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ON THE "SEIDENFADEN COLLECTION" AND THE MULTIPLE ROLES BOTANICAL GARDENS CAN PLAY IN ORCHID CONSERVATION

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Abstract. Using the "Seidenfaden collection" in Copenhagen as an example, we address the common view that botanical garden collections of orchids are important for conservation. Seidenfaden collected live orchids all over Thailand from 1957 to 1983 and created a traditional collection for taxonomic research, characterized by high taxonomic diversity and low intraspecific variation. Following an extended period of partial neglect, we managed to set up a five-year project aimed at expanding the collection with a continued focus on taxonomic diversity, but widening the geographic scope to tropical Asia. Since its establishment, the collection has contributed significantly to *ex situ* conservation and to research-based development of powerful tools for improving *in situ* conservation-related decisions and priorities. The collection has been, and still is, an important basis for taxonomic and floristic research which has enabled treatment of the Orchidaceae in the Thai red-list. However, the primary focus of our project has shifted to micro-propagation, DNA-barcoding and phylogenetic analysis. The close link between collection-based research and conservation is remarkable and probably applicable to plant collections in botanical gardens in general. Thus, if the collections are managed and used properly, they have great potential for contributing to conservation in many different ways.

Key words: DNA barcoding, gene banks, Orchidaceae, phylogenetics, public education, red-lists

According to the GardenSearch database (www.bgci/garden_search.php; accessed 30 January 2018) more than 3400 botanical gardens currently exist, distributed among c. 150 countries. Clearly, the vast majority of botanical gardens grow a certain number of orchid species, a significant proportion have collection sections entirely devoted to orchids, and some of the special orchid collections are more than century-old – for example those in Kew (Stewart 1992), Leiden (Schuiteman & de Vogel 1999) and Copenhagen (Sterll 2002). This is no coincidence, as botanical garden collections of orchids are indispensable for research (Schuiteman & de Vogel 1999). During expeditions in the wet tropics, more than 80% of the orchid species are found without flowers, but if live plants are taken into cultivation, they can be identified and important parts can be preserved when they bloom. Besides, living collections offer excellent opportunities for experimental studies of biology. For more than a century, these obvious advantages have underlain the establishment of orchid collections in botanical gardens. Consequently, the vast majority of such collections contain high taxonomic diversity, but limited intraspecific genetic diversity.

Gunnar Seidenfaden, Danish pioneering explorer of the Thai orchid flora (Friis 2002, Pedersen, Watthana & Srimuang 2009, Rasmussen 2010), recognized the scientific potential and necessity of living orchid collections already in the mid-1950s, when he was appointed Denmark's first ambassador to Thailand. At the Royal Forest Department in Bangkok he met the young Thai botanist Tem Smitinand, and they soon started a long-lasting collaboration collecting and studying Thai orchids. Initially, their accessions were cultivated in the embassy compound, but they were transferred to the Botanical Garden, University

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FIGURE 1. The Seidenfaden collection anno 2014 – accommodated in a modern greenhouse donated by the Augustinus Foundation in 2000. Photo by H. Æ. Pedersen.

of Copenhagen, around 1959 when Seidenfaden was posted to Moscow as Danish ambassador to the Soviet Union. Upon his return to Denmark in 1961, he was able to resume expedition activities during recurrent visits to Thailand. Consequently, the living collection kept growing until Seidenfaden's last expedition in 1983.

At this time, the collection in Copenhagen was larger than any other collection of Thai orchids, and five years later it still had about 3000 individual plants (Sterll & Rasmussen 1988); regrettably, it is unclear how many species were represented. Due to unfortunate circumstances, the collection was not properly maintained for several years from c. 1970 onwards, and periodical lack of a specialist orchid gardener to look after the plants added to the problems. An annual loss of c. 5% of the individual plants is not unusual even in the best managed orchid collections; but the mortality rate in the Seidenfaden collection was significantly higher in the most critical periods, and quite a number of species were lost completely.

In August 2000, the orchid collection was moved to a state-of-the-art greenhouse donated by the Augustinus Foundation (Pedersen 2004) (Fig. 1). A few years later, a gardener with special interest in orchid cultivation was transferred to the collection, and the automated shading and watering facilities were optimized, making the remaining plants (c. 750 accessions representing c. 240 species) gradually recover. Besides, a tissue culture laboratory and a DNA laboratory that became available to the Botanical Garden offered interesting new possibilities for cultivation and research based on the collection. To further strengthen the living collection and to utilize the new technical opportunities, we conducted a five-year combined research and conservation project: "Seidenfaden's Orchids – from Conventional Study Collection to Modern Research Facility and Gene Bank" (March 2012–February 2017).

Botanical garden collections of orchids are often emphasized as being of importance for conservation (e.g. Koopowitz 2001, Schuiteman & de Vogel 1999, Swarts & Dixon 2009, Tasker 1989), and the need for *ex situ* conservation increases parallel to increasing threats (e.g. habitat destruction, over-collection and

global warming; Koopowitz 2013, Seaton, Hu, Perner & Pritchard 2010, Wyse Jackson & Sutherland 2013). However, the limited intraspecific genetic variation in traditional collections may clearly represent a serious limitation of the extent to which propagated plants from these can potentially be used for genetically sustainable recovery programmes in the wild. If this is the case, it raises the question whether traditional collections are useful at all in recovery contexts? A few other questions also seem relevant: Is plant material properly shared with sister collections to secure long-term *ex situ* conservation? Do gene banks of seeds and tissue cultures have a role to play? Do traditional collections contribute to conservation in any other way? In this paper, we will address these questions, using the "Seidenfaden collection" in Copenhagen as an example.

Development and characteristics of the Seidenfaden collection. Seidenfaden aimed at establishing a living study collection for morphology-based taxonomic and floristic research. This strategy is clearly reflected in the composition of the collection which is characterized primarily by high diversity at genus and species level and secondarily by many species being represented by a few clones of different provenance. In other words, it was established as a traditional botanical garden collection, though with a narrow geographic focus. Besides providing an ideal resource for taxonomic studies, the high diversity at genus and species level made the collection very well suited for comparative morphological, ontogenetic and biological studies, including experimental hybridization (e.g. Andersen, Johansen, Lund, Rasmussen, Rasmussen & Sørensen 1988, Johansen 1990, 1993, Rasmussen 1982). Throughout Seidenfaden's era, accession was very strongly focused on properly documented, wild-collected material from Thailand. However, the enforcement of national and international regulations, partly as a consequence of CITES (www.cites.org) and the Convention on Biological Diversity (www.cbd.int), made it increasingly difficult to add to the collection in this manner.

In our recent project, Seidenfaden's original collection, supplemented with the relatively few other tropical Asian orchid species in the Botanical Garden, was further developed with a continued focus on maximizing primarily its taxonomic diversity and secondarily the number of provenances of each species. However, right from the start we had to realize that it would be impossible to obtain additional wild-collected adult plants from Thailand. Instead, we decided to concentrate our effort on two other options: (1) donations of plant material from other European botanical gardens and, in special cases, from private orchid growers; (2) donations of seeds from Queen Sirikit Botanic Garden (QSBG) for asymbiotic germination and subsequent transfer of juvenile plants to the greenhouse. Wild-collected Thai orchids are rare in all other European botanical gardens, and whereas amateur collections often contain many orchid species known to occur in Thailand the plants are usually of unknown provenance. Partly as a consequence of our limited possibilities to obtain new plants of Thai provenance, we broadened the scope of the collection to represent tropical Asian orchids in general. However, for scientific reasons we particularly had in view to increase the holdings of (1) Thai orchids, (2) the genus *Dendrochilum* Blume, which is exceptionally rich in narrow endemics, and (3) endemic taxa in general. The majority of new accessions were of well-documented provenance, but occasional exceptions were accepted for material of rare endemic species. During the project, we received 244 new accessions (228 adult plants, 16 seed samples) – mainly from Hortus Botanicus (Leiden), Royal Botanic Gardens (Kew), QSBG (Chiang Mai), Malcolm Perry (Bristol) and Richard C. Warren (Barnard Castle). Of the 16 seed samples, only seven germinated sufficiently well to result in new adult plants for the greenhouse. In total, new plants for the greenhouse represented c. 150 species, most of which did not already exist in the collection.

In conclusion, the living collection of tropical Asian orchids in Copenhagen remains primarily targeted on taxonomic diversity. This makes the collection very well suited for systematic and a wide range of biological studies. The long history of the collection makes it probable that it contains genotypes from wild populations that are now extinct.

From collections to red-listing. Largely by sampling his living collection, as the plants came into flower, Seidenfaden gradually built a comprehensive spirit collection. After his death in 2001 the spirit collection,

consisting of more than 11,000 vials, was transferred to the Botanical Museum in Copenhagen (now part of the Natural History Museum of Denmark).

During his career as orchidologist, Seidenfaden conducted two complete revisions of the Thai orchid flora – the first in collaboration with Tem Smitinand (Seidenfaden & Smitinand 1959-1965), the last on his own (Seidenfaden 1975-1980, 1982-1988). In both cases, the taxonomic and floristic research relied to a wide extent on examination of the spirit samples, combined with observations made in the living collection (Pedersen *et al.* 2009, Rasmussen 2010).

Exploration of the Thai orchid flora (and of the Thai flora in general) started late, implying that the knowledge of species diversity and distribution patterns remained fragmentary until modern time. For example, Williams (1904-1905) included just c. 100 orchid species in his "Liste des Plantes Connues du Siam". Arthur F. G. Kerr, who lived in Thailand from 1902 to 1932, made more than 2000 orchid collections (Parnell *et al.* 2015), but published very little on the orchid flora (Jacobs 1962). Indeed, the book of Seidenfaden & Smitinand (1959-1965) marked the beginning of serious exploration of the Thai orchid flora (documenting 771 identified and 87 unidentified species), and Seidenfaden's later revision increased the number of known species to c. 1200.

The highly improved knowledge of the overall diversity and composition of the Thai orchid flora and the identity, distribution and frequency of individual species – mainly achieved through Seidenfaden's monumental contribution – created the necessary basis for a reasonably complete and sound treatment of the Orchidaceae in the first national Thai red-list (Santisuk, Chayamarit, Pooma & Suddee 2006).

By definition, taxonomic and distributional surveys of national floras always represent a point in time and can never be perfect; species disperse, populations disappear, field exploration reveals previously overlooked occurrences, and new species are recognized while others are rejected as being taxonomically unwarranted. Consequently, continued taxonomic and floristic research is needed for improving the red-lists and keeping them up-to-date. A third complete revision of the Thai orchid flora is now being conducted as part of the Flora of Thailand project; two of six planned instalments have already been published (Pedersen, Kurzweil, Suddee & Cribb 2011, Pedersen *et al.* 2014). A comparison of the Flora of Thailand account on the Orchidoideae (Pedersen *et al.* 2011) with the two previous revisions of this subfamily has amply demonstrated the usefulness of revising the Thai orchid flora repeatedly (Pedersen 2013). The three revisions done during half a century exhibited a progressive increase in the net number of taxa accepted, and the total number of changes was even higher, as additions and exclusions partly neutralized each other.

Although the current orchid studies for Flora of Thailand depend less on the living collection in Copenhagen for solving taxonomic problems, the live plants still provide an important resource for checking and completing species descriptions – especially concerning colours, leaf texture, flowering mode and floral scent. Surprisingly, it also still happens that new national records for Thailand are revealed among Seidenfaden's old plants; the latest examples are *Liparis vestita* Rchb.f. (Tetsana, Pedersn & Sridith 2013) and *Coelogyne lawrenceana* Rolfe (Pedersen *et al.* 2014) (Fig. 2).

DNA barcoding. The concept of DNA barcoding as identification tool was formalized around 2000 (e.g. Hebert, Cywinska, Ball & deWard 2003), and rapid development of formal international collaboration (covering all organismal kingdoms) resulted in establishment of the Consortium for the Barcode of Life (CBOL) in May 2004. However, using only one barcode for all life was soon shown to be unrealistic. As far as land plants are concerned, a core-barcode consisting of portions of two coding chloroplast regions, *matK* and *rbcL*, was recommended (CBOL Plant Working Group 2009). Subsequent studies targeted on taxonomically or geographically defined groups of orchids have indicated that other molecular markers offer better resolution (e.g. Kim, Oh, Bhandari, Kim & Park 2014, Xiang, Hu & Jin 2011), but these studies have ignored the advantages of a broadly applied consensus barcode.

For a few decades, the living orchid collection in Copenhagen has served as a useful source of tissue samples for DNA analysis. Until recently, the sampling was very much *ad hoc* and usually prompted by requests from foreign researchers who needed additional

Figure 2. The two latest examples of new national records for Thailand revealed in Seidenfaden's living collection; both species are obvious candidates for inclusion in the next edition of the national Thai red-list. A. *Liparis vestita* Rchb.f. – in Thailand only known from Amphoe Rong Kwang in Phrae and from two sites in Khao Yai National Park (Nakhon Nayok, Prachin Buri). B. *Coelogyne lawrenceana* Rolfe – in Thailand only known through a single plant collected on Doi Inthanon (Chiang Mai) in 1978. Photos by H. Æ. Pedersen.

samples for their phylogenetic studies. However, sampling was standardized considerably in our recent project, as we decided to DNA barcode as many of the identified species as funding would allow. For this purpose, we adopted the officially recommended core-barcode for land plants, supplemented by ITS. We sampled a total of 131 species from the collection, and the prepared barcodes will be made publicly available as soon as possible.

Establishment of a vouchered reference collection of barcode data, such as the Barcode of Life Data Systems (BOLD), is a prerequisite for consistent applications of DNA barcoding. Admittedly, the potential and resolution power of the new technique have been questioned by a number of authors (e.g. Seberg & Petersen 2009, Taylor & Harris 2012), but if used with care, DNA barcoding is a cheap, quick and sufficiently reliable technique for many purposes. In a conservation context, as reviewed by Krishna Krishnamurthy & Francis (2012), DNA barcodes can provide information for the use of different stakeholders. For example, they may offer quicker species identification, help to pinpoint groups of species complexes in need of in-depth studies, and may empower policy makers to take the most appropriate conservation measures.

We primarily envisage two useful purposes for the future use of our barcode data: (1) as a tool enabling customs authorities to identify even non-flowering orchids and thus reveal their CITES status

and whether the claimed geographic origin of the plants is plausible; (2) as a tool for virtually non-destructive inventories and comparisons of species diversity of orchids in selected nature areas, thus facilitating quick and qualified conservation priorities to be made without any need to observe the plants in bloom. Both options would require our data to be used in conjunction with additional reference data provided by other researchers, but building a reference library of barcodes is the necessary first step towards more general use.

Phylogenetic studies. Whereas the core-barcode itself is mainly suited for species identification, DNA extractions offer a rich and readily accessible source of material for additional DNA sequencing that can be used for in-depth phylogenetic studies of selected taxa or in genomics. This opportunity was also utilized in our recent project. Thus, in collaboration with colleagues abroad (and partly based on comprehensive sampling in the Copenhagen collection), we made a phylogenetic reconstruction of subtribe Eriinae (Ng *et al.* 2018), and a similar study of the large genus *Dendrochilum* is underway (Pedersen *et al.*, in prep.).

Species diversity is by far the most commonly used measure of biodiversity, but Vane-Wright, Humphries & Williams (1991) proposed "phylogenetic diversity", a measure based on evolutionary relationships between species, as an additional parameter for setting conservation priorities (see also Mace, Gittleman & Purvis 2003). Although the relevance and applicability of this measure is in need of further clarification (Winter, Devictor & Schweiger 2012), phylogenies offer an interesting alternative biodiversity measure that is largely resistant to taxonomic inflation (e.g. Pillon, Fay, Shipunov & Chase 2006).

Gene banking and micro-propagation. Notwithstanding the value of traditional botanical garden collections, such collections can only have a few individuals of each species (e.g. Justice 2016). Consequently, there is a pressing need for supplementary, less space-demanding *ex situ* conservation facilities such as seed banks and *in vitro* gene banks (e.g. Ramsay & Dixon 2003, Seaton *et al.* 2010, Seaton & Pritchard 2003).

In vitro recalcitrance (the inability of plant cells and tissue to respond to manipulations *in vitro*) can be a major limiting factor for conservation initiatives (Sarasan 2011), and mature seeds of many orchid species are recalcitrant (e.g. Butcher & Marlow 1989). This problem can be addressed either by developing techniques to break the recalcitrance or by using immature seeds. The latter option usually implies successful asymbiotic germination, but immature seeds in a suitable stage are only available in a short time-window, as efficient and broadly applicable preservation techniques have not yet been developed (Sarasan 2011). Even the viability of mature seeds stored at cool or temperate conditions deteriorates gradually over time, but techniques for cryopreservation in nitrogen vapour (-156°C) are within reach for mature orchid seeds and have already been implemented for a number of species (e.g. Hicks 2002, Thammasiri 2013). Cryopreservation can also be applied to tissue cultures to circumvent the potential problem of somaclonal variation.

Plant tissue culture under sterile conditions provides a technique for clonal propagation of plants from small amounts of vegetative tissue such as stem and shoot meristems and leaf fragments (e.g. Stewart 1989). In cases of self-incompatibility combined with lack of suitable genotypes for cross-pollination, in cases of strongly recalcitrant seeds etc., clonal tissue culture can be the only choice for micro-propagation. This technique normally increases the number of plants more quickly than could be done through division of adult plants.

