Posthumous Papers Bequeathed to the Hon., the East India Company*,

- and Printed by Order of the Government of Bengal: Notulae Ad Plantas Asiaticas. III. Bishop's College Press, 1 – 806.
- Gurav, R.V., 2007. Studies in Orchids from Western Ghats. Shivaji University, Maharashtra, Ph.D. Thesis.
- Haines, H.H., 1922. Botany of Bihar & Orissa. Wentworth Press, 1 – 159.
- Hirata A., Kamijo T., Saito S., 2009. Host trait preferences and distribution of vascular epiphytes in a warm-temperate forest. *Plant Ecol.* 201, 247 – 254. doi:10.1007/s11258-008-9519-6
- Holttum, R.E., 1977. A personal view of orchids, in: *Orchid Biology-Reviews and Perspectives*. Springer New York, USA, 1 – 12.
- Hooker, J.D., 1890. *The Flora of British India: Volume 5 Chenopodiaceae to Orchideae*. London Reeve Publisher, 1 – 914.
- Hooker, J.D., 1894. *Flora of British India: Volume 6 Orchideae to Cyperaceae*. London Reeve Publisher, 1 – 792.
- Hooker, J.D., 1895. A Century of Indian Orchids, *Annals of the Royal Botanic Garden, Calcutta*. J. Cramer, 1 – 68.
- Hooker, J.D., 1906. *A Sketch of the Flora of British India*. Eyre and Spottiswoode Press, 1 – 69.
- Hunt, P.F., 1968. Conservation of Orchids. *Orch. Rev.* 76, 320 – 327.
- Hunt, P.F., 1970. Conservation Orchids. *Amm. Orch. Soc. Bull.* 78, 83 – 85.
- Hynniewta, T.M., 1984. *Orchidaceae of Nagaland*. University of Guwahati, Assam, Ph.D. Thesis.
- Hynniewta, T.M., Kataki, S.K., Wadhwa, B.M., 2000. *Orchids of Nagaland*. Botanical Survey of India, Howrah, Calcutta, India, 1 – 306.
- Inamdar, J.A., Patel, R.M., 1971. A Preliminary Floristic Survey of Bulsar-Tithal-Dungari Area in Gujarat State. *Indian For.* 97, 322 – 331.
- Jain, S.K., Mehrotra, A., 1984. A Preliminary Inventory of Orchidaceae in India.

- Botanical Survey of India, Howrah, Calcutta, India, 1 – 133.
- Jain, S.K., Rao, R.R., 1977. A Handbook of Field and Herbarium Methods. Today & Tomorrow's Printers and Publishers, 1 – 157.
- Jalal J.S., 2012. Distribution pattern of orchids in Uttarakhand, Western Himalayas, India, *Int. J. Plant Bio.* 3(e5), 24 – 26.
- Jalal J.S., Jayanthi J., 2018. An Updated Checklist of the Orchids of Maharashtra, India. *Lankesteriana* 18(1), 23 – 62.
- Jalal, J.S., 2012. Status, threats and conservation strategies for orchids of western Himalaya, India. *J. Threat. Taxa.* 4(15), 3401 – 3409.
- Jalal, J.S., Jayanthi, J., 2012. Endemic orchids of peninsular India: a review. *J. Threat. Taxa* 4, 3415 – 3425.
- Jalal, J.S., Jayanthi, J., 2015. An Annotated Checklist of the Orchids of Western Himalaya, India. *Lankesteriana* 15, 7 – 50.
- Jalal, J.S., Kumar, P., Rawat, G.S., Pangtey, Y.P.S., 2008. Orchidaceae, Uttarakhand, Western Himalaya, India. *Check List* 4, 304 – 320.
- Joseph, J., 1982. Orchids of Nilgiris, Records of the botanical survey of India, vol 22. Howrah, Botanical Survey of India, 1 – 144.
- Joseph, J., 1987. Orchids of Nilgiris, [Flora of India : Series 4]. Botanical Survey of India, 1 – 186.
- Joshi, G.C., Tewari, L.M., Lohani, N., Upreti, K., Jalal, J.S., Tewari, G., 2009. Diversity of Orchids in Uttarakhand and their Conservation Strategy with Special Reference to their Medicinal Importance. *Rep. Opin.* 1, 47 – 52.
- Joshi, J.V., 1980. A study of Flora of Surat and its environs. The Maharaja Sayajirao University of Baroda, Vadodara, Gujarat, Ph.D. Thesis.
- Joshi, M.C., 1983. Floristic and Phytosociological survey of some parts of South Gujarat with reference to Medicinal and Ethnobotanical plants. The Maharaja Sayajirao University of Baroda, Vadodara, Gujarat, Ph.D. Thesis.