Based on the Copenhagen collection of tropical Asian orchids, supplemented by seeds received from QSBG, we made a research-based effort at germinating orchid seeds asymbiotically (Fig. 3), and we used the resulting tissue cultures to establish an *in vitro* gene bank. We particularly aimed at developing techniques for breaking the recalcitrance of mature seeds, although immature seeds were occasionally applied. We also developed techniques for successful clonal propagation of species of *Bulbophyllum* Thouars and *Dendrobium* Sw. (Fig. 4). Altogether, we established an *in vitro* gene bank comprising cultures of 26 species (Table 1) – including seven that are endemic to Thailand or the Philippines and 16 that are included in the latest edition of the national Thai red-list (Chamchumroon, Suphuntee, Tetsana, Poopath & Tanikkool 2017). Gene

Figure 3. Plantlets of *Sirindhornia pulchella* H. A. Pedersen & Indham. grown from asymbiotically germinated seeds. This species is considered endemic to Doi Chiang Dao in the northern Thai province of Chiang Mai, and it is classified as endangered (EN) in the national Thai red-list. Photo by J. I. Find.

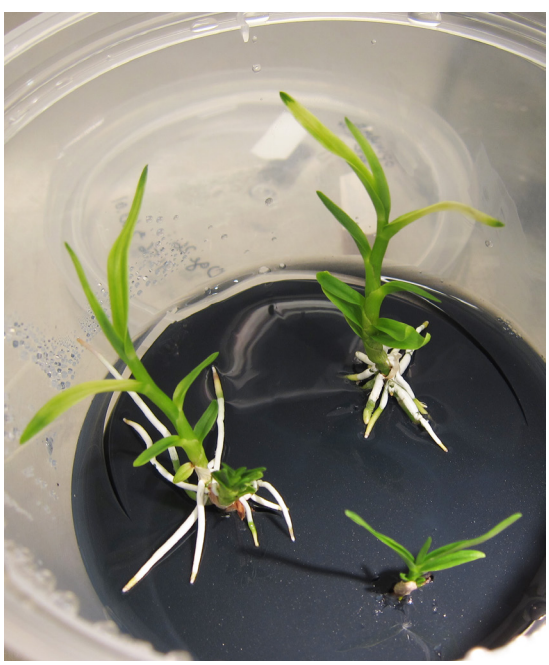

Figure 4. Plantlets of the rare *Dendrobium chrysanthum* Lindl. grown asymbiotically from vegetative explants. This was one of the first nationally red-listed species for which we were able to offer our Thai counterparts mass-propagated material for preparation of a recovery project in the wild. Photo by J. I. Find.

banking through cryopreservation was not part of our project. However, we did use subsets of most seed samples for development of suitable cryo-techniques, and the established *in vitro* gene bank provides a solid basis for potentially using cryopreservation in the future.

Sharing of material. *Ex situ* collections ensure conservation of a high number of species – and often for a very long period when combined with *in vitro* techniques and cryopreservation. Still, the individual collections are vulnerable to local threats such as virus attacks, failing heating systems, shortage of (qualified) staff etc. Therefore, it is crucial that material of rare and narrowly endemic species is propagated and shared with other scientific collections to the widest possible extent allowed under international legislation. Though not impossible, one has to realize that the implementation of the Nagoya-protocol (www.cbd.int/abs/) is going to complicate such exchanges, at least for all material collected after October 12th, 2014.

For years, the orchid collection in Copenhagen has been involved in exchange of material with a number of botanical gardens in Europe; and a subset of the first asymbiotically propagated plants of Thai orchids was donated to QSBG in 2016 (Table 1).

TABLE 1. Survey of the 26 orchid species that we established in the *in vitro* gene bank of the Botanical Garden in Copenhagen. For each species is indicated whether it is endemic to a single country, and for those occurring in Thailand the current national conservation status in that country is indicated according to Chamchumroon *et al.* (2017) (EN = endangered, R = rare, VU = vulnerable). Finally, it is indicated how many plantlets of each species we donated to QSBG in 2016.

Species	Endemic?	Status in Thailand	Plantlets to QSBG
Acriopsis liliifolia (J.Koenig) Seidenf.	-	-	-
Bletilla foliosa (King & Pantl.) Tang & F.T.Wang	-	VU	-
[a]*Bulbophyllum brevistylidium* Seidenf.	Thailand	-	55
Bulbophyllum nesiotes Seidenf.	Thailand	EN	7
Bulbophyllum peninsulare Seidenf.	Thailand	VU	-
Bulbophyllum propinquum Kraenzl.	-	VU	3
Bulbophyllum smitinandii Seidenf. & Thorut	-	VU	-
Coelogyne lawrenceana Rolfe	-	-	-
Dendrobium chrysanthum Wall. ex Lindl.	-	R	75
Dendrobium devonianum Paxton	-	R	78
Dendrobium friedericksianum Rchb.f.	-	VU	-
Dendrobium jenkinsii Wall. ex Lindl.	-	R	-
Dendrobium sulcatum Lindl.	-	R	6
Dendrobium wardianum R.Warner	-	R	9
Dendrochilum diabloviride Cootes & R.Boos	Philippines	n/a	-
Dendrochilum filiforme Lindl.	Philippines	n/a	-
Dendrochilum glumaceum Lindl.	-	n/a	-
Epipactis flava Seidenf.	-	EN	-
Grammatophyllum speciosum Blume	-	VU	-
Liparis sp.	?	-	-
Liparis viridiflora (Blume) Lindl.	-	-	-
Odontochilus elwesii C.B.Clarke ex Hook.f.	-	-	-
Odontochilus lanceolatus (Lindl.) Blume	-	-	-
Sirindhornia mirabilis H.A.Pedersen & Suksathan	Thailand	EN	-
Sirindhornia pulchella H.A.Pedersen & Indham.	Thailand	EN	-
Trichoglottis triflora (Guillaumin) Garay & Seidenf.	-	VU	-

[a] By some authors treated as synonym of the non-endemic *Bulbophyllum longerepens* Ridl.

Recovery programmes. The ultimate success of *ex situ* conservation activities would be if propagated plants could be used for genetically sustainable recovery programmes in the wild – preferably integrated in ambitious ecological restoration projects (e.g. Hardwick *et al.* 2011, Miller, Lowry II, Aronson, Blackmore, Havens & Maschinski 2016). It is frequently argued that for *ex situ* collections to be of use in such programmes, the plants must be of known wild origin and possess a genetic diversity representative of one or more wild populations (cf. Rae 2011).

While being well documented, the collection of orchids in Copenhagen does not fulfil the latter criterion – a deficiency shared with the vast majority of other scientific orchid collections. Although the great diversity of breeding systems and widely divergent levels of genetic diversity among individual orchid species (e.g. Phillips, Dixon & Peakall 2012, Tremblay, Ackerman, Zimmerman & Calvo 2005) should always be borne in mind, it is evident that, in most cases, propagated plants from collections will be inadequate for genetically sustainable recovery of natural populations. However, as stressed by Pence (2011), they can be used to test the suitability of

habitats and microhabitats in preparation of recovery programmes. Such experiments should be performed following detailed autecological field studies of wild populations (e.g. Watthana & Pedersen 2008), and also niche modelling and genetic screening of natural populations are useful tools. Due to the need for collecting comprehensive material for propagation purposes, recovery programmes normally have to be conducted on a national basis (e.g. Pedersen 2010). For detailed recommendations on plant reintroduction programmes in general, see Godefroid *et al.* (2011).

Among the material that we donated to QSBG in 2016, the plantlets of *Dendrobium chrysanthum* Lindl. (Fig. 4) and *D. devonianum* Paxton were so numerous that QSBG intends to use some of them for field experiments in preparation of reintroduction (or reinforcement) programmes.

Education and public outreach. Light, Kell & Wyse Jackson (2003), Rae (2011) and Wyse Jackson & Sutherland (2013) highlighted training, public outreach and schools education as some of the foremost roles botanical gardens and their collections could play in a conservation context. Furthermore, Williams, Jones, Gibbons & Clubbe (2015) provided quantitative evidence suggesting that botanical gardens can indeed positively influence visitors' environmental attitudes.

Material from the recently expanded orchid collection in Copenhagen was used in the university course Plant-Animal Interactions in 2014 and 2015, and our project in its entirety was presented as case in the course International Nature Conservation in 2015. In connection with the donation of tissue cultures to QSBG in June 2016, we made a press release ("Rare orchids return to Thailand"), the content of which found its way to at least 25 media. The project and the collection were presented to a large and broad selection of public visitors in connection with the annual "Botanical Garden's Day" in Copenhagen during 2012-2015. In addition, we continuously updated the Botanical Garden's permanent guides on the progress of our project and thus enabled them to explain to the public why the collection is internationally important in a conservation context. The guides now provide qualified information on the orchid collection and its conservation-related importance during almost all the c. 80 guided tours of the Botanical Garden that are booked every year.

Conclusions and perspectives. Any sound conservation contribution rooted in a botanical garden collection rests on a base of good horticultural practice and succession of staff (securing long-term survival and propagation of the plants) as well as continuity of qualified scientific input (securing accurate identifications and a well thought-out accession policy). As outlined above, the Seidenfaden collection has contributed significantly to *ex situ* conservation and to research-based development of powerful tools for improving *in situ* conservation decisions and priorities. Its contributions have been continuous and diverse, and have changed over time. Its original role as a collection for taxonomic and floristic studies could be fulfilled with hardly any other means than the collection itself, vials with spirit and a low-power binocular microscope. In contrast, most of the new initiatives – such as DNA barcoding, DNA-based phylogenetic studies, *in vitro* propagation etc. – mainly utilize the collection as a source of material for laboratory use. Periods of intensive research have implied increased external funding and/or increased international collaboration, both of which have boosted the conservation-related contributions.

We find it obvious to assume that the overall importance and dynamics exhibited by the Seidenfaden collection represent the role of active botanical garden collections in general: increased scientific research generates increased contributions to conservation. Thus, if the traditional collections of, e.g., live orchids are assigned scientific attention, they have great opportunities for contributing to conservation (see also Delmas, Larpin & Haevermans 2011, Pedersen 2010, Swarts & Dixon 2009). Some collection-based contributions are as conventional as making the collections themselves in the field, while others are much more high-tech. As time progresses, contributions from DNA barcoding (providing new identification and inventory tools), phylogenies (for improved conservation priorities), cryopreservation (for millennium-long *ex situ* conservation) and large-scale micro-propagation (in preparation of recovery programmes) may all become important routine contributions. Living collections also have an important

role for upcoming techniques that are nowhere near showing their full potential, like genomics.

All in all, botanical gardens offer more diverse contributions to conservation of orchids (and other species) than commonly recognized – see also Donaldson (2009). However, any potential contribution ultimately depends on access to scientifically well-curated plant material and continuous qualified nursing of individual plants – conditions that require a targeted core budget and proper scientific management of the botanical garden concerned.

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VEGETATIVE ANATOMY OF THE ORCHID *BULBOPHYLLUM STERILE* (ORCHIDACEAE: EPIDENDROIDEAE)

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Abstract. The anatomical characteristics of leaf, pseudobulb, and root of *Bulbophyllum sterile* of the subfamily Epidendroideae (Orchidaceae) were investigated. The anatomical investigation involved observing sections after staining with different stains as well as scanning electron microscopy. Additionally, the cell dimensions were also measured. The amphistomatic leaves of *B. sterile* had a thick cuticle, paracytic type of stomata, collateral vascular bundles and starch grains. The rhizome had cuticularized uniseriate epidermis and a single layer of the hypodermis. The parenchymatous stem ground tissue was distinguished into outer and inner regions separated by a band of sclerenchymatous tissue. Collateral vascular bundles were distributed in the inner ground tissue. The size of the vascular bundles generally increased from the periphery towards the center. A sclerenchymatous patch covered the phloem pole, whereas the xylem is covered by thin walled parenchymatous cells. The outer surface of the pseudobulb is covered by a thick cuticle. The parenchymatous ground tissue consisted of starch grains, aeration, water and algal cells and scattered collateral vascular bundles. Sclerenchymatous cells covered the phloem pole, whereas the xylem is covered by thin-walled cells. The velamen in *B. sterile* is single layered consisting of highly elongated compactly arranged cells. Uniseriate exodermis is dimorphic consisting of long and short cells. Cortical cells are differentiated into exodermis and endodermis. The O-thickened endodermal cell layer is interrupted by thin walled passage cells. Pith is sclerenchymatous. From this study, it can be concluded that *B. sterile* possess anatomical adaptations to xeric conditions in all the vegetative organs..

Key words: pseudobulb, raphides, rhizome, velamen, xerophyte

Introduction. Described by Thouars in 1822, the genus *Bulbophyllum* belonging to the subfamily Epidendroideae, is the second largest genera of flowering plants with more than 2000 species next only to *Astragalus* of Fabaceae (Smidt *et al*. 2007, Govaerts *et al*. 2017). With Papua New Guinea as the center of diversity, taxa of this genus are pantropical spreading across Africa, Australia, India, Madagascar, Southeast Asia, and in tropical South and Central America (Dressler 1990). In India, this genus is represented by over 100 species of which 75 species occur in north-eastern India (Misra 2007). Although 4-5 species of *Bulbophyllum* were reported previously by Hooker (1894) and Fischer (1928) from South India, Abraham & Vatsala (1981) reported seven species of *Bulbophyllum* endemic to peninsular India. However, Henry *et al.* (1989) listed 11 species of *Bulbophyllum* in their list of angiosperms occurring in the south Indian state of Tamilnadu, India.

Investigations on the vegetative anatomy of *Bulbophyllum* dates back to 1856 when Chatin examined the structure and function of roots in several orchids including *Bulbophyllum careyanum* (Hook.) Spreng (Stern 2014b). Anatomical studies on *Bulbophyllum* were reviewed by Stern *et al*. (2014b). Piazza *et al*. (2015) recently compared the vegetative anatomy of 13 species of epiphytic or rupicolous *Bulbophyllum* belonging to sections *Didactyle* and *Xiphizusa* to identify the anatomical characters that would be useful in differentiating species between and among the sections and the adaptations of the species to the xeric environments. The results of the study revealed certain anatomical variation among the species of the two sections. Moreover, the study

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also indicated the lipophilic secretion by the trichomes of the young leaves and the presence of common xeromorphic characters among the species of the two sections.

An examination of the leaf anatomy of 14 *Bulbophyllum* species of the section Micranthae and its comparison with the results of the molecular analysis revealed that the anatomical characters and the molecular analysis may complement each other in developing phylogenetic hypotheses (Smidt *et al*. 2013). The leaf anatomy of *B. dissitiflorum* Seidenf., *B. appendiculatum* (Rolfe) J.J.Sm. and *B. gamblei* (Hook.f.) Hook.f. was studied by Chowlu *et al*. (2015) while examining the extended distribution of these species in India. All the three species had cuticle of varying thickness, polygonal epidermal cells, heterogeneous mesophyll, hypostomatic stomata distribution and wax secreting cells and multicellular glandular hairs on both the leaf surfaces (Chowlu *et al*. 2015). In spite of the long history, anatomical investigations on *Bulbophyllum* are limited to a small percentage of species when compared to the number of species constituting the genus.

The epiphytic orchid *Bulbophyllum sterile* (Lam.) Suresh (=*Bulbophyllum neilgherrens* Wight) is distributed in Bangladesh, peninsular India, Nepal, and Myanmar, and is the commonest species of *Bulbophyllum* found in South India (Abraham & Vatsala 1981, Jose & George 2015). It occurs in a wide range of elevations ranging from plains up to 900 m (Abraham & Vatsala 1981). There is a wide variation in flower colour and arrangement depending on the altitude (Abraham & Vatsala 1981).

Bulbophyllum species have many medicinal and artistic uses in Africa and Asia (Lawler 1984). In China, some species are used to treat primary tuberculosis and stomach cancer (Pridgeon *et al*. 2014). The pseudobulbs are used as a tonic for rejuvenation (Jonathan & Raju 2005, Teoh 2016). In India, the chopped pseudobulbs of *B. sterile* are boiled in coconut oil and applied to cure rheumatism (Shanavaskhan *et al*. 2012). The extract prepared from the pseudobulbs of *B. sterile* sold in the name of Purusharantha are used as a tonic as well as for the restoration of adolescence (Chowdhery *et al*. 1998, Roy *et al*. 2007, Hossain 2009). The fine paste prepared from the leaves and pseudobulbs of *B. neilgherrense* Wight (=*B. sterile*) is taken orally for treating leucoderma and heart diseases (Rajendran *et al*. 1997, Harshitha *et al*. 2013). A recent study on the active fractions of pseudobulbs and roots of *B. sterile* for antitumor activities suggested that the active fractions of bulbs and roots possessed anticancer activity (Biswas *et al*. 2016). The medicinal value of *B. sterile* has resulted in the large-scale unsustainable harvest of plants from the wild in Western Ghats region of southern India. Though the therapeutic value of *B. sterile* is well recognized, the anatomical aspects of this species are not known. Further, it is also important to understand the adaptations of *B. sterile* for its wide range of occurrence in different types of environments. Therefore, the aim of the present study is to investigate the anatomical features of different vegetative organs of *B. sterile* and to identify the anatomical adaptations of this species that enable it to survive in the arid epiphytic conditions.

Materials and methods. Three plants of *B. sterile* (Fig. 1A–B) were collected from a home garden in Coimbatore (11°04` N to 76°93` E) during January 2017. The elevation of Coimbatore is 426 to 550 m a.s.l and the annual rainfall varies from 500 to 700 mm. The leaf, rhizome, bulb, and root of the fresh plants were used for the anatomical studies. The plant materials were washed with distilled water and used or fixed in FAA (Formalin-Acetic Acid-70% ethanol) solution until processing.