- Karatela, Y.Y., 1973. A contribution to the floristics and Phytosociology of Chhota Udepur Forest division in Gujarat state. Sardar Patel University, Vallabh Vidyanagar, Gujarat, Ph.D. Thesis.
- Karthigeyan, K., Jayanthi, J., Sumathi, R., Jalal, J.S., 2014. A review of the orchid diversity of Andaman & Nicobar Islands, India. *Richardiana* 15, 9 – 85.
- Kataki, S.K., 1971. Orchidaceae of United Khasi and Jaintia hills, Meghalaya, Assam. University of Guwahati, Assam, Ph.D. Thesis.
- Kataki, S.K., 1976. Indian Orchids - A note on conservation. *Amm. Orch. Soc. Bull.* 45, 912 – 914.
- Kataki, S.K., Goswami, N., 1986. Orchids of Meghalaya. Adland Publicity Pvt, Shillong, 1 – 258.
- Kataki, S.K., Jain, S.K., Sastry, A.R.K., 1984. Distribution of Orchids of Sikkim and North Eastern India. *Plant Cons. Bull.* 5, 1 – 38.
- Kindlmann, P., Balounová, Z., 2001. Irregular flowering patterns in terrestrial orchids: theories vs empirical data. *Web Ecol.* 2, 75 – 82.
- King, G., Pantling, R., 1967. The Orchids of Sikkim Himalaya. Lubrecht & Cramer, Limited, 1 – 448.
- Koopwitz, H., Lavarack, P.S., Dixon, K.W., 2003. The nature of threats to orchid conservation. In. *Orchid Conservation (Eds.) Natural History Pub.*, Kota Kinabalu, Sabah, 25 – 42.
- Kottaimuthu, R., Ganesan, R., Ganesan, V., Sundaram, V.M., 2008. Enumeration of Orchids of Sirumalai Hills (Eastern Ghats), Tamil Nadu, India. *Ethnobot. Leaflet.* 12, 506 – 512.
- Krömer, T., Kessler, M., Gradstein, S.R., 2007. Vertical stratification of vascular epiphytes in submontane and montane forest of the Bolivian Andes: the importance of the understory. *Plant Ecol.* 189, 261 – 278.
- Kumar, C.S., Manilal, K.S., 1994. A catalogue of Indian orchids. Bishen Singh Mahendra Pal Singh Publisher, 1 – 162.

- Kumar, P., Jalal, J.S., Rawat, G.S., 2007. Orchidaceae, Chotanagpur, state of Jharkhand, India. Check List 3, 297 – 304. <https://doi.org/10.15560/3.4.297>
- Kumar, S.C., 1990. Taxonomic studies on the orchids of Kerala. University of Calicut, Kerala, Ph.D. Thesis.
- Kusum, 2014. Population and Ecological Analysis of Some Orchids of Himachal Pradesh and Biochemical Studies on Some Polymorphic Species. Shoolini University, Himachal Pradesh, Ph.D. Thesis.
- Lakshminarasimhan, P., 1996. Flora of Maharashtra State: In Monocotyledones (Shrama, B.D., Karthikeyan, S., Singh, N.P.). Botanical Survey of India, Howrah, Calcutta, India, 8 – 64.
- Lindley, J., 1857. Contributions to the Orchidology of India. No. I. J. Proc. Linn. Soc. London. Bot. 1, 170 – 190.
- Lindley, J., 1858. Contributions to the Orchidology of India. No. II. J. Proc. Linn. Soc. London. Bot. 3, 1 – 63. <https://doi.org/10.1111/j.1095-8339.1858.tb02055.x>
- Linnaeus, C., 1753. Species Plantarum. Laurentius Salvius, Stockholm, 1 – 560.
- Mac, R.N., 1982. A contribution to the Flora of Surat District, Gujarat (Kamrej, Vyara, Songadh, Uchchhal & Nizar talikas). South Gujarat Univerisity, Surat, Gujarat, Ph.D. Thesis.
- Maheshwari, J.K., 1963. The Flora of Delhi. Council of Scientific & Industrial Research, 1 – 447.
- Manilal, K.S., Kumar, C.S., 1993. Field Key for Identification of the Native Orchids of Kerala. Mentor Books, Calicut, 1 – 54.
- Manilal, K.S., Sivarajan, V.V., 1982. Flora of Calicut: the flowering plants of the Greater Calicut area consisting of the western sectors of Calicut and Malappuram districts. Bishen Singh Mahendra Pal Singh Publisher, 1 – 387.
- Mao, A.A., 2010. *Paphiopedilum* of northeast India. Orch. Rev. 118, 88 – 95.
- Mayuranathan, P.V.P., 1929. The flowering plants of Madras City and its immediate neighbourhood. Periodical Expert, 1 – 345.