For light microscopy, the fresh/preserved plant materials were hand sectioned using a razor blade (transverse sections, 25–30 μm) and stained with safranin. Other stains and histological reagents like Sudan IV (lamellar suberin), Toluidine blue/HCl–phloroglucinol (lignin and tannin), and Iodine (starch) were also used to detect the presence of specific histochemical (Johansen 1940). The complete thin sections were used for the evaluation of plant structural parameters. Stained sections were mounted in glycerine on microscopic slides and observed under a BX 51 light microscope. In addition to the general observations, size of parts or cell length and width or layers were recorded or measured using a calibrated ocular scale in leaves (stomata length and width and pore size, epidermis, mesophyll), pseudobulb (epidermis), rhizome (epidermis, ground tissue,

Figure 1. Habit of *Bulbophyllum sterile* showing vegetative parts (a) and the inflorescence axis (b). Scale bars = 5 cm.

vascular bundle) and roots (velamen, exodermis, cortex, endodermis, xylem arches). The measured values are presented either as range or length (mean ± standard error) × width (mean ± standard error) or mean ± standard error. Images of the sections were photographed using a ProgRes3 camera attached to an Olympus BX 51 light microscope. Stomatal index (%) was calculated (n=10) from the number of epidermal cells and stomata in ten randomly selected microscopic fields (×200) according to Salisbury (1927).

For scanning electron microscopy (SEM) a section of 5 mm^2 of leaf lamina or thin transverse section of pseudobulb, rhizome, and root was fixed on to double sided adhesive tape onto labeled stubs. The specimens were coated with gold and scanned in Philips SEM 515 Scanning electron microscope. For epidermal studies, samples were taken from midway between the base and apex of the lamina.

Data on the stomatal index was subjected to paired *t*- test to assess the significance of variation in the distribution of the stomata on the adaxial and abaxial leaf surfaces.

Results

Leaf (Fig. 2 A–H).— Superficial view. The leaves are covered by a 4 µm thick cuticle which is wrinkled and present both on the adaxial and abaxial surfaces. Stomata are more numerous (t_{10} = -8.456; P<0.001; n=10) on the abaxial (9.44 ± 0.40) than the adaxial (5.24 ± 0.394) surface. The stomata are tetracytic where the 2 guard cells are surrounded by four subsidiary cells. Chloroplasts present in guard cells. The stomatal pore measures 20.35±0.35 × 18.55±0.18 µm. The guard cells measures 36.05±0.27 × 11.65±0.17 µm and subsidiary cells measures 59.65±0.34 × 22.00±0.47 µm. Hairs absent.

Cross section. Upper and lower epidermis uniseriate, compactly arranged, rectangular, thick-walled cells, nucleate and parenchymatous. Cells of the upper epidermis measure 46.2 ± 0.45 × 24.25 ± 0.45 µm and those of the lower epidermis measure 47.3 ± 0.47 × 28.1 ± 0.31 µm. Hypodermis and fibrous bundles absent. Mesophyll homogenous not differentiated into palisade and spongy cells but are rich in chlorophyll. The number of cell layers in the mesophyll varies from 34–38 (average 36.45 ± 0.23). The mesophyll contains pitted and striated idioblasts and air cells. The vascular bundles are arranged in a single row in the middle. The largest vascular bundle is present in the midrib region. In the lamina, a large vascular bundle alternates 2–3 smaller vascular bundles. The vascular bundles are collateral and surrounded by a distinct bundle sheath. Both xylem and phloem poles are covered by a sclerenchymatous patch.

Pseudobulb (Fig. 3A–H).— The bulb is green in colour and ridged. The surface of the bulb is covered by a 4–5 µm thick cuticle. Stomata are absent. The epidermis is uniseriate with thin walled

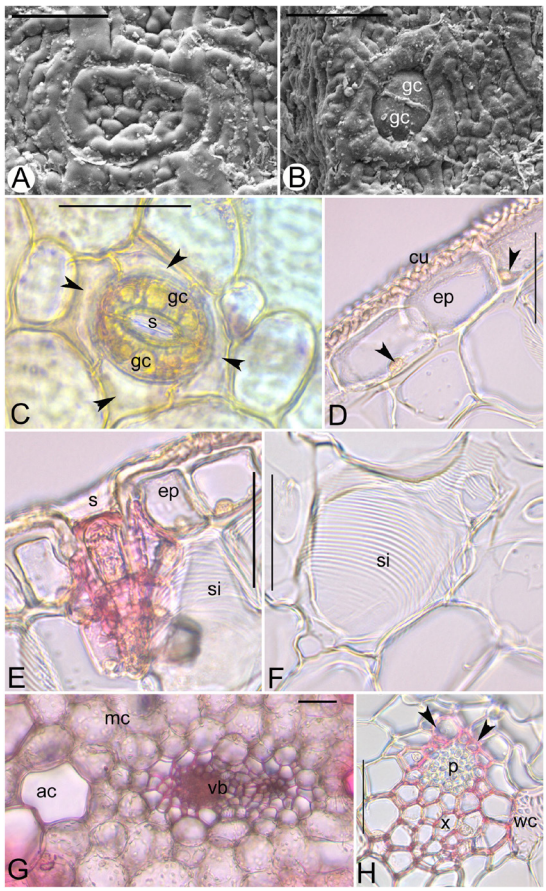

FIGURE 2. Leaf anatomy of *Bulbophyllum sterile*. A. Scanning electron microscope (SEM) view of the adaxial leaf surface, B. SEM view of the stomata and guard cells. C. Adaxial leaf surface showing stomatal pore (s), guard cells (gc) and four subsidiary cells (arrow heads), D. T.S. of leaf showing epidermis (ep), cuticle (cu), and nucleus (arrow heads); E. epidermis (ep) and striated idioblast (si), F. Striated idioblast cells with secondary thickenings (si), G. Aeration cell (ac), homogenous mesophyll (mc) and vascular bundle (vb), H. Collateral vascular bundle with phloem (p), xylem (x), Sclerenchymatous patch (arrow heads) and water cells with secondary thickenings (wc). Scale bars = 30 µm (A), 50 µm (B-H).

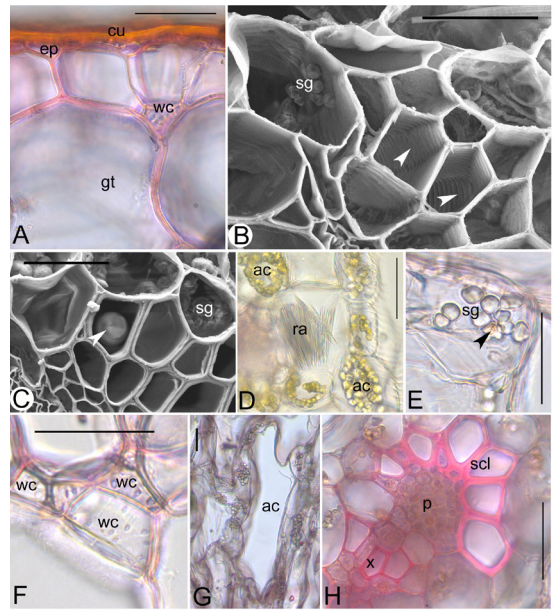

FIGURE 3. Pseudobulb anatomy of *Bulbophyllum sterile*. A. T.S of pseudobulb showing epidermis(ep) covered with a cuticle (cu), and water cell with thickening (wc) in the ground tissue (gt), B. SEM of pseudobulb TS showing ground tissue cells with ladder-like thickenings (arrow heads) and starch grains (sg), C. Spherical calcium oxalate crystal (arrow head) and starch grains (sg) in the ground cells, D. Raphides (ra) and algal cells (ac) in the ground tissue, E. Starch grains (sg) and druse crystal (arrow head) in a single cell, F. Band of pitted water cells (wc), G. Aeration cell (ac) in the ground tissue, H. Vascular bundle with xylem (x), phloem (p) and sclerenchymatous tissue (scl). Scale bars = 30 µm (B, C); 50 µm (A, E-H).

rectangular cells measuring 25.15 ± 0.3 × 9.25 ± 0.16 µm. Hypodermis is absent. The ground tissue is parenchymatous consisting of starch grains, raphides, spherical stegmata and druse crystals (calcium oxalate crystals), aeration and algal cells. Pitted water cells are also associated with the mesophyll. The vascular bundles are scattered in the ground tissue and collateral. Sclerenchymatous cells cover the phloem pole, whereas the xylem is covered by thin-walled cells.

Rhizome (Fig 4. A–F). — The rhizome is cylindrical and brown. It is covered by a cuticle that is 4–5µm thick and contoured. The epidermis is uniseriate, comprising compactly arranged oblong shaped parenchymatous cells measuring 114.3±2.79 × 29.00±0.45 µm. Ground tissue is parenchymatous and distinguished into outer and inner regions. The two regions of the ground tissue are separated by a sclerenchymatous band that is 3–6 layered. Starch grains are present in the ground tissues. Outer ground tissue region consists of 17–20 layers of angular

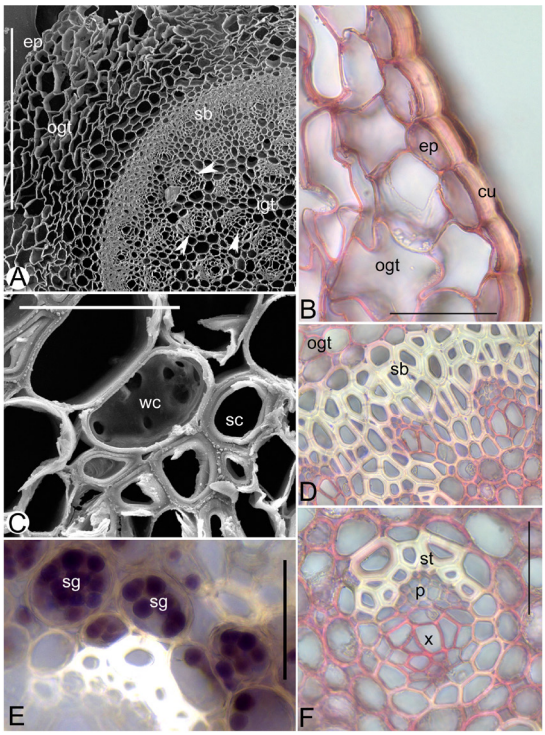

FIGURE 4. Rhizome anatomy of *Bulbophyllum sterile*. A. Scanning electron microscope (SEM) of rhizome TS showing epidermis (ep), outer ground tissue (ogt), sclerenchymatous band (sb), inner ground tissue (igt) and vascular bundles (arrow heads), B. Thick cuticle (cu), epidermis (ep) and parenchymatous outer ground tissue (ogt), C. SEM of rhizome TS showing pitted water storage cell (wc) and sclerenchyma cell (sc), D. Parenchymatous outer ground tissue (ogt) and sclerenchymatous band (sb), E. Starch grain (sg) filled cells surrounding the vascular bundle, F. Vascular bundle showing xylem (x), phloem (p) and sclerenchymatous tissue (st). Scale bars = 30 µm (C), 50 µm (B, D–F), 400 µm (A).

parenchymatous cells and vascular bundles are absent in this region. The inner ground tissue is also parenchymatous with isodiametric cells and contains vascular bundles in the scattered form. The size of the vascular bundles generally increases from the periphery towards the center. The vascular bundles are collateral and measures 87.25±0.29 × 74.00±0.18 µm. A sclerenchymatous patch covers the phloem pole, whereas the xylem is covered by thin walled parenchymatous cells. Parenchymatous cells adjacent to the sclerenchymatous patch are packed with starch grains that stain brown with iodine.

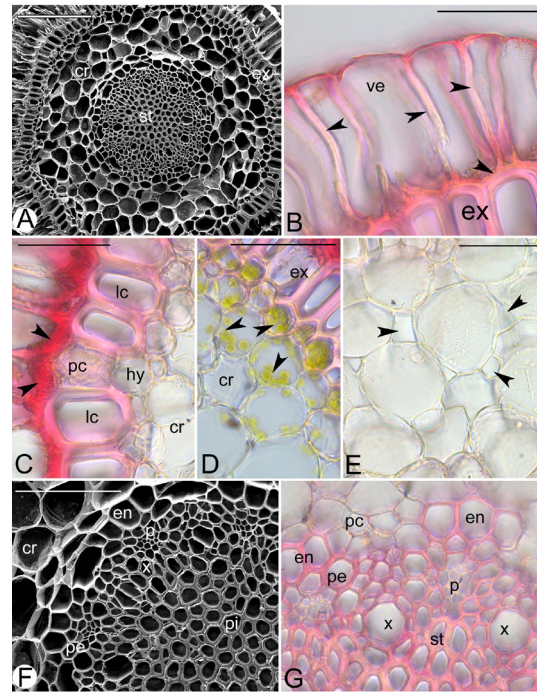

FIGURE 5. Root anatomy of *Bulbophyllum sterile*. A. Scanning electron microscope (SEM) of root TS showing velamen (v), exodermis (ex), cortex (cr) and stele (st), B. Velamen cells (ve) with thickened radial and inner periclinal walls (arrow heads) and exodermis (ex), C. Tilosomes (arrow heads), long (lc) and passage cells of the exodermis (pc) of the exodermis, layer of small parenchymatous cells (hy) and cortex (cr), D. Exodermis (ex) and cells of the cortex (cr) containing chlorophyll (arrow heads), E. Aerenchyma cells with squarish, triangular and circular intercellular spaces (arrow heads), F. SEM of the root TS showing cortex (cr), endodermis (en), pericycle (pe), xylem (x), phloem (p) and sclerenchymatous pith (pi), G. Vascular bundle showing O-thickened endodermal cells, passage cells (pc), pericycle (pe) and xylem (x) and phloem (p) embedded in sclerenchymatous tissue. Scale bars = 50 µm (B–E, G), 100 µm (F), 400 µm (A).

Root (Fig 5. A–G).— The roots are cylindrical and covered by a layer of velamen. Root hairs absent. The cells of the velamen are highly elongated and compactly arranged without any thickenings. The velamen cells measure 95.85±0.43 × 26.03±0.50 µm. The radial and inner periclinal walls of the velamen cells are much thickened than the outer periclinal walls. The velamen is followed by a uniseriate exodermis that is dimorphic consisting of long and short cells. The cells of the

exodermis are much smaller than those of the velamen. Cover cells absent, but broadly lamellate tilosomes present. Long cell measures 43.04±0.49 × 21.85±0.46 µm, walls O-thickened; short cells are ¾ of the long cells and thin walled. The cortex is parenchymatous with intercellular spaces that are squarish, triangular or circular and 4–10 layered. Outer one to two layers of the cortical cells are smaller than rest of the cortical cells and often contain chloroplasts. The cells of endodermis measure 21.25±0.34 × 19.95±2.06 µm and are O-thickened. The thick walled endodermal cell layer is interrupted by the presence of one to three thin walled passage cells. The cells of the pericycle are thick walled opposite to the phloem and thin walled opposite to the xylem. The number of xylem arches ranges from 7–11 (average 8.90±0.43). The xylem and phloem elements are embedded in the sclerenchymatous tissue. The pith is sclerenchymatous. Cell inclusions like starch grains or cell modifications like the water cells or air cells absent.

Discussion. During the course of evolution, tropical orchids have developed several adaptations to grow in highly stressful epiphytic habitats. The extreme environmental conditions induce a large number of physiological changes in plants which result in modifications in the structure of the vegetative organs (Stern 2014a, Yang *et al*. 2016). Generally, plants that thrive in extreme environmental conditions have one or more types of adaptation that help them to cope up the stresses. The anatomical modification is one of the most common strategy plants adapt to grow in extreme habitats (Hlwatika & Bhat 2002). Although certain characteristics are common for plants growing in the stressed habitats, species of the same genus may adopt different strategies for the same environment (Piazza *et al*. 2015).

The vegetative anatomy of *B. sterile* exhibited variation in certain aspects compared to other *Bulbophyllum* species and adaptations to xeric conditions of the epiphytic habitats in all the organs analyzed. Though hairs of various natures were reported on leaf surfaces in several species of *Bulbophyllum*, hairs were completely absent in leaves of *B. sterile* (Gravendeel *et al*. 2014). The leaf surface was peculiar presenting a cobblestone-like arrangement. These wrinkly leaf surfaces in *B. sterile* were not the result of the bulging of the outer periclinal walls of the epidermal cells, but the varied deposition of the cuticle as evidenced by the cord-like appearance in transverse section. The thickness of the leaf cuticle in *B. sterile* is almost similar to those reported for *Dendrobium chrysotoxum* Lindl., and *Dendrobium officinale* Kimura & Mego which are shown to have reduced transpiration rates (Yang *et al*. 2016). These observations confirm the fact that cuticle may act as an efficient barrier in preventing water loss from plants. The amphistomatal nature of *B. sterile* leaves is in contrast to the hypostomatal nature reported in other species of *Bulbophyllum* (Smidt *et al*. 2013, Stern 2014a, b, Piazza *et al*. 2015). Generally in angiosperms, hypostomatal leaves are prevalent in mesophytic species, whereas species growing in environments that are extremely dry or humid have amphistomatal leaves (Stancato *et al*. 1999, Parkhurst 1978). Nevertheless, when amphistomatal nature occurs, the number of stomata is less on the adaxial surface than the abaxial surface as observed in *B. sterile*. The uniseriate epidermis of *B. sterile* leaf consisted of rectangular parenchymatous cells with uniform thickened walls in contrast to the irregularly polygonal cells with variedly thickened walls reported in some species of *Bulbophyllum* (Piazza *et al*. 2015).

The presence of spiral idioblasts and air cells in *B. sterile* can be due to their habitat. This explains for the thick and fleshy nature of the leaves. Olatunji & Nengim (1980) termed these water storage cells as tracheoidal elements. Tracheoidal idioblasts usually occur when plants are associated with dry environments (Olatunji & Nengim 1980). According to Pridgeon & Stern (1982), during the shortage of water, these cells either get filled with air or may become involved in water storage. Otherwise, they play a role in the mechanical support of adjacent tissues (Aybeke *et al*. 2010). In the present study, the water storage cells are pitted or striped. Kaushik (1983) observed simple and special water storage cells in many Himalayan orchids. Nevertheless, the absence of hypodermis in *B. sterile* simulated the study of Stern & Carlsward (2009), where the members of the sub tribe Laeliinae were characterized by the absence of hypodermis. The homogenous nature of mesophyll cells in *B. sterile* is supported

by the studies of Stern & Carlsward (2009) as well as Mohana Rao & Khasim (1987) and Gravendeel *et al*. (2014).

The rhizome tissues in orchids have a specialized function of absorbing water from the roots, leaves, and stem succulence (Benzing *et al*. 1983, Moreira & Isaias 2008). The rhizome in *B. sterile* revealed a thick contoured cuticle similar to cell height followed by a uniseriate epidermis consisting of compactly arranged parenchymatous cells contrary to the observations of Mohana Rao & Khasim (1987) where the epidermal cells were tubular in *Bulbophyllum andersonii* (Hook. f.) J.J. Sm., and *Bulbophyllum dyerianum* (King & Pantl.) Seidenf. The ground tissue was differentiated into outer and inner regions, separated by sclerenchymatous band. This contrasts the results of Mohana Rao & Khasim (1987) where such sclerenchymatous bands were absent in *Bulbophyllum* species examined. The phloem pole in *B. sterile* was covered by a sclerenchymatous band contrary to the xylem which was covered by thin walled parenchymatous cells. Sclerenchymatous bundle caps were observed in the rhizomatous taxa studied by Aybeke *et al*. (2012) namely *Cephalanthera epipactoides* Fisch. & C.A. Mey, *Cephalanthera longifolia* (L.) Fritsch, and *Epipactis helleborine* (L.) Crantz. The presence of abundant starch grains in the inner ground tissues surrounding the vascular bundles is unique to this species which aids in the function of storage.

The pseudobulb of *B. sterile* is ovoid and covered by a thick cuticle as in *B. occultum* Thouras, and *B. lobbii* Lindl. (Stern 2014b). The thin-walled rectangular cells in the epidermis contrast the observations of Mohana Rao & Khasim (1987) where the cells were squarish and turgid. However, Mohana Rao & Khasim (1987) reported that in *B. andersonii* and *B. dyerianum*, some mesophyll cells change into columnar and club-shaped cells having multi-spiral cellulosic thickenings to function as water storage cells whereas *B. leopardianum* (Wall.) Lindl. ex Wall. is characterized by simple and special water storage cells. In the present study, the water storage cells in the pseudobulb of *B. sterile* were pitted. Moreover, the ground tissue also contained starch grains, raphides, aeration and algal cells which were not observed in any of the three *Bulbophyllum* species examined by Mohana Rao & Khasim (1987). The sclerenchymatous band in *B. sterile* that separates the outer and inner ground tissue is much wider than the 1–2 layer of sclerenchymatous band reported in other species of *Bulbophyllum* (Stern 2014b). Thick-walled sclerenchyma cells adjacent to phloem and xylem subtended by thin-walled, polygonal parenchyma cells were also observed in *Gramatophyllum* (Yukawa & Stern 2002). The parenchymatous bridge in the vascular bundles reported in other species of *Bulbophyllum* (Stern 2014b) was however absent in *B. sterile*.

The thin roots of *B. sterile* are cylindrical whereas the roots attached to the substratum are flattened at the point of contact and lacked root hairs. The velamen of *B. sterile* is typical of *Bulbophyllum* type proposed by Porembski & Barthlott (1988). The velamen is single layered composed of highly elongated cells that are compactly arranged unlike in *Bulbophyllum weddellii* (Lindley) Rchb.f., where it is two layered (Piazza *et al*. 2015). The outer periclinal wall of the velamen cells is much thinner than the inner periclinal and radial walls. Further, the stabilizing wall thickenings of the velamen cells are absent in roots of *B. sterile* as in other *Bulbophyllum* species (Porembski & Barthlott 1988). It is often suggested that the size of the velamen could be related to specific environmental factors like temperature and water. Hence the species occurring in dry habitats or exposed habitats have a multilayered velamen while those like *Bulbophyllum* that occur in humid environments are characterized by a single layered velamen (Sanford & Adanlawo 1973). The velamen is an important structure in orchid roots adapted for the uptake of water and nutrients in conditions of drought. It helps in the quick absorption of water and prevents moisture loss from the roots, apart from providing mechanical protection, reflecting infra- red radiation, screening of roots against ultraviolet radiation and absorbing immobilized nutrients from rain water (Muthukumar & Kowsalya 2017). Apart from this, the other functions that can be attributed to this tissue include amplifying access to mineral-rich solutions (Benzing *et al*. 1982), and exchange of oxygen and carbon dioxide between the root and atmosphere (Moreira & Isaias 2008).

The exodermis being the outer layer of the cortex (Engard 1944) consisted of long and short cells. Though the thick secondary wall development in long cells renders the cells dead at maturity (Pridgeon

1986), nucleus was observed in some long cells of *B. sterile* exodermis. The deposition of lignin and suberin in the exodermal cell walls empower these cells to give mechanical protection and to maintain a layer of high humidity around the cortex (Sanford & Adanlawo 1973, Benzing *et al*. 1983, Moreira & Isaias 2008). In the present study, *B. sterile* had O- thickenings in their large cells. In contrast, the exodermis of *B. involutum* Borba, Semir & F.Barros, *B. medusa* (Lindl.) Rchb.f., and *B. perii* Schltr. has been reported to possess ∩-thickened walls or variable wall thickening has been reported in *B. imbricatum* Lindl. (Stern 2014b, Piazza *et al*. 2015). The short passage cells of the exodermis are thin walled and living cells. These cells play a significant role in the nutrition and hydration of the epiphytic orchids (Stern 2014b).

Like in other species of *Bulbophyllum*, tilosomes of *B. sterile* was broadly lamellate (Pridgeon *et al*. 1983). In contrast, spongy tilosomes have been reported in *Bulbophyllum micholitzianum* Kranzl., and *Bulbophyllum ornatissimum* (Rchb.f.) J.J.Sm (Stern 2014b). This same author suggests that tilosomes in *Bulbophyllum* might have arose several times independently and at least once in tropical Asia, Africa, and the Neotropics possibly after the emergence of the epiphytic habit. This suggestion was based on the consistency in the morphology of tilosomes in this genus. Though not well resolved, tilosomes are presumed to play an important role in reducing transpiration in arid and exposed conditions. In addition, tilosomes are also believed to aid the movement of water into the root cortex when velamen is completely soaked with water (Pridgeon *et al*. 1983).

Raphides and water cells were present in the parenchymatous root cortex of *B. sterile* as in other *Bulbophyllum* species. Although raphides were present in root cortical cells, prismatic and druses of calcium oxalate crystals reported in some *Bulbophyllum* species were absent in the roots of *B. sterile* (Piazza *et al*. 2015). Generally, the fungal peloton was detected only in the cortical region that was that were opposite to the root portion that was attached to the substrate. The endodermal cells had O-thickened walls typical of *Bulbophyllum* species. The exodermal and endodermal wall thickening was considered as an adaptation to the epiphytic habit to prevent water loss from the cortical region and vascular cylinder (Moreira & Isaias 2008). The pericycle and pith are sclerenchymatous with thin walled pericycle cells opposite to xylem poles. Like many epiphytic orchids, the vascular tissues in *B. sterile* roots are embedded in sclerenchymatous tissues. This anatomical feature is considered to be a highly significant character that is related to the endurance of the plant during drought conditions (Nawaz *et al*. 2013, Muthukumar & Kowsalya 2017). The number of xylem arches (9–12) is well within the range reported for *Bulbophyllum* species (Stern 2014b, Piazza *et al*. 2015). Nevertheless, experimental evidence is necessary to ascertain if *B. sterile* actually benefits from these anatomical modifications as recently shown for *Dendrobium* species by Yang *et al*. (2016).

Conclusions. Vegetative anatomy of *B. sterile* differs from other *Bulbophyllum* species in possessing leaves with a thick wrinkled cuticle, and amphistomatous distribution of stomata. The sclerenchymatous band in the rhizome of *B. sterile* is much wider than the 1–2 layered sclerenchyma band reported for other species of *Bulbophyllum*. Further, the major function of the rhizome appears to be storage as evidenced by the abundant starch grain filled cells of the inner ground tissue. In addition to these, *B. sterile* possessed anatomical adaptations to xerophytic conditions like the thick cuticle covering the whole aerial plant parts, amphistomatous condition, and special cells for water storage.

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AN UPDATED CHECKLIST OF THE ORCHIDS OF MAHARASHTRA, INDIA

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Abstract. A checklist of the Orchidaceae of Maharashtra is presented based on herbarium collections and recent botanical explorations. This list comprises 32 genera with 106 taxa. The best represented genus is *Habenaria* with 23 species, followed by *Dendrobium* with eleven, *Eulophia* and *Oberonia* with seven and *Peristylus* with six. In Maharashtra, the total endemic orchid species are 41 spread over in 13 genera. Of these 30 species, six species are endemic to Peninsular India and five species are endemic to India. Generally orchids are found in the nine major habitats in Maharashtra of which the best representation was observed in the semi-evergreen forests (55 species) followed by moist deciduous forests (48 species), high altitude rocky plateaus (26 species) and dry deciduous forests (25 species). Flowering, habit, habitat, endemic status and distribution in Maharashtra are presented in the checklist.

Key words: India, Maharashtra, orchids, Western Ghats

Introduction. The Maharashtra state of the Western India is known for its flowering plant wealth was explored since 18th century by Law, Graham, Nimmo, Sykes, Jacquemont, Gibson and Dalzell, followed by Birdwood, Nairne, Hallberg, Acland, Cooke, Woodrow, Gammie & Ryan, etc. Graham was the pioneer to publish a Catalogue of Bombay Plants where he mentioned 31 species of orchids under 11 genera (Graham 1839). The following publication was by Dalzell and Gibson (1861) titled 'Flora of Bombay' that described 57 species of orchids under 23 genera. However, prior to this Dalzell separately published his floristic work in the form of articles in 'Hooker's Journal of Botany and Kew Garden Miscellany' from 1850 to 1852. Nairne (1894) in his book 'Flowering Plants of Western India' mentioned 45 orchid species under 14 genera. Birdwood (1886) mentioned six species of orchids in his catalogue of the flora of Matheran. After that, he produced a catalogue of the flora of Mahabaleshwar and Matheran (Birdwood 1887) and mentioned 19 orchid species. Woodrow (1898–1900) documented 68 orchids in Flora of Western India. Gammie (1904a, b, 1906, 1907a, b, 1908a, b, 1909a, b, 1910, 1911a, b, 1912) published a series of papers in Journal of Bombay Natural History Society on orchids of the Bombay Presidency and included 61 species under 30 genera. Cooke (1907) described 31 genera and 75 species of orchids from Bombay Presidency. Subsequently, Blatter and McCann (1931a, b, c, 1932) revised the orchid flora of Bombay Presidency and documented 132 species under 37 genera including many endemic orchids. They explored the dense forest of North Kanara district as well as Konkan area of Maharashtra and made collections. However, many of those species collected do not precisely indicate the localities and a majority of these collections are hardly available in Indian herbaria such as BSI, BLAT, CAL, etc.

Santapau (1903–1970) had a special interest on the flora of Western Ghats and his explorations had resulted in publication of several floras significant to this region. He critically re-investigated the Orchidaceae of Bombay State and published series of articles in Journal of Bombay Natural History Society in 1959–1963. Later on in 1966, these published articles were reprinted in the form of book "The Orchids of Bombay". The work enumerates a total of 118 taxa under 36 genera. The Botanical Survey of India (BSI) after its reorganization in 1956 established its Western Circle at Pune. Since then several BSI scientists have led plant exploration tours to different places of Maharashtra. Botanists from Agharkar Institute, Pune University, Shivaji University, Kolhapur and Dr. Babasaheb Ambedkar Marathwada

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University, Aurangabad have also made frequent plant collection in the state and published several new records and rediscoveries. In the last half century, a number of floras have been published on different regions and districts of Maharashtra. The Botanical Survey of India published a Flora of Maharashtra in 1996 and accounted for a total 113 orchid taxa under 34 genera. Later, M. R. Almeida also published a Flora of Maharashtra in 2009 and accounted for a total 157 taxa in 46 genera which included many cultivated species. Recently Pande *et al*. (2010) were able to report 99 species of orchids occurring in the wild in North Western Ghats (including Maharashtra, Goa and Karnataka) and lately, Barbhuiya and Salunkhe (2016) enumerated 122 taxa in 36 genera. Previous enumerations, Almeida (2009) and Barbhuiya and Salunkhe (2016) have included many taxa from cultivated source. Moreover, many species were included due to misidentifications, ignorance or lack of critical study. Thus, there is a need to provide a rationalized inventory on the orchids of Maharashtra.

Materials and Methods

Study Area.— The state of Maharashtra lies in the Western and Central part of India between the latitudes 22°1' to16°4' N and longitudes 72°6' to 80°9' E. It is bordered by Gujarat and the Union territory of Dadra and Nagar Haveli to the NorthWest, Madhya Pradesh to the North and NorthEast, Chhattisgarh to the East, Karnataka to the South, Telangana to the South East, and Goa to the SouthWest (Fig. 1). It occupies an area of 307,731 km2, which accounts for about 9.84% of the total area of India. The elevation ranges from sea level to 1646 m a.s.l. It comprises 36 districts and physiographically, this state may be divided into three natural divisions: the coastal strip (the Konkan), the Sahyadri or the Western Ghats and the Maharashtra Plateau. The 'Konkan' is a narrow strip of coastal land lying between the Arabian Sea and the Western Ghats. The western side of the Konkan region has a coastal length of about 720 km, whereas the width of this region ranges from 30 to 60 km. The area of the Western Ghats of Maharashtra is known as 'Sahyadris', with a total length of 750 km and average width of 80 km. The western face of the Ghats is cut by deep ravines and canyons. Many of

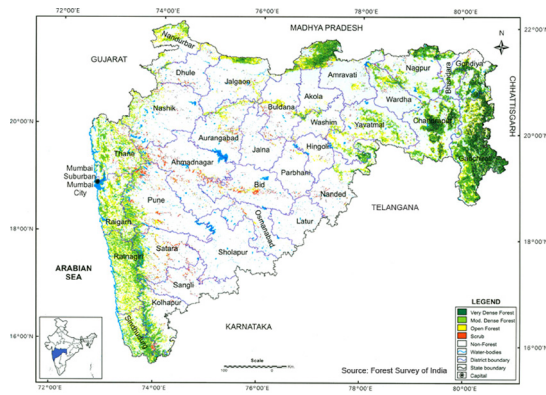

FIGURE 1. Location map of Maharashtra.

the peaks of the Western Ghats are more than 1400 m in height. Kalsubai (1646 m) is the highest peak in Maharashtra. Other important peaks are Salher (1567 m), Mahabaleshwar (1438 m), Saptashringi (1416 m) and Trimbakeshwar (1304 m). The extensive tableland known as the Deccan or Maharashtra plateau is situated in the eastern region of Western Ghats. Over 90% of the area of the state is occupied by this plateau: the east-west stretch is 750 km long and the north-south width is about 700 km, the average height is 450 m. It is made of an impervious base of basaltic rocks overlaid with Deccan lavas. Tapi, Godavari, Bhima and Krishna are the main rivers of the state. This state has a tropical monsoon climate. Over 90% of the rainfall is due to the south-western monsoon (June to September). There is heavy rainfall in the coastal region (about 2000 mm), scanty rains in the rain shadow areas in the centralparts (about 500 mm) and medium rains in the easternparts (about 1000 mm) of the state. As per Champion and Seth (1968) the State has 16 forest types, which belong to six forest type groups *i.e*., Tropical Semi-Evergreen, Tropical Moist Deciduous, Littoral and Swamp, Tropical Dry Deciduous, Tropical Thorn and Subtropical Broad-leaved Hill Forests.

Data Collection.— The present checklist is an outcome of four years field visits from 2012 to 2015, supported with critical herbarium (CAL, BSI, BLAT, SUK, BAMU, Sardar Patel University Herbarium) studies and vast literature consultation (Almeida 1990, 2009, Bachulkar 2010, Bachulkar & Yadav 1993, Bachulkar *et al*. 2011, Barbhuiya & Salunkhe 2016, Birdwood 1886, 1887, Blatter 1908, 1909,

1930, Blatter & McCann 1931a,b,c, 1932, Cerejo-Shivkar & Shinde 2015, Cooke 1907, Datar & Ghate 2012, Gaikwad *et al*. 2012, Gammie 1904a,b, 1906, 1907a,b, 1908a,b, 1909a,b, 1910, 1911a,b, 1912, Jalal & Jayanthi 2013, Jalal *et al*. 2013, Jalal *et al*. 2014, Kamble & Pradhan 1988, Kothari & Moorthy 1993, Kulkarni 1988, Lakshminarasimhan & Sharma 1991, Lakshminarasimhan *et al*. 1996, Mudaliar 1991, Nayar & Kochhar 1984, Punekar 2002a,b, Sanghamitra *et al*. 2012, Santapau & Kapadia 1966, Sardesai & Yadav 2004, Sardeshi *et al*. 2002, Shah & Badrinath 1985, Ugemuge 1986, Yadav & Sardesai 2002, Yadav & Sardesai 2002). A total of fifteen field visits of 10–20 days duration were undertaken to collect orchids from selected districts. Priority was given to those districts from where maximum numbers of orchid species have been reported (Fig. 2). A total of 21 districts were surveyed covering all the seasons in the year. Maximum field tours were undertaken during pre-monsoon (April–May) and monsoon (June–September) periods since this is the time with most orchid species flowering. All the collected specimens were processed with the standard herbarium technique (Jain & Rao 1977). Specimens collected in vegetative conditions were brought and cultivated in the Conservatory of Botanical Survey of India, Pune for observation of flowering. After the study and identification, the standard online world databases, namely, Govaerts *et al*. (2016), Tropicos (2016), IPNI (2016) were also consulted for recent updates on the nomenclature and their global distributional details. Herbarium specimens collected during field work were deposited in the herbarium of Botanical Survey of India, Western Regional Centre, Pune (BSI).