- Misra, S., 2004. Orchids of Odisha: A Handbook. Bishen Singh Mahendra Pal Singh Publisher, 1 – 424.
- Misra, S., 2007. Orchids of India: A Glimpse. Bishen Singh Mahendra Pal Singh Publisher, 1 – 104.
- Moir, W.W.G., 1968. Conservation and Orchids. *Orch. Rev.* 76, 327 – 331.
- More, P.G., 1972. A contribution to the flora of Panera hills, Pardi and Udhawada area in South Gujarat. South Gujarat University, Ph.D. Thesis.
- Murthy, K.R.K., Yoganarasimham, S.N., 1990. Flora of Coorg (Kodagu) Karnataka, India: With Data on Medicinal Plants and Chemical Constituents. Vimsat Publishers, 1 – 700.
- Nayar, M.P., 1982. Endemic flora of Peninsular India and its significance. *Bull. Bot. Surv. India* 19, 145 – 155.
- Nayar, M.P., 1996. Hot spots of endemic plants of India, Nepal and Bhutan. Tropical Botanic Garden and Research Institute, 202 – 223.
- Nayar, T., Beegam, A., Sibi, M., 2014. Flowering plants of the Western Ghats, India volume 1. Jawaharlal Nehru Tropical Botanic Garden and Research Institute, Thiruvananthapuram, Kerala, India, 1 – 1683.
- Pande, S., Sant, N., Vishwasrao, V., Datar, M., 2010. Wild Orchids of Northern Western Ghats. Tata Power and Ela Foundation, 1 – 21.
- Pandey, V.B., 2011. Plant Species Diversity and their Ethnobotanical study in Tribal area of Bhiloda (West) Forest range of Sabarkantha District (North Gujarat). Hemchandracharya North Gujarat University, Patan, Gujarat, Ph.D. Thesis.
- Patel, R.M., 1971. Flora of Bulsar Environs Gujarat. Sardar Patel University, Vallabh Vidhyanagar, Gujarat, Ph.D. Thesis.
- Paul, P., Kumaria, S., 2017. Orchids, the Marvelous Plants. *NEHU J.* XV, 31 – 40.
- Pfeifer, M., Heinrich, W., Jetschke, G., 2006. Climate, size and flowering history determine flowering pattern of an orchid. *Bot. J. Linn. Soc.*, 151, 511– 526.