Results and Discussion

This study has resulted in the documentation of 32 genera and 106 species for Maharashtra State. Of which, 53 species are epiphytic and 53 species are terrestrial, including one mycoheterotrophic (*Epipogeum roseum*). During the present survey 66 species (62%) were studied alive and were found in the field, 30 species (28%) were studied in herbarium and the remaining 10 (9%) were included from literature with no voucher specimens available in any Indian herbaria. *Habenaria* with 23 species is the largest genus in the state followed by *Dendrobium* (11), *Eulophia* and *Oberonia* (7) and *Peristylus* (6). In Maharashtra, the total endemic orchid species are 41 spread over in 13 genera. Of these, 30 species are endemic to Western Ghats (*Bulbophyllum fimbriatum, B. sterile, B. stocksii, Conchidium filiforme, C. exile, C. microchilos, Dendrobium aqueum, D. barbatulum, D. lawianum, D. microbulbon, D. nanum, D. nodosum, D. ovatum, Gastrochilus flabelliformis, Habenaria elwesii, H. foliosa, H. heyneana, H. hollandiana, H. multicaudata, H. ovalifolia, H. rariflora, H. suaveolens, Oberonia brunoniana, O. verticillata, Pinalia mysorensis, P. polystachya, Plectoglossa perrottiana, Smithsonia maculata, S. straminea and S. viridiflora*); six species are endemic to Peninsular India (*Aerides maculosa, Eulophia pratensis, Habenaria brachyphylla, H. gibsonii, H. grandifloriformis* and *H. panigrahiana*); and five species are endemic to India (*Dendrobium herbaceum, Eria reticosa, Eulophia ochreata, Peristylus stocksii* and *Porpax jerdoniana*). The concentrations of endemic orchids are observed mainly in high rainfall areas such as Khandala-Lonavala, Mahabaleshwar-Koyna-Chandoli, Amboli and Radhanagari of Western Ghats. However, the Deccan plateau have a significantly lower number of species due to the little rainfall. The majority of the endemic species are confined to selected hill tops or small hill areas of semi-evergreen forests, plateaus and moist deciduous forests, making those areas very important for conservation.

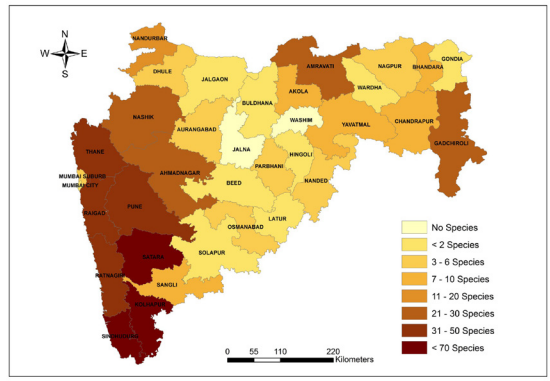

Figure 2. District wise representation of orchid richness in Maharashtra (data based on herbarium records and literature).

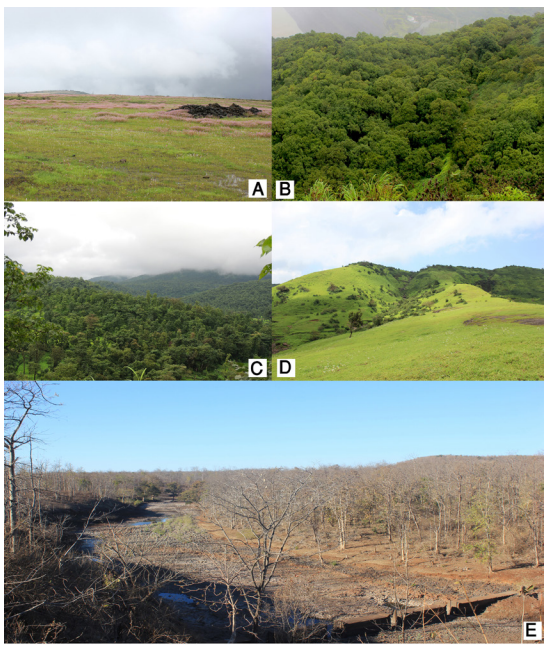

FIGURE 3. A. High altitude rocky plateau at Khambadev, Sindhudurg district, B. A view of semi-evergreen forest at Mahabaleshwar, C. Moist deciduous forest during rainy season at Kasara ghat, D. Mountain grassy slopes, E. Dry deciduous forest at Melghat Tiger Reserve, Amravati district

Habitats. Broadly orchids occur in the following major habitats in Maharashtra viz., semi-evergreen forests, moist deciduous forests, dry deciduous forest, coastal forests, high altitude rocky plateaus, low altitude rocky plateaus, mountain grassy slopes, semi-arid grasslands and roadside avenue plantation (Fig. 3). Of the different habitats the semi-evergreen and moist deciduous forests harbors maximum number of species followed by plateaus and dry deciduous forests (Table 1).

Semi-evergreen forests. These forests are mostly occurring in patches along the upper elevations between 500–1000 m. This is an important vegetation type having rainfall about 2000–4000 mm and a dry season of seven months. This forest type includes secondary evergreen dipterocarp forests, lateritic semi-evergreen forests, bamboo brakes, and riparian forests as described by Champion and Seth (1968). Important trees observed in semi-evergreen forests are *Terminalia chebula, T. bellirica, Alstonia scholaris, Careya arborea, Holigarna arnottiana, H. grahamii, Macaranga peltata, Mangifera indica, Mitragyna parviflora, Syzygium cumini, Ixora brachiata* and *Kydia calycina*. Epiphytic orchids such as *Aerides crispa* are found growing on medium sized trees in open canopies. Similarly, endemic orchid *Smithsonia viridiflora* which grows on tree trunks and is found in the open canopy area. Interesting examples like *Chierostylis parvifolia*, which is a ground orchid but sometimes is found growing as epiphytes on the crevices of moss laden trunks. *Dendrobium aqueum* and *D. microbulbon* are also found growing as epiphytes on branches of small trees. Between the gaps of semi-evergreen forest patches, *Habenaria brachyphylla* has found suitable habitat for growth. *Peristylus stocksii, P. plantagineus, P. aristatus, Habenaria ovalifolia* and *Malaxis versicolor* are generally found in undergrowth of evergreen forests. *Zeuxine affinis, Z. longilabris* and *Habenaria digitata* grow under the shade of semi-evergreen forests. *Strobilanthes callosus* is one of the dominant shrubs on the outskirts of semi-evergreen forests. *Habenaria heyneana* and *Pecteilis gigantea* are found along the margins of *Strobilanthes callosus* patches.

TABLE 1. Orchid species richness in different habitats.

Sl. No.	Habitat types	Species richness
1	Semi-evergreen forests	55
2	Moist deciduous forests	48
3	Dry deciduous forests	25
4	Coastal forests	3
5	High altitude rocky plateaus	26
6	Low altitude rocky plateaus	10
7	Mountain grassy slopes	9
8	Semi-arid grassland	2
9	Roadside avenue plantations	6

Moist deciduous forests. Moist deciduous forests are one of the common vegetation types at the base of Western Ghats and Konkan region with high rainfall of 1500–2500 mm. The rainfall is restricted to south-west monsoon. The common trees are *Albizia chinensis, Canthium dicoccum, Careya arborea, Catunaregam spinosa, Dalbergia latifolia, Diospyros chloroxylon, Dillenia pentagyna, Ficus racemosa, Macaranga peltata, Madhuca longifolia, Mallotus philippensis, Meyna laxiflora, Syzygium cumini, Terminalia paniculata* and *Xylia xylocarpa,* etc. The percentage of epiphytic species is more prevalent in moist deciduous forests than compared to other forests types. The top canopy trees shed their leaves in winter, then the epiphytic species start flowering soon after this phenomenon. Epiphytic orchids such as *Aerides maculosa, Conchidium microchilos, Dendrobium barbatulum, D. ovatum, D. peguanum, Oberonia recurva* and common ground orchids such as *Eulophia spectabilis, Geodorum densiflorum, Habenaria digitata, H. foliosa, H. gibsonii, Nervilia concolor, N. crociformis, Pecteilis gigantea, Peristylus lawii* and *P. plantagineus* are commonly found in this habitat.

Dry deciduous forests. This type of forests comprises mixed tree species which remain deciduous for several months during the dry season. Teak predominates in this type of habitat. The rainfall varies from 90–1300 mm. Trees such as *Tectona grandis, Anogeissus latifolia, Bombax ceiba, Boswellia serrata, Holoptelea integrifolia, Lagerstroemia parviflora, Lannea coromandelica, Hardwickia binata, Butea monosperma, Erythrina stricta, Sterculia urens* etc. are common hosts for many epiphytic orchids such as *Rhynchostylis retusa*, *Vanda tessellata* and *V. testacea.* In the rainy season ground orchids such as *Eulophia spectabilis, Habenaria furcifera, H. plantaginea, H. roxburghii, Nervilia concolor, N. crociformis,* and *Pecteilis gigantea* are commonly found.

Coastal forests. Although in Maharashtra there is no well defined coastal forest, some regions along the west coast still harbor mangrove vegetation. They are mainly found along the estuaries along the coasts of Greater Bombay, Raigad, Ratnagiri, Sindhudurg and Thane districts. All along the coastline there are tidal swamps and mudflats mostly covered by mangroves. Species such as *Avicennia officinalis, Ceriops tagal, Rhizophora mucronata, Sonneratia apetala, Lumnitzera racemosa, Excoecaria agallocha, Xylocarpus granatum, Barringtonia racemosa* and *Thespesia populnea* are common. In some localities along Konkan the vegetation is also mixed with semi-evergreen elements. Orchids such as *Acampe praemorsa, Aerides maculosa* and *Cottonia peduncularis* are infrequently seen in this type of vegetation.

High altitude rocky plateaus. These habitats are the characteristic features of Western Ghats of Maharashtra. These laterites are most typically hardened flat topped hills, also known as tablelands. These have an elevation range between 800 and 1400 m, and are found in the districts of Pune, Satara, Kolhapur, Sangli, Ratnagiri and Sindhudurg. Lateritic rock shows brown and black colors because of the high concentration of ferrous and aluminum. The soil formation on the outcrops is extremely slow and the soil depth varies from a few centimeters on flat areas to about a meter in deep cracks and depressions. The soil is sandy to sandy loam in texture, highly acidic and poor in phosphates. Fourteen orchid species were reported in these high altitude rocky plateaus, of these seven species are epiphytic and the rest are ground orchids. In many plateaus where the soil depth is about 1 m, there is support for stunted host trees such as *Memecylon umbellatum* which forms forest patches. These stunted forest patches support many epiphytic orchids such as *Aerides crispa, A. maculosa, Bulbophyllum fimbriatum*, *Conchidium filiforme*, *Dendrobium aqueum, D. barbatulum*, *D. herbaceum, D. microbulbon* and *Oberonia recurva.* Sometimes epiphytic species are also seen growing on the boulders as lithophytes. Boulders are found on the plateau, either aggregated or scattered. *Conchidium reticosum* always grows on small boulders on plateaus. The shady surface also supports terrestrial orchids such as *Habenaria brachyphylla, H. foliosa, H. gibsonii, Liparis odorata, Malaxis versicolor, Nervilia crociformis, N. infundibulifolia, Pecteilis gigantea, Peristylus aristatus*, *P. plantagineus* and *P. stocksii*. The moss and duff covering these boulders allows sometimes for terrestrial orchids to grow

too. During the monsoon these plateaus provides many microhabitats for endemic ground orchids. In Mahabaleshwar, Panchgani and Chandgad area one can see the mass flowering of thousands of *Habenaria suaveolens, H. grandifloriformis, H. heyneana, H. rariflora* and *Peristylus densus*.

Low altitude rocky plateaus. This particular habitat occurs along the Konkan region between 20–200 m in Raigad, Ratnagiri and Sindhudurg districts. The coastal laterites of Konkan region are derived from the materials deposited from erosion of the Western Ghats and *in-situ* formation from low level basalts, mixed together. It covers the largest land surface in the central and southern Konkan, and these are locally known as sadas (Watve 2013). It is also a recognised habitat category under the IUCN habitat classification. The rocky plateaus in the Konkan region and the southern parts of the Northern Western Ghats have basalt as their base rock, capped with laterite. The laterites are normally subjected to alternate wet and dry climates, appearing totally barren during the dry season and followed by drastic changes in physiognomy over a period of four months during the rainy season (Prabhu 2013). The early phase of the monsoon is the period of vegetative growth of many plants including orchids. Ten orchid species including three endemic orchids are reported in this habitat. The gregarious populations of *Habenaria grandifloriformis* are seen during the month of June. In mid August, *Habenaria diphylla* and *H. marginata* are seen. The tubers of these ground orchids remain almost eight months in a dormant stage during the dry season. Tubers are modified organs that have nutrient storage for growth of new plants in the next growing season. Due to the thin layer of soil in plateaus, the tubers size reach only about 0.5–1 cm.

Semi-arid grassland. Two types of grassland habitats are reported in the study area. One is mountain grassy slopes which are found along the mountain slopes. These mountain grassy slopes though dominated by grasses are also rich in orchid diversity. Orchids such as *Habenaria commelinifolia*, *H. diphylla, H. grandifloriformis, H. heyneana, H. longicorniculata* and *Pecteilis gigantea* are recorded from these grasslands. Another grassland habitat is found in the Deccan plateau region. The grasslands of the Deccan plateau are of the semi-arid type with dry climatic conditions. These grasslands occur in districts such as Ahmednagar, Solapur, and Osmanabad, etc. Orchid diversity in this grassland is very poor, represented by a few species such as *Eulophia graminea, E. ochreata, E. pratensis* and *Zeuxine strateumatica*.

Roadside avenue plantation. Other than different forest habitats, orchids are also found in plantations, orchards, and roadside trees in different parts of Maharashtra which receives considerable rainfall. Large colonies of *Acampe praemorsa* were found growing on roadside trees such as *Samanea saman*, *Tamarindus indica*, and *Ficus benghalensis*. Other epiphytic orchids such as *Aerides maculosa*, *Dendrobium barbatulum*, *D. ovatum*, *Cottonia peduncularis* can be found growing in mango plantations, and cashew plantations. In Panchgani, Chandgad and Bhimashankar where rainfall is high some epiphytic orchids such as *Dendrobium barbatulum, Aerides maculosa* and *Conchidium filiforme* are found growing in *Eucalyptus globulus* plantations.

Host species diversity of epiphytic orchids. The present study reports a total 58 host plants of 29 species of epiphytic orchids. *Dendrobium barbatulum* is one endemic orchid that shows diverse host ranges and can be found growing on more than 29 host trees, followed by *Aerides maculosa* and *D. ovatum* which can be found to grow adding on 25 and 22 host trees respectively. They show their tolerance to wideranging microclimatic conditions available over the host trees. Epiphytic orchids, that are found on less than 10 host tree species constituted 58% of the total epiphytic species. Out of 58 host tree species recorded with epiphytic orchids, *Mangifera indica* supports 20 species of orchids. Other host tree species more important for epiphytic orchids are *Careya arborea*, *Terminalia bellirica*, *T. chebula,* and *Syzygium cumini,* and they supported about 13 to 15 species respectively. In the plateaus the most suitable host is *Memecylon umbellatum*. In many areas *Catunaregam spinosa* was found to be a suitable host for *Dendrobium barbatulum*. In the dry deciduous forests of Satpura range epiphytic orchids such as *Rhynchostylis retusa*, *Vanda tessellata* and *V. testacea*

are commonly seen on *Diospyros melanoxylon*, *Holoptelea integrifolia*, *Lagerstroemia parviflora*, *Madhuca longifolia* var. *latifolia, Ougeinia oojeinensis*, *Stereospermum chelonoides*, *Tectona grandis* and *Ziziphus mauritiana.* It was also observed that in the Konkan region *Acampe praemorsa* can be found growing on the main trunk of *Cocos nucifera*. Similarly, two other interesting host species were also reported such as *Phoenix sylvestris* and *Euphorbia neriifolia*. In high rainfall pockets *Eucalyptus citriodora* and *Eucalyptus globulus* also support some epiphytic orchids.

Threats. Habitat degradation is the main threat to the orchids in Maharashtra. Orchids populations are also threatened by habitat loss and unsustainable exploitation. A decline in the number of orchid species is reported from Panchgani, Kas Plateau and Khandala. Kas plateau, known as the valley of flowers, is facing a surge of tourists. Excited visitors take the orchids for their homes, leaving little chance for these rare orchids to survive. The fragrant *Pecteilis gigantea* popularly known as the queen of Khandala was found very commonly fifty years ago and sold in the Khandala hill station's markets. This led to a fall in the species population and now it is confined to a few spots only. Likewise, *Habenaria suaveolens* (with popular synonym *Habenaria panchganiensis*) popularly known as Panchgani orchid, was once abundant in Panchgani plateau and now became a rare sight due to the tourism activities such as horse rides and camel rides that almost converted the flora rich plateau to a barren land. In Konkan region many of the good forests patches have been cleared for cash crops such as Areca nut, Cashew nut and mango orchards. Likewise, grazing also damages several terrestrial orchids in plateau areas. *Eulophia spectabilis* is a terrestrial orchid which is being extracted from wild leading to drastic depletion of wild populations. It is commonly known as *Amarkanda* and is widely used to cure various health problems and ailments. The corm of the plant is used in the preparation of 'salep', which is taken as an aphrodisiac (Jalal *et al*. 2014). In many locations in Maharashtra, orchids are also facing threats due to the invasion of alien weeds such as *Eupatorium odoratum, Mikania cordata, Lantana camara* and *Parthenium hysterophorus*.

In the present study the entire list of species is arranged alphabetically. For each taxon, the current name with its basionym is provided, followed by a full reference to the original publication and further synonyms (restricted to those that were used in the relevant literature). Flowering months of the taxon, life form, habitat, distribution in Maharashtra, global distribution and specimen examined are given. At the end, excluded taxa are given with justification.

CHECKLIST

Acampe Lindl.

Acampe praemorsa (Roxb.) Blatt. & McCann, J. Bombay Nat. Hist. Soc. 35: 495. 1932. Fig. 4A.

Epidendrum praemorsum Roxb., Pl. Coromandel 1: 34, t. 43. 1795.

Flowering: April–June.

Life form: Epiphyte.

Habitat*:* Found in the moist deciduous forests, dry deciduous forests and coastal forests.

Distribution in Maharashtra*:* Gadchiroli, Kolhapur, Mumbai Suburban, Raigad, Ratnagiri, Satara, Sindhudurg and Thane.

General distribution: India (Andhra Pradesh, Odisha, Goa, Gujarat, Maharashtra, Karnataka, Kerala, Tamil Nadu Daman & Diu, Dadara & Nagar Haveli, Jharkhand, Chhattisgarh, Madhya Pradesh, Rajasthan), Nepal, Sri Lanka, Myanmar.

Specimens examined*:* Gadchiroli district, Surajgad, *R.S.Govekar 1652* (BAMU). Kolhapur district, Udegiri, *M.M.Sardesai 1723* (SUK). Mumbai Suburban district, Borivali, *P.S.Herbert 1615* (BLAT). Raigad district, Alibagh, *J.S.Jalal 200875* (BSI). Ratnagiri district, Mangaon, *J.S.Jalal 194905* (BSI). Satara district, Koyna, *J.S.Jalal 200792* (BSI). Sindhudurg district, Sawantwadi, *J.S.Jalal 194993* (BSI). Thane district, Mal, *J.S.Jalal 200729* (BSI).

Acampe ochracea (Lindl.) Hochr., Bull. New York Bot. Gard. 6: 270. 1910.

Saccolabium ochraceum Lindl., Edwards's Bot. Reg. 28(Misc.): 2 (1842).

Flowering: May – August.

Life form: Epiphyte.

Distribution in Maharashtra: Raigad.

General distribution: India (Assam, Manipur, Meghalaya, Mizoram, Nagaland, Arunachal Pradesh, Sikkim, West Bengal, Andhra Pradesh, Odisha, Karnataka, Kerala, Tamil Nadu), Bangladesh, Bhutan, Nepal, Sri Lanka, China, Myanmar, Thailand, Indo-China.

Note: This species is included based on Kothari and Moorthy (1993) who reported it from Karnala fort in Raigad district. There is no herbarium specimen traced in herbarium BSI to confirm its occurrence in Maharashtra.

Aerides Lour.

Aerides crispa Lindl., Gen. Sp. Orchid. Pl.: 239. 1833. Fig. 4B.

Flowering: April–June.

Life form: Epiphyte.

Habitat: Found in semi-evergreen forests.

Distribution in Maharashtra: Kolhapur, Pune, Ratnagiri, Satara, Sindhudurg and Thane.

General distribution: India (Goa, Gujarat, Karnataka, Kerala, Maharashtra, Tamil Nadu, Dadara & Nagar Haveli), Bangladesh.

Specimens examined: Kolhapur district, Radhanagari, *J.S.Jalal 200518* (BSI). Pune district, Lonavala, *J.S.Jalal 200406* (BSI). Ratnagiri district, Kudavale, *J.S.Jalal 194917* (BSI). Satara district, Mahabaleshwar, *J.S.Jalal 200806* (BSI). Sindhudurg district, Amboli, *J.S.Jalal 200492* (BSI). Thane district, Tokavada range, *K.V.Billore 115624* (BSI).

Aerides maculosa Lindl., Edwards's Bot. Reg. 31: 58. 1845. Fig. 4C.

Flowering: May – July.

Life form: Epiphyte.

Habitat: Found growing in moist deciduous, dry-deciduous and semi-evergreen forests.

Distribution in Maharashtra: Amravati, Gadchiroli, Kolhapur, Nandurbar, Nashik, Pune, Raigad, Ratnagiri, Satara, Sindhudurg and Thane.

General distribution: India (Andhra Pradesh, Odisha, Goa, Gujarat, Maharashtra, Karnataka, Kerala, Tamil Nadu, Madhya Pradesh, Rajasthan), **endemic to Peninsular India.**

Specimens examined: Amravati district, Chikhaldara, *J.S.Jalal 200736* (BSI). Gadchiroli district, Jharapapada, *R.S.Govekar 1671* (BAMU). Kolhapur district, Radhanagari, *J.S.Jalal 200532* (BSI). Nandurbar district, Toranmal, *J.S.Jalal 195112* (BSI). Nashik district, Kasara Ghat, *J.S.Jalal 200874* (BSI). Pune district, Lonavala, *J.S.Jalal 200406* (BSI). Raigad district, Phansad WLS, *J.S.Jalal 200883* (BSI). Ratnagiri district, Dapoli, *J.S.Jalal 194926* (BSI). Satara district, Mahabaleshwar, *J.S.Jalal 200812* (BSI). Sindhudurg district, Amboli, *J.S.Jalal 194954* (BSI). Thane district, Tansa, *J.S.Jalal 200853* (BSI).

Aerides multiflora Roxb., Pl. Coromandel 3: 68. 1820.

Flowering: May – October.

Life form: Epiphyte.

Habitat: Found growing in dry-deciduous forest.

Distribution in Maharashtra: Gadchiroli.

General distribution: India (Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura, Arunachal Pradesh, Sikkim, West Bengal, Uttarakhand, Himachal Pradesh, Odisha, Andhra Pradesh, Madhya Pradesh, Chhattisgarh, Rajasthan, Andaman & Nicobar), Bangladesh, Bhutan, Nepal, Myanmar, Thailand, Indo-China.

Specimen examined: Gadchiroli district, Gatta, *R.S.Govekar s.n.* (BAMU).

Aerides odorata Lour., Fl. Cochinch.: 525. 1790.

Flowering: May–June.

Life form: Epiphyte.

Habitat: Found growing in moist deciduous forest.

Distribution in Maharashtra: Gadchiroli.

General distribution: India (Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura, Arunachal Pradesh, Sikkim, West Bengal, Uttarakhand, Odisha, Andhra Pradesh, Karnataka, Madhya Pradesh, Chhattisgarh, Andaman & Nicobar), Bangladesh, Bhutan, Nepal, Myanmar, Malaysia, Indonesia, Philippines, Thailand, Indo-China.

Specimen examined: Gadchiroli district, Kawande, *R.S.Govekar 1692* (BAMU).

Aerides ringens (Lindl.) C.E.C.Fisch. in J.S.Gamble, Fl. Madras: 1442. 1928.

Saccolabium ringens Lindl., Gen. Sp. Orchid. Pl.: 220. 1833.

Flowering: May–July.

Life form: Epiphyte.

Distribution in Maharashtra: Thane and Satara.

General distribution: India (Andhra Pradesh, Odisha, Goa, Gujarat, Karnataka, Kerala, Tamil Nadu), Sri Lanka.

Note: This species is included here based on Dalzell and Gibson (1861) collection from Salsette and Woodrow's collection from Mahabaleshwar. Mulgaonkar and Dabhade (2005) reported it from Panvel in Raigad District. However, there is no specimen available in any of the herbaria. Recently it was reported from Valsad district of Gujarat near Maharashtra border by Bhatt and Nagar (2014). There is a possibility of its occurrence in Maharashtra.

Bulbophyllum Thouars

Bulbophyllum fimbriatum (Lindl.) Rchb.f. in W.G.Walpers, Ann. Bot. Syst. 6: 260. 1861. Fig. 4D.

Cirrhopetalum fimbriatum Lindl., Edwards's Bot. Reg. 25(Misc.): 72. 1839.

Flowering: December–May.

Life form: Epiphyte.

Habitat: Found in semi-evergreen forests.

Distribution in Maharashtra: Pune, Satara and Sindhudurg.

General distribution: India (Goa, Karnataka, Kerala, Maharashtra, Tamil Nadu), **endemic to Western Ghats.**

Specimens examined: Pune district, Junnar, *J.S.Jalal 200831* (BSI). Sindhudurg district, Bhedshi, *B.G.Kulkarni 120453* (BSI). Satara district, Mahabaleshwar, *J.S.Jalal 200810* (BSI).

Bulbophyllum sterile (Lam.) Suresh in D.H.Nicolson, C.R.Suresh & K.S.Manilal, Interpret. Van Rheede's Hort. Malab.: 298. 1988. Fig. 4E.

Epidendrum sterile Lam., Encycl. 1: 189. 1783.

Bulbophyllum nilgherrense Wight, Icon. Pl. Ind. Orient. 5: t. 1680. 1851.

Life form: Epiphyte.

Flowering: December–May.

Habitat: Found in semi-evergreen forests.

Distribution in Maharashtra: Sindhudurg and Kolhapur.

General distribution: India (Andhra Pradesh, Goa, Karnataka, Kerala, Maharashtra, Tamil Nadu), **endemic to Western Ghats.**

Specimens examined: Kolhapur district, Patgaon, *M.M.Sardesai 2027* (SUK). Sindhudurg district, Konshi, Sawantwadi, *S.M.Almeida 5232* (BLAT).

Bulbophyllum stocksii (Benth. ex Hook.f.) J.J.Verm., Schuit. & de Vogel, Phytotaxa 166: 111. 2014.

Trias stocksii Benth. ex Hook.f., Fl. Brit. India 5: 781. 1890.

Flowering: February–March.

Life form: Epiphyte.

Distribution in Maharashtra: Konkan at c. 100 m.

General distribution: India (Maharashtra, Karnataka, Kerala and Tamil Nadu), **endemic to Western Ghats.**

Specimens examined: Konkan "*Concan*", Stocks & Law *s.n*. (GH-00287630, GOET-008707).

Note: It is included on the authority of J.D. Hooker (1980). He mentioned it based on the collection by Law from south and north Konkan region. It has not been recollected by any subsequent workers from Maharashtra region. There is no herbarium record of its collection from Maharashtra.

Cheirostylis Blume

Cheirostylis flabellata (A.Rich.) Wight, Icon. Pl. Ind. Orient. 5: 16. t. 1727. 1851.

Goodyera flabellata A.Rich., Ann. Sci. Nat., Bot., ser. 2, 15: 79. 1841.

Monochilus flabellatus (A.Rich.) Wight, Icon. Pl. Ind. Orient. 5: t. 1727. 1851.

Flowering: November.

Life form: Terrestrial.

Habitat: Found under the shade of semi-evergreen forests.

Distribution in Maharashtra: Satara.

General distribution: India (Karnataka, Kerala, Maharashtra, Tamil Nadu), Sri Lanka, Myanmar.

Specimen examined: Satara district, Mahabaleshwar, *P.V.Bole 2244* (BLAT).

Cheirostylis parvifolia Lindl., Edwards's Bot. Reg. 25(Misc.): 19. 1839.

Flowering: November–February.

Life form: Terrestrial.

Habitat: Found under the shade of semi-evergreen forests.

Distribution in Maharashtra: Kolhapur, Satara and Sindhudurg.

General distribution: India (Kerala, Maharashtra, Odisha, Tamil Nadu), Sri Lanka.

Specimens examined: Kolhapur district, Chandgad, *J.S.Jalal 197709* (BSI). Satara district, Koyna, *Prajakta Pathare 198950* (BSI). Sindhudurg district, Sawantwadi, *S.M.Almeida s.n.* (BLAT!).

Cleisostoma Blume

Cleisostoma tenuifolium (L.) Garay, Bot. Mus. Leafl. 23: 175. 1972.

Epidendrum tenuifolium L., Sp. Pl.: 952. 1753.

Flowering: June–November.

Life form: Epiphyte.

Habitat: Found in semi-evergreen forests.

Distribution in Maharashtra: Sindhudurg.

General distribution: India (Goa, Karnataka, Kerala, Maharashtra, Tamil Nadu), Sri Lanka, Thailand.

Specimen examined: Sindhudurg district, Sawantwadi, *S.M.Almeida 4948* (BLAT).

Conchidium Griff.

Conchidium filiforme (Wight) Rauschert, Feddes Repert. 94: 444. 1983. Fig. 5J.

Eria filiformis (Wight) Rchb.f. in W.G.Walpers, Ann. Bot. Syst. 6: 268. 1861.

Dendrobium filiforme Wight, Icon. Pl. Ind. Orient. 5: t. 1642. 1851.

Eria dalzellii (Hook. *ex* Dalzell) Lindl., J. Proc. Linn. Soc., Bot. 3: 47. 1858 (nom. et syn. tantum, non descr.).

Eria conrardii M.R.Almeida, Fl. Maharashtra 5A: 42. 2009.

Eria conrardii var. fimbriata (Hook.f.) M.R.Almeida, Fl. Maharashtra 5A: 43. 2009.

Flowering: July–August.

Life form: Epiphyte.

Habitat: Found in moist-deciduous and semi-evergreen forests.

Distribution in Maharashtra: Kolhapur, Pune, Raigad, Ratnagiri, Sindhudurg, Satara and Thane.

General distribution: India (Gujarat, Goa, Karnataka, Kerala, Maharashtra, Tamil Nadu), **endemic to Western Ghats**.

Specimens examined: Kolhapur district, Radhanagari, *J.S.Jalal 200531* (BSI). Pune district, Lonavala, *J.S.Jalal 200409* (BSI). Raigad district, Matheran, *J.S.Jalal 200585* (BSI). Ratnagiri district, Dapoli, *J.S.Jalal 194940* (BSI). Satara district, Mahabaleshwar, *J.S.Jalal 200411* (BSI). Sindhudurg district, Khamdadev plateau, *J.S.Jalal 195013* (BSI). Thane district, Tansa, *J.S.Jalal 200859* (BSI).

Conchidium exile (Hook.f.) Ormerod, Taiwania 57: 119. 2012. Fig. 5I.

Eria exilis Hook. f., Fl. Brit. India 5: 788. 1890.

Leaves: June–October; Flowering: October–December.

Life form: Epiphyte.

Habitat: Found in semi-evergreen forests on moss laden tree trunks.

Distribution in Maharashtra: Kolhapur, Pune, Satara, Sindhudurg.

General distribution: India (Goa, Kamataka, Kerala, Maharashtra, Tamil Nadu), **endemic to Western Ghats.**

Specimens examined: Kolhapur district, Chandgad, *J.S.Jalal 195199* (BSI). Pune district, Khandala, *Z.J.Kapadia 2297* (BLAT). Satara district, Mahabaleshwar, *J.S.Jalal 200433* (BSI). Sindhudurg district, Khamdadev plateau, *J.S.Jalal 195014* (BSI).

Conchidium microchilos (Dalzell) Rauschert, Feddes Repert. 94: 444. 1983. Fig. 5K.

Dendrobium microchilos Dalzell, Hooker's J. Bot. Kew Gard. Misc. 3: 345. 1851. *Eria microchilos* (Dalzell) Lindl., J. Proc. Linn. Soc., Bot. 3: 47. 1858.

Flowering: July–August.

Life form: Epiphyte.

Habitat: Found in moist-deciduous forests and semi-evergreen forests.

Distribution in Maharashtra: Kolhapur, Pune, Raigad, Satara and Sindhudurg.

General distribution: India (Goa, Karnataka, Kerala, Maharashtra, Tamil Nadu), **endemic to Western Ghats.**

Specimens examined: Kolhapur district,

Radhanagari, *J.S.Jalal 200516* (BSI). Pune district, Amby valley, *J.S.Jalal 200570* (BSI). Raigad district, Matheran, *J.S.Jalal 200589* (BSI). Satara district, Mahabaleshwar, *P.V.Bole 329* (BLAT). Sindhudurg district, Amboli, *J.S.Jalal 195022* (BSI).

Conchidium reticosum (Wight) Ormerod, Taiwania 57: 119. 2012. Fig. 6A.

Eria reticosa Wight, Icon. Pl. Ind. Orient. 5(1): 4, t. 1637. 1851.

*Conchidium braccatum*auct. non. (Lindl.) Brieger: R. Govaerts, World Checkl. Monocot. 2014 (only syn. *E. reticosa* Wight &*E. uniflora* Dalzell).

Flowering: May–June.

Life form: Epiphyte.

Habitat: Found in semi-evergreen forests between 600–1200 m and rarely seen growing on trees but common occurrence on rocky surfaces in high altitude plateaus.

Distribution in Maharashtra: Kolhapur, Pune, Satara, Sindhudurg and Thane.

General distribution: India (Uttarakhand, Goa, Karnataka, Kerala, Maharashtra, Tamil Nadu), **endemic to India**.

Specimens examined: Kolhapur district, Borbet, *M.M.Sardesai 168* (SUK). Pune district, Ambe plateau, Junnar, *J.S.Jalal 200823* (BSI). Satara district, Kas, *M.P.Bachulkar 5437* (SUK). Sindhudurg district, Khamdadev plateau, *J.S.Jalal 195012* (BSI).

Cottonia Wight

Cottonia peduncularis (Lindl.) Rchb.f., Cat. Orchids-Samml. Schiller, ed. 3: 22. 1857. Fig. 4F.