- Pijl, L., Dodson, C.H., 1966. Orchid flowers: their pollination and evolution. The Fairchild Tropical Garden and the University of Miami Press, 1 – 214.
- Pradeepkumar, G., 1993. Vegetational and ecological studies of shoolpaneshwar wildlife sanctuary. The Maharaja Sayajirao University of Baroda, Vadodara, Gujarat, Ph.D. Thesis.
- Pradhan, G.M., 1974. Orchid conservation in India. *Amm. Orch. Soc. Bull.* 13, 135– 139.
- Pradhan, U.C., 1976. Indian orchids: guide to identification & culture, Indian Orchids: Guide to Identification & Culture. Pradhan, 12 – 86.
- Pullaiah, T., 1997. Flora Of Andhra Pradesh : Volume III. Scientific Publishers, Jodhpur, India, 301 – 350.
- Raghavan, R.S., Wadhwa, B.M., Ansari, M.Y., Rao, R.S., 1981. A check list of the plants of Gujarat. *Rec. Bot. Surv. India* 21, 1 – 127.
- Raizada, M.B., Duthie, J.F., 1976. Supplement to Duthie’s Flora of the Upper Gangetic Plain and of the adjacent Siwalik and sub-Himalayan tracts, Bishen Singh Mahendra Pal Singh Publisher, 263 – 323.
- Raizada, M.B., Naithani, H.B., Saxena, H.O., 1981. Orchids of Mussoorie. Bishen Singh Mahendra Pal Singh Publisher, 1 – 99.
- Raju, V.S., Reddy, C.S., Reddy, K.N., Rao, K.S., Bahadur, B., 2008. Orchid wealth of Andhra Pradesh, India. *Proc. Andhra Pradesh Akad. Sci.* 12, 180 – 192.
- Rao, A.S., 1979. Orchids of India. National Book Trust, New Delhi, India, 1 – 104.
- Rao, M.R., 1914. Flowering plants of Travancore. Government Press, Trivandrum, Kerala, 396 – 399.
- Rao, R.R., 2012. Floristic diversity in Western Ghats: Documentation, Conservation and Bioprospection-A priority agenda for action. Sahyadri E-News, Western Ghats Biodiversity Information System. Bangalore: Indian Institute of Sciences.
- Rao, R.R., Razi, B.A., 1981. A synoptic flora of Mysore District: with an appendix of unani, ayurvedic, and trade names of drugs, International bioscience series. Today & Tomorrow’s Printers and Publishers, 385 – 597.

- Rao, T.A., 1998. Conservation of Wild Orchids of Kodagu in the Western Ghats. Centre for Technology Development, Bangalore, 79 – 231.
- Rao, T.A., Sridhar, S., 2007. Wild Orchids in Karnataka: A Pictorial Compendium. A Brahmatantra Swatantra Parakalaswamy Matham Publications, 1 – 152.
- Rathore, S.R., 1979. Ecological notes on *Cymbidium aloifolium* Sw. (Orchidaceae) in the Indian Botanic Garden, Howrah. Bull. Bot. Surv. India 21, 168 – 170.
- Rathore, S.R., 1983. Endemic and rare Species of *Calanthe* R. Br. (Orchidaceae) in India, in: An Assessment of Threatened Plants of India (Jian SK, Rao RR). Botanical Survey of India, Howrah, 238 – 239.
- Razi, B.A., 1955. Some Observations on Plants of the South Indian Hilltops and their Distribution. Proc. Nat. Inst. Sci. India, 79 – 89.
- Reddy, A.S., 1987. Flora of Dharampur forests. Sardar Patel University, Vallabh Vidyanagar, Gujarat, Ph.D. Thesis.
- Reddy, C.S., Brahmam, M., Raju, V.S., 2006a. Conservation Prioritization of Endemic plants of Eastern Ghats, India. J. Econ. Taxon. Bot. 30, 755 – 772.
- Reddy, C.S., Pattanaik, C., Murthy, M.S.R., Reddy, K.N., 2006b. Floristic census of Orchids of Eastern Ghats, India. Bot. 56, 1 – 18.
- Rodgers, W.A., Panwar, H.S., Mathur, V.B., 2002. Wildlife Protected Area Network in India: A Review, Executive Summary. Wildlife Institute of India, Dehradun, India, 1 – 44.
- Rosa-Manzano, E., Andrade, J.L., Zotz, G., Reyes-García, C., 2014. Epiphytic orchids in tropical dry forests of Yucatan, Mexico – Species occurrence, abundance and correlations with host tree characteristics and environmental conditions. Flora - Morphology, Distribution, Functional Ecology of Plants. 209(2), 100 – 109.
- Roxburgh, W., 1832. Flora indica, or, Descriptions of Indian plants. Volume 3. Mission Press, 1 – 768.
- Saldanha, C.J., Nicolson, D.H., 1976. Flora of Hassan District, Karnataka, India. Amerind Publishing Company, 1 – 915.