Vanda peduncularis Lindl., Gen. Sp. Orchid. Pl.: 216. 1833.

Flowering: March–April.

Life form: Epiphyte.

Habitat: Found in moist-deciduous forests and semi-evergreen forests.

Distribution in Maharashtra: Kolhapur, Nashik, Raigad, Ratnagiri, Sindhudurg and Thane.

General distribution: India (Odisha, Goa, Karnataka, Kerala, Maharashtra Tamil Nadu), Sri Lanka.

Specimens examined: Nashik district, Igatpuri, *J.S.Jalal 195152* (BSI). Raigad district, Talerwarphatta, *J.S.Jalal 194901* (BSI). Ratnagiri district, Vetadvadi, Dapoli, *J.S.Jalal 194927* (BSI). Sindhudurg district, Sawantwadi, *J.S.Jalal 195023* (BSI). Thane district, Usgaon, *N.Y.Das 3198* (BLAT).

Cymbidium Swartz

Cymbidium aloifolium (L.) Sw., Nova. Acta. Regial Soc. Sci. Upsal. 6: 73. 1799. *Epidendrum aloifolium* L., Sp. Pl. 953. 1753.

Flowering: May–June.

Life form: Epiphyte.

Habitat: Found in the moist-deciduous forests at elevations between 50–100 m.

Distribution in Maharashtra: Kolhapur and Sindhudurg.

General distribution: India (Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura, Arunachal Pradesh, Sikkim, West Bengal, Uttarakhand, Goa, Karnataka, Kerala, Maharashtra, Tamil Nadu, Bihar, Chhattisgarh, Jharkhand, Madhya Pradesh, Andaman & Nicobar), Bangladesh, Nepal, Sri Lanka, China, Myanmar, Indonesia, Malaysia, Thailand, Indo-China.

Specimens examined: Kolhapur: Patgaon, *M.M.Sardesai 2031* (SUK). Sindhudurg: Amboli, *P.D.Mahekar s.n.* (SUK).

Cymbidium bicolor Lindl., Gen. Sp. Orchid. Pl.: 164. 1833. Fig. 4G.

Flowering: May–June.

Life form: Epiphyte.

Habitat: Found in the moist-deciduous forests at elevations between 50–100 m.

Distribution in Maharashtra: Sindhudurg.

General distribution: India (Odisha, Goa, Karnataka, Kerala, Maharashtra, Tamil Nadu), Nepal, Sri Lanka.

Specimen examined: Sindhudurg district, Pulas, Sawantwadi *J.S.Jalal 195027* (BSI).

Dendrobium Swartz

Dendrobium aqueum Lindl., Edwards's Bot. Reg. 28: Misc. 5. 1843.

Flowering: September–October.

Life form: Epiphyte.

Habitat: Found in semi-evergreen forests at elevations between 100–1300 m.

Distribution in Maharashtra: Ahmednagar, Kolhapur, Nashik, Pune, Satara and Sindhudurg.

General distribution: India (Andhra Pradesh, Goa, Karnataka, Kerala, Maharashtra, Tamil Nadu), **endemic to Western Ghats**

Specimens examined: Ahmednagar district, Pachnai plateau, Harishchandragad, *K.V.Billore 115751* (BSI). Kolhapur district, Ajara, *J.S.Jalal 200490* (BSI). Nashik district, Ambewadi, *P.L. Narasimhan 167518* (BSI). Pune district, Durga khilla, Junnar, *Hemadri 89935* (BSI). Sindhudurg district, Amboli, *J.S.Jalal 194962* (BSI). Satara district, Mahabaleshwar, *J.S.Jalal 200808* (BSI).

Dendrobium barbatulum Lindl., Gen. Sp. Orchid. Pl.: 84. 1830. Fig. 4H.

Flowering: January–May.

Life form: Epiphyte.

Habitat: Found in dry-deciduous, moist-deciduous and semi-evergreen forests at elevations between 50–1200 m.

Distribution in Maharashtra: Kolhapur, Nandurbar, Nashik, Pune, Raigad, Ratnagiri, Satara, Sindhudurg and Thane.

General distribution: India (Gujarat, Goa, Karnataka, Kerala, Maharashtra, Tamil Nadu), **endemic to Western Ghats**.

Specimens examined: Kolhapur district, Radhanagari, *J.S.Jalal 200515* (BSI). Nandurbar district, Toranmal, *J.S.Jalal 195109* (BSI). Nashik district, Igatpuri, *H. Santapau 22957* (BLAT). Pune district, Bhimashankar, *J.S.Jalal 200401* (BSI). Raigad district, Phanshad, *J.S.Jalal 200885* (BSI). Ratnagiri district, Panchvali, Dapoli, *J.S.Jalal 194943* (BSI). Satara district, Mahabaleshwar, *J.S.Jalal 200811* (BSI). Sindhudurg district, Amboli, *J.S.Jalal 195020* (BSI). Thane district, Tansa, *J.S.Jalal 200863* (BSI).

Dendrobium crepidatum Lindl. & Paxton, Paxton's Fl. Gard. 1: 63. 1850. Fig. 5A.

Flowering: April–June.

Life form: Epiphyte.

Habitat: Found in semi-evergreen forests.

Distribution in Maharashtra: Kolhapur, Pune and Sindhudurg.

General distribution: India (Assam, Manipur, Meghalaya, Mizoram, Nagaland, Arunachal Pradesh, Sikkim, West Bengal, Uttarakhand, Odisha, Goa, Karnataka, Kerala, Maharashtra, Tamil Nadu, Bihar, Jharkhand Chhattisgarh), Bangladesh, Bhutan, Nepal, China, Myanmar, Thailand, Laos, Vietnam.

Specimens examined: Kolhapur district, Ajara, *M.M.Sardesai 1204* (*SUK*). Pune district, Bhovargiri, *K.P.Janardhanan 76570* (BSI). Sindhudurg district, Shivapur, Dukanwad, *B.G.Kulkarni 129647* (BSI).

Dendrobium herbaceum Lindl., Edward's, Bot. Reg. 26: Misc. 69. 1840. Fig. 4I.

Flowering: February–March.

Life form: Epiphyte.

Habitat: Found in semi-evergreen and moist deciduous forests.

Distribution in Maharashtra: Ahmednagar, Kolhapur, Nashik, Pune, Satara, Sindhudurg and Thane.

General distribution: India (Mizoram, West Bengal, Bihar, Chhattisgarh, Jharkhand, Madhya Pradesh, Andhra Pradesh, Odisha, Goa, Maharashtra, Karnataka, Kerala, Tamil Nadu), **endemic to India.**

Specimens examined: Ahmednagar district, Piprichavran, Harishchandragadh, *B.M.Wadhwa 127857* (BSI). Kolhapur district, Panhala, *M.M.Sardesai 1825* (SUK). Nashik district, Ambewadi forest, *P.L.Narasimhan 167517* (BSI). Pune district, Bhimashankar, *J.S.Jalal 200723* (BSI). Satara district, Mahabaleshwar, *J.S.Jalal 200413* (BSI). Sindhudurg district, Khamdadev plateau, *J.S.Jalal 195016* (BSI). Thane: Tokavada range, *K.V. Billore 115729* (BSI).

Dendrobium lawianum Lindl., J. Proc. Linn. Soc., Bot. 3: 10. 1858. Fig. 5B.

Flowering: March–April; *Leaves*: May–October.

Life form: Epiphyte.

Habitat: Found in moist deciduous and semi-evergreen forests.

Distribution in Maharashtra: Kolhapur, Sindhudurg and Thane.

General distribution: India (Goa, Karnataka, Kerala, Maharashtra, Tamil Nadu), **endemic to Western Ghats.**

Specimens examined: Kolhapur district, Ajara, *J.S.Jalal 200491* (BSI). Sindhudurg district, Amboli, *J.S.Jalal 194963* (BSI). Thane district, Usgaon, *N.Y.Das 3195* (BLAT).

Note: Govaerts *et al*. (2016), Tropicos (2016) and IPNI (2016) have treated this species as a synonym of *Dendrobium crepidatum* Lindl. However, *Dendrobium lawianum* can be distinguished based on characters such as, pseudobulbs curving in one direction, flowers white *ca*. 2 cm across, with obscure mentum, lip slightly clawed at the base without a yellow patch.

Dendrobium macrostachyum Lindl., Gen. & Sp. Orchids Pl.: 78. 1830. Fig. 5C.

Flowering: May–June; *Leaves*: May–November.

Life form: Epiphyte.

Habitat: Found in semi-evergreen forests.

Distribution in Maharashtra: Kolhapur, Pune, Satara and Sindhudurg.

General distribution: India (Arunachal Pradesh, West Bengal, Uttarakhand, Odisha, Goa, Karnataka, Maharashtra Jharkhand), Nepal, Bangladesh, Sri Lanka, Indonesia, Thailand, Vietnam.

Specimens examined: Kolhapur district, Chandgad, *J.S.Jalal 200436* (BSI). Pune district, Durga khilla, *Hemadri 94362* (BSI). Ratnagiri district, Konal R.F., Bhedshi, *B.G.Kulkarni 129422* (BSI). Satara district, Koyna valley, *T.Cooke s.n*. (BSI). Sindhudurg district, Danoli, *S.M.Almeida 1649* (BLAT).

Dendrobium microbulbon A. Rich., Ann. Sci. Nat. Bot. 2, 15: 19, t. 8. 1841. Fig. 5D.

Flowering: December–January; Leaves: July–October.

Life form: Epiphyte.

Habitat: Found in moist-deciduous forests and semi-evergreen forests.

Distribution in Maharashtra: Kolhapur, Nashik, Pune, Raigad, Satara, Sindhudurg and Thane.

General distribution: India (Gujarat, Goa, Karnataka, Kerala, Maharashtra, Tamil Nadu), **endemic to Western Ghats.**

Specimens examined: Kolhapur: Udegiri, *M.M.Sardesai 1492* (SUK). Pune: Junnar, *J.S.Jalal 200818* (BSI). Nashik district, Igatpuri, *Z.J.Kapadia 1374* (BLAT). Raigad district, Matheran, *J.S.Jalal 200707* (BSI). Satara district, Mahabaleshwar, *H.M.Chibber s.n.* (BSI). Sindhudurg district, Amboli, *J.S.Jalal 195021* (BSI). Thane district, Kasara, *K.V.Billore 116451* (BSI).

Dendrobium nanum Hook.f., Hooker's Icon. Pl. 19: t. 1853. 1889. Fig. 5E.

Dendrobium mabelae Gammie, J. Bombay Nat. Hist. Soc. 16: 567. 1903.

Flowering: July–September.

Life form: Epiphyte.

Habitat: Found in semi-evergreen forest at elevations between 600–1200 m.

Distribution in Maharashtra: Raigad and Satara.

General distribution: India (Goa, Karnataka, Kerala, Maharashtra, Tamil Nadu), **endemic to Western Ghats.**

Specimens examined: Satara district, Mahabaleshwar, *J.S.Jalal 200419* (BSI). Raigad district, Matheran, *J.S.Jalal 200599* (BSI).

Dendrobium nodosum Dalzell, Hooker's J. Bot. Kew Gard. Misc. 4: 292. 1852.

Flickingeria nodosa (Dalzell) Seidenf., Dansk Bot. Ark. 34: 41. 1980.

Dendrobium macraei sensu Barbhuiya & Salunkhe in Richardiana 15: 130. 2016.

Flowering: July–August.

Life form: Epiphyte.

Habitat: Found in semi-evergreen forests.

Distribution in Maharashtra: Kolhapur, Satara and Thane.

General distribution: India (Goa, Karnataka, Kerala, Maharashtra, Tamil Nadu), **endemic to Western Ghats**.

Specimens examined: Kolhapur district, Chandgad, *J.S.Jalal 195195* (BSI). Satara district, Mahadurga, Koyna, *R.K.Kochhar 154704* (BSI). Thane district, Usgaon, *N.Y.Das 3192* (BLAT).

Dendrobium ovatum (L.) Kraenzl. in H.G.A. Engler (Ed.), Pflanzenr., IV, 5 II B 21: 71. 1910. Fig. 5F.

Epidendrum ovatum L., Sp. Pl.: 952. 1753.

Flowering: September–February.

Life form: Epiphyte.

Habitat: Found in moist-deciduous and semi-evergreen forests.

Distribution in Maharashtra: Kolhapur, Mumbai Suburban, Satara, Sindhudurg, Raigad and Thane.

General distribution: India (Andhra Pradesh, Karnataka, Gujarat, Goa, Kerala, Maharashtra, Tamil Nadu, Dadara & Nagar Haveli), **endemic to Western Ghats.**

Specimens examined: Kolhapur district, Kalakdara, *M.M.Sardesai 2033* (SUK). Mumbai Suburban district, Malad, *G.L.Shah 9632* (BLAT). Raigad district, Matheran, *N.A.Irani 2818* (BLAT). Satara district, Mahabaleshwar, *J.S.Jalal 200805* (BSI). Sindhudurg district, Karulgaon, *J.S.Jalal 200541* (BSI). Thane district, Murbad, *J.S.Jalal 200730* (BSI).

Dendrobium peguanum Lindl., J. Proc. Linn. Soc., Bot. 3: 19. 1858. Fig. 5G.

Flowering: October–December; *Leaves*: June–October.

Life form: Epiphyte.

Habitat: Found in dry-deciduous forests and moist-deciduous forests.

Distribution in Maharashtra: Kolhapur, Thane and Nashik.

General distribution: India (Mizoram, Sikkim, West Bengal, Odisha, Gujarat, Karnataka, Maharashtra, Jharkhand, Chhattisgarh), Nepal, Myanmar, Thailand.

Specimens examined: Kolhapur district, Amba ghat, *J.S.Jalal 195035* (BSI). Nashik district, Igatpuri, *Z.J.Kapadia 1375* (BLAT). Thane district, Kasara, *Z.J.Kapadia 897* (BLAT).

Epipogium Borkh.

Epipogium roseum (D. Don) Lindl., J. Proc. Linn. Soc., Bot. 1: 177. 1857. Fig. 5H.

Limodorum roseum D. Don, Prodr. Fl. Nepal. 30. 1825.

Flowering: May–June.

Life form: Mycoheterotrophic.

Habitat: It prefers to grow under the dense semi-evergreen forests.

Distribution in Maharashtra: Kolhapur and Satara.

General distribution: India (Meghalaya, Mizoram, Arunachal Pradesh, Sikkim, West Bengal, Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Karnataka, Kerala, Maharashtra, Tamil Nadu), Nepal, Sri Lanka, China, Myanmar, Indonesia, Japan, Malaysia, Philippines, Thailand, Laos, Vietnam, Pacific islands, Africa.

Specimens examined: Kolhapur district, Amba-Vishalgad road, *M.M.Sardesai 2035* (SUK). Satara district, Dicholi, Koyna, *Bachulkar 3502* (SUK).

Eulophia R.Br. ex Lindl.

Eulophia dabia (D.Don) Hochr., Bull. New York Bot. Gard.6: 270. 1910.

Bletia dabia D.Don, Prodr. Fl. Nepal.: 30. 1825.

Flowering: March – April.

Life form: Terrestrial.

Habitat: Found in dry-deciduous forests near marshy and grassy area along river-beds.

Distribution in Maharashtra: Nagpur.

General distribution: India (Assam, Manipur, Arunachal Pradesh, Sikkim, West Bengal, Himachal Pradesh, Jammu & Kashmir, Uttarakhand, Odisha, Maharashtra, Bihar, Haryana, Jharkhand, Punjab, Uttar Pradesh, Andaman & Nicobar), Bangladesh, Bhutan, Nepal, Pakistan, Afganistan, China, Myanmar, Tajikistan, Turkmenistan, Uzbekistan.

Note: This species is included based on the authority of Ugemuge (1986) from Nagpur. He collected it from Ambazari. His collection number 1010 couldn't be traced in the Herbarium, Nagpur University, Nagpur.

Eulophia epidendraea (Retz.) C.E.C.Fisch. in J.S.Gamble, Fl. Madras: 1434. 1928. *Serapias epidendraea* Retz., Observ. Bot. 6: 65. 1791.

Flowering: November–January.

Life form: Terrestrial.

Habitat: Found under the shade of moist-deciduous forests and dry deciduous forests between 600–800 m.

Distribution in Maharashtra: Pune and Sindhudurg.