- Santapau, H., 1953. Plants of Saurashtra (a preliminary list.). Saurashtra Res. Soc. Rajkot 1 – 45.
- Santapau, H., 1955. Contributions to the Botany of the Dang Forest. Gujarat Research Society, 1 – 320.
- Santapau, H., 1957. The Flora of Khandala on the Western Ghats of India, Records of the Botanical Survey of India. Manager of Publications, 1 – 335.
- Santapau, H., Kapadia, Z., 1966. The Orchids of Bombay. Manager of Publications, Government of India, New Delhi, India, 1 – 239.
- Santapau, H., Raizada, M.B., 1954. Contribution to the flora of the Gir Forest in Saurashtra. Indian For. 80, 379 – 389.
- Sardesai, M.M., Yadav, S.R., 2004. Genus *Habenaria* Willd. (Orchidaceae) in Maharashtra, in: Biodiversity in India - Volume 3 (Pullaiah, T.). Regency Publications press, New Delhi, India, 144 – 172.
- Sarkar, P.K., 1995. An up-to-date census of Indian orchids. J. Econ. Taxon. Bot. 1 – 31.
- Seidenfaden, G., 1983. Orchidaceae, in: The Flora of the Tamilnadu Carnatic (Mathew K.M.). Rapinat Herbarium, St. Joseph's College, 1609 – 1611.
- Seidenfaden, G., Arora, C.M., 1982. An enumeration of the orchids of Northwestern Himalaya. Nord. J. Bot. 2, 7 – 28. <https://doi.org/10.1111/j.1756-1051.1982.tb01431.x>
- Shah, G.L., 1978. Flora of Gujarat State. Sardar Patel University Press, 1 – 1074.
- Sharma, A.K., 2010. Studies on the diversity, distribution and local utility of medicinal plants in Shoolpaneshwar Wild Life Sanctuary, Gujarat. Sardar Patel University, Vallabh Vidyanagar, Gujarat, Ph.D. Thesis.
- Sharma, B.D., Karthikeyan, S., Singh, N.P., 1996. Flora of Maharashtra State, Volume 2 in: Flora of India, Botanical Survey of India, 8 – 64.
- Sharma, B.D., Singh, N.P., Raghavan, R.S., Deshpande, U.R., 1984. Orchidaceae, in: Flora of Karnataka: Analysis, Flora of India. Botanical Survey of India, Howrah, Calcutta, India, 264 – 278.

- Sharma, S., Singh, S.K., Kumar, R., Mao, A.A., 2013. A compendium of Monopodial Orchids of Meghalaya. *Keanean J. Sci.* 2, 93 – 106.
- Shetty, B.V., Singh, V., 1991. Flora of Rajasthan, Volume II. Botanical Survey of India, Howrah, 1 – 280.
- Shetty, B.V., Singh, V., 1993. Flora of Rajasthan, Volume 2 in: Flora of India Series 2, Botanical Survey of India, 820 – 825.
- Singh, A.P., Parabia, M., 2003. The Floral Diversity of Gujarat State: a Review. *Indian For.* 129, 1461 – 1469.
- Singh, D.K., 2001. Orchid diversity in India: an overview, in: *Orchids : Science and Commerce*, 35 – 65.
- Singh, N.P., Khanna, K.K., Mudgal, V., Dixit, R.D. 2001. Flora of Madhya Pradesh Volume III, Angiosperms and Gymnosperms, Botanical Survey of India and Ministry of Environment and Forests, 8 – 76.
- Singh, V., 1983. Flora of Banswara, Rajasthan, Flora of India. Botanical Survey of India, Department of Environment, 1 – 312.
- Singh, V.K., 1969. Taxonomical studies on the flora of Rajpipla Forest eastern part of Gujarat India. Sardar Patel University, Vallabh Vidhyanagar, Gujarat, Ph.D. Thesis.
- Sisodia, P.S., 2007. Plant inventory and some ecological studies in gir national park and sanctuary. The Maharaja Sayajirao University of Baroda, Vadodara, Gujarat, Ph.D. Thesis.
- Srivastava, T.N., 1976. Flora Gorakhpurensis. Today & Tomorrow's Printers & Publishers, 1 – 411.
- Stanley, O.D., 2004. Wetland ecosystems and coastal habitat diversity in Gujarat, India. *J. Coast. Dev.* 7, 49 – 64.
- Subramanyan, K., 1969. Nature Conservation: A losing battle. Sreemadhavan C.P. 95, 719 – 723.
- Suryanarayana, B., 1968. A Contribution to the flora of Dangs Forest Gujarat Part II.

- Sardar Patel University, Vallabh Vidhyanagar, Gujarat, Ph.D. Thesis.
- Tadvi, D.S., 2013. Floristic diversity of Dangs. Gujarat. The Maharaja Sayajirao University of Baroda, Vadodara, Gujarat, Ph.D. Thesis.
- Thaker, D.N., 1974. Floristic and ethnobotanical studies on Kawant range forests in central Gujarat. The Maharaja Sayajirao University of Baroda, Vadodara, Gujarat, Ph.D. Thesis.
- Thaker, J. I., 1910. Vanaspati Sastara - Barda Dungarni Jadibuti tani Pariksha anae Upyog. (Botany - A complete and Comprehensive Account of the Flora of Barda Mountain, Kathiawad). Gujarati Printing Press, Bombay: 29 – 45.
- Timsina, B., Rokaya, M.B., Munzbergova, Z., Kindlmann, P., Shrestha, B., Bhattarai, B., Raskoti, B.B., 2016. Diversity, distribution and host-species associations of epiphytic orchids in Nepal. *Biodivers. Conserv.* 25, 2803 – 2819. doi:10.1007/s10531-016-1205-8
- Tuyama, T., 1975. Orchidaceae, in: The Flora of Eastern Himalaya. University of Tokyo press, Tokyo, 137 – 164.
- Udupa, K.E.S., 2012. Studies on distribution and biology of orchids in Chikmagalure district Karnataka. Kuvempu University, Karnataka, Ph.D. Thesis.
- Van Rheede, H.A., 1693. Van Rheede's Hortus Malabaricus (Malabar Garden). University of Kerala, Kerala, Ph.D. Thesis.
- Vediya, S.D., Kharadi, H.S., 2011. Floristic diversity of Isari zone, Mehraj range forest District Sabarkantha, Gujarat, India. *Int. J. Pharm. Life Sci.* 2, 1033 – 1034.
- Verma, D., Singh, S.K., A.A. Mao, 2015. Notes on diversity and distribution of tribe Orchideae in Meghalaya. *Keanean J. Sci.* 2, 1 – 10.
- Verma, J., 2008. North western Himalayan orchids taxonomic assessment and ecological adaptations. Panjab University, Panjab, Ph.D. Thesis.
- Vij, S.P., Shekhar, N., Kashyap, S.K., Garg, A.K., 1983. Observations on the orchids of Nainital and adjacent hills in the Central Himalaya (Ecology and Distribution). *Res. Bull. Panjab Univ.* 34, 63 – 76.

- Vij, S.P., Sood, A., Khurana, A., 1986. In vitro study of morphogenetic effect of different growth retardants on preotocorms of *Rhynchostylis retusa* Bl., in: Biology, Conservation and Culture of Orchids. East-West Pvt.Ltd, New Delhi, India, 429 – 435.
- Vora, H.M., 1980. Contribution to the flora of Dharampur, Kaprada and Nana ponda ranges. South Gujarat University, Surat, Gujarat, Ph.D. Thesis.
- Werner, F.A., Gradstein, S.R., 2009. Diversity of dry forest epiphytes along a gradient of human disturbance in the tropical Andes. *J. Veg. Sci.* 20, 59 – 68. doi:10.1111/j.1654-1103.2009.05286.x
- Wolf, J.H., 2005. The response of epiphytes to anthropogenic disturbance of pine-oak forests in the highlands of Chiapas, Mexico. *Forest Ecology and Management* 212, 376 – 393. doi:10.1016/j.foreco.2005.03.027
- Wolf, J.H., Flamenco, S.A., 2003. Patterns in species richness and distribution of vascular epiphytes in Chiapas, Mexico. *J. Biogeogr.* 30, 1689 – 1707. doi:10.1046/j.1365-2699.2003.00902.x
- Yadav, S.R., 1979. Contribution to the Flora of Some parts of South Gujarat. Sardar Patel University, Vallabh Vidyanagar, Gujarat, Ph.D. Thesis.
- Yadav, S.R., Sardesai, M.M., 2002. Flora of Kolhapur District. Shivaji University, Maharashtra, 1 – 680.
- Yoganarasimhan, S.N., Subramanyam, K., Razi, B.A., 1982. Flora of Chikmagalur District, Karnataka, India. International Book Distributors, 13 – 338.
- Zimmerman, J.K., Olmsted, I.C., 1992. Host tree utilization by vascular epiphytes in a seasonally inundated forest (Tin-tal) in Mexico. *Biotropica* 24, 402 – 407.
- Zotz, G., 2013. The systematic distribution of vascular epiphytes – a critical update. *Bot. J. Linn. Soc.* 171, 453 – 481.