General distribution: India (West Bengal, Uttarakhand, Odisha, Andhra Pradesh, Karnataka, Kerala, Maharashtra, Tamil

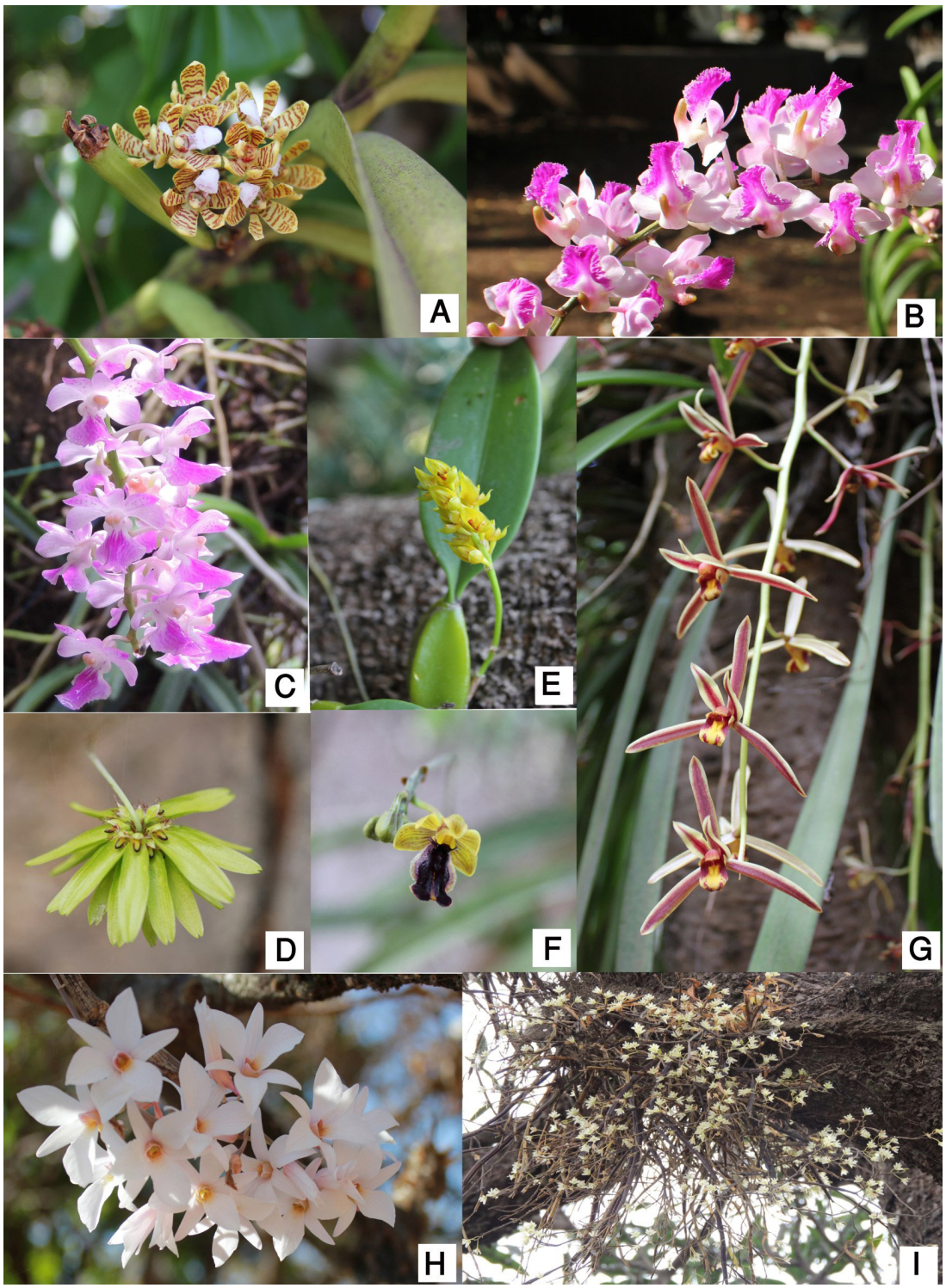

Figure 4. A. *Acampe praemorsa*, B. *Aerides crispa*, C. *Aerides maculosa*, D. *Bulbophyllum fimbriatum*, E. *Bulbophyllum sterile*, F. *Cottonia peduncularis*, G. *Cymbidium bicolor*, H. *Dendrobium barbatulum*, I. *Dendrobium herbaceum*

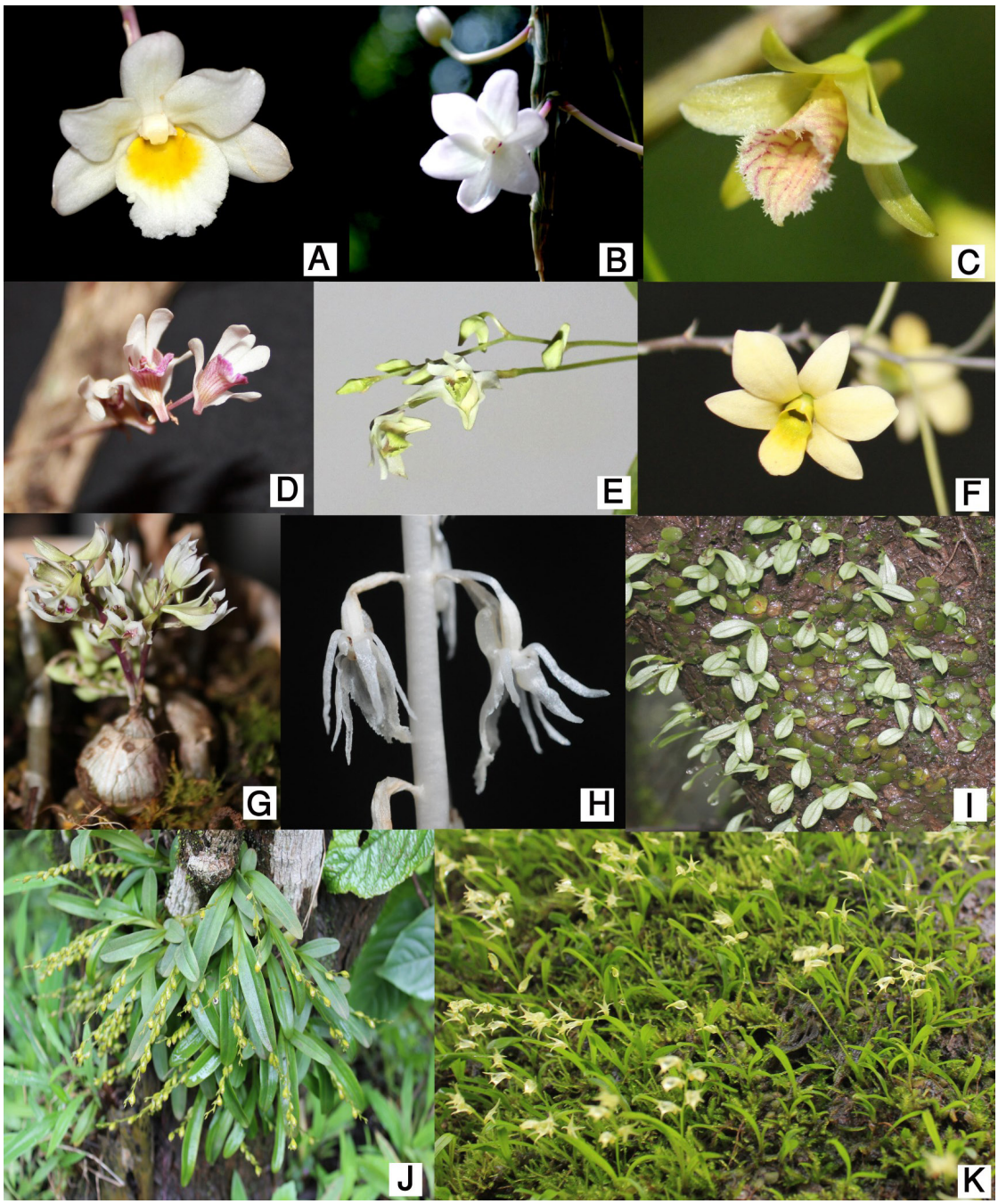

FIGURE 5. A. *Dendrobium crepidatum*, B. *Dendrobium lawianum*, C. *Dendrobium macrostachyum*, D. *Dendrobium microbulbon*, E. *Dendrobium nanum*, F. *Dendrobium ovatum*, G. *Dendrobium peguanum*, H. *Epipogium roseum*, I. *Conchidium exile*, J. *Conchidium filiforme*, K. *Conchidium microchilos*.

Nadu, Chhattisgarh, Andaman & Nicobar), Bangladesh, Sri Lanka.

SPECIMENS EXAMINED: Pune district, Khandala, *H.Santapau 10532* (BLAT). Sindhudurg district, Ramghat, *B.G.Kulkarni 119300* A (BSI).

Eulophia graminea Lindl., Gen. Sp. Orchid. Pl.: 182. 1833. Fig. 6B.

Flowering: March–April.

Life form: Terrestrial.

Habitat: Found in moist-deciduous forests, scrub forests, in open places at *c*. 600 m.

Distribution in Maharashtra: Gadchiroli, Osmanabad and Sangli.

General distribution: India (Assam, Meghalaya, Mizoram, Nagaland, Tripura, Arunachal, Pradesh, Sikkim, West Bengal, Uttarakhand, Andhra Pradesh, Odisha, Kerala, Maharashtra, Tamil Nadu, Bihar, Jharkhand, Madhya Pradesh, Punjab, Uttar Pradesh, Andaman & Nicobar), Bangladesh, Bhutan, Nepal, Sri Lanka, China, Myanmar, Indonesia, Japan, Malaysia, Singapore, Thailand, Laos, Vietnam.

Specimens examined: Gadchiroli district, Podewada, *R.S.Govekar 1009* (BAMU). Osmanabad district, Apsinga, *R.D.Gore 78* (Walchand College of Arts and Science, Solapur). Sangli district, Sangli, *S.R.Yadav 4397* (SUK).

Eulophia herbacea Lindl., Gen. Sp. Orchid. Pl. 182. 1833. Fig. 6C.

Flowering: June–July.

Life form: Terrestrial.

Habitat: Found under the shade of moist-deciduous forests and in open scrub area between 200–600 m.

Distribution in Maharashtra: Mumbai Suburban and Thane.

General distribution: India (Manipur, Mizoram, Tripura, Sikkim, West Bengal, Himanchal Pradesh, Uttarakhand, Odisha, Karnataka, Gujarat, Maharashtra, Chhattisgarh, Madhya Pradesh), Bangladesh, Nepal, China, Myanmar, Thailand, Laos.

Specimens examined: Mumbai Suburban district, Borivali National Park, *Z.J.Kapadia 1252* (BLAT). Pune district, Lonavala, *S.R.Yadav s.n.* (SUK). Thane district, Mumbra, *H.Santapau 15664* (BLAT).

Eulophia ochreata Lindl., J. Proc. Linn. Soc., Bot. 3: 24. 1858.

Flowering: June–July.

Life form: Terrestrial.

Habitat: Found in slopes and rocky areas of dry-deciduous and moist-deciduous forests between 100–1000 m.

Distribution in Maharashtra: Amravati, Chandrapur, Kolhapur, Mumbai Suburban, Nandurbar, Pune, Ratnagiri and Thane.

General distribution: India (Meghalaya, West Bengal, Odisha, Andhra Pradesh, Gujarat, Karnataka, Maharashtra, Chhattisgarh, Jharkhand, Madhya Pradesh, Rajasthan), **endemic to India.**

Specimens examined: Amravati district, Melghat, *M.Y.Ansari 147182* (BSI). Chandrapur district, Devada forest, *B.M.Wadhwa 137434A* (BSI). Kolhapur district, Panhala, *M.M.Sardesai 1522* (SUK). Mumbai Suburban district, Mumbai, *H.Santapau 1266* (BLAT). Nandurbar district, Toranmal, *J.S.Jalal 195129* (BSI). Pune district, Sinhgad, *M.Y.Ansari 87371* (BSI). Ratnagiri district, Malwan, *B.G.Kulkarni 131787* (BSI). Thane district, Bhivandi range, *K.V.Billore 116239* (BSI).

Eulophia pratensis Lindl., J. Proc. Linn. Soc., Bot. 3: 25. 1858. Fig. 6D.

Eulophia ramentacea Wight, Icon. Pl. Ind. Orient. 5: t. 1666. 1851, *nom. illeg.*

Flowering: December–February.

Life form: Terrestrial.

Habitat: Found in marshy and grassy area along river-beds and seasonal water channels between 500–1000 m.

Distribution in Maharashtra: Kolhapur, Pune and Satara.

General distribution: India (Gujarat, Karnataka, Kerala, Maharashtra, Tamil Nadu), **endemic to Peninsular India.**

Specimens examined: Kolhapur district, Radhanagari, *V.D.Patil 75* (SUK). Pune district, Pashan, *G.A.Gammie s.n.* (BSI). Satara district, Khindwadi, *M.P.Bachulkar 5424* (SUK).

Eulophia spectabilis (Dennst.) Suresh in D.H.Nicolson, C.R.Suresh & K.S.Manilal, Interpret. Van Rheede's Hort. Malab.: 300. 1988. Fig. 6E.

Wolfia spectabilis Dennst., Schlüssel Hortus Malab.: 38. 1818.

Flowering: It produces floral stalks on the onset of rain from May to June and foliar shoot emerges

after flowering shoot.

Life form: Terrestrial.

Habitat: Found in dry-deciduous forests and occasionally along the edges of semi-evergreen forests at elevations between 50–1250 m.

Distribution in Maharashtra: Kolhapur, Pune, Satara and Sindhudurg.

General distribution: India (Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura, Arunachal Pradesh, Sikkim, West Bengal, Uttarakhand, Uttar Pradesh, Jharkhand, Bihar, Madhya Pradesh, Chhattisgarh, Punjab, Odisha, Andhra Pradesh, Karnataka, Maharashtra, Kerala, Tamil Nadu, Andaman & Nicobar), Bangladesh, Bhutan, Nepal, Sri Lanka, China, Myanmar, Japan, Indonesia, Malaysia, Philippines, Thailand, Singapore, Indo-China, New Guinea, Pacific islands.

Specimens examined: Kolhapur district, Radhanagari, *J.S.Jalal 200521* (BSI). Pune district, Lavasa, *J.S.Jalal 195106* (BSI). Satara district, Mahabaleshwar, *J.S.Jalal 200424* (BSI). Sindhudurg district, Amboli Ghat, *J.S.Jalal 200473* (BSI).

Gastrochilus D.Don

Gastrochilus flabelliformis (Blatt. & McCann) C.J. Saldanha in C.J. Saldanha & Nicolson, Fl. Hassan Dist. 830. 1976.

Saccolabium flabelliforme Blatt. & McCann in J. Bombay Nat. Hist. Soc. 35: 722, t. 1. 1932.

Flowering: Mach–July.

Life form: Epiphyte.

Habit and Habitat: Epiphytic. Found in evergreen forests ca 400 m.

Distribution in Maharashtra: Sindhudurg.

General distribution: India (Maharashta, Goa, Karnataka, Kerala), **endemic to Western Ghats.**

Note: This was reported by S. M. Almeida (1990) as *Gastrochilus calceolaris* from Sawantwadi. There are no herbarium records of its collection in BLAT. Sardesai *et al.* (2002) reported it from Dodamarg in Sindhudurg district. During herbarium scrutiny his collection number *2502* (SUK) couldn't be traced.

Geodorum G. Jacks.

Geodorum densiflorum (Lam.) Schltr.in Fedde, Repert. 4: 259. 1919. Fig. 6F.

Limodorum densiflorum Lam., Encycl. 3: 516. 1792.

Flowering: June–July.

Life form: Terrestrial.

Habitat: Found under the shade of semi-evergreen and moist-deciduous forests between 400–800 m.

Distribution in Maharashtra: Gadchiroli, Kolhapur and Nashik.

General distribution: India (Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura, Arunachal Pradesh, Sikkim, West Bengal, Uttarakhand, Andhra Pradesh, Odisha, Goa, Karnataka, Kerala, Maharashtra, Tamil Nadu, Bihar, Chhattisgarh, Jharkhand, Madhya Pradesh, Andaman & Nicobar), Bangladesh, Bhutan, Nepal, Sri Lanka, China, Myanmar, Indonesia, Japan, Malaysia, Philippines, New Guinea, Thailand, Indo-China, S.E.Asia, Pacific Islands, Australia.

Specimens examined: Gadchiroli district, Surajgad, *R.S.Govekar 21* (BAMU). Kolhapur district, Chandgad, *J.S.Jalal 195170* (BSI). Nashik district, Satana, *P.L.Narasimhan 167662* (BSI).

Geodorum recurvum (Roxb.) Alston in H.Trimen, Handb. Fl. Ceylon 6(Suppl.): 276. 1931.

Limodorum recurvum Roxb., Pl. Coromandel 1: t. 39. 1795.

Flowering: June–July.

Life form: Terrestrial.

Habitat: Found under the shade of moist-deciduous forests.

Distribution in Maharashtra: Gadchiroli.

General distribution: India (Assam, Manipur, Andhra Pradesh, Odisha, Jharkhand, Maharashtra), Sri Lanka, China, Myanmar, Thailand, Cambodia, Vietnam.

Specimen examined: Gadchiroli district, Jharapapada, *R.S.Govekar 1667* (BAMU).

Habenaria Willd.

Habenaria brachyphylla (Lindl.) Aitch., J. Linn. Soc., Bot. 19: 188. 1882. Fig. 6G.

Platanthera brachyphylla Lindl., Gen. Sp. Orchid. Pl.: 293. 1835.

Habenaria crassifolia A.Rich., Ann. Sci. Nat., Bot., II, 15: 72. 1841.

Flowering: August–October.

Life form: Terrestrial.

Habitat: Found in semi-evergreen forests along the sedges and open grassy slopes at higher plateaus between 200–1350 m.

Distribution in Maharashtra: Bhandara, Kolhapur, Nashik, Pune and Satara.

General distribution: India (Odisha, Karnataka, Kerala, Maharashtra, Tamil Nadu), **endemic to Peninsular India.**

Specimens examined: Bhandara district, Pangni forest, *S.K.Malhotra 144573* (BSI). Kolhapur district, Panhala, *D.H.Jugadale s.n.* (SUK). Nashik district, Ambewadi, *P.L.Narasimhan 167518A* (BSI). Pune district, Ambe ghat, *J.S.Jalal 200815* (BSI). Satara district, Mahabaleshwar, *J.S.Jalal 200423* (BSI).

Habenaria commelinifolia (Roxb.) Wall. ex Lindl., Gen. Sp. Orchid. Pl. 325. 1835**. Fig. 6H.**

Orchis commelinifolia Roxb., Fl. Ind. ed. 1832, 3: 451. 1832.

Flowering: August–November.

Life form: Terrestrial.

Habitat: Found in open grassy slopes between dry deciduous and semi-evergreen forests between 0 and 600 m.

Distribution in Maharashtra: Gondia, Mumbai Suburban, Pune, Raigad, Ratnagiri, Sindhudurg and Thane.

General distribution: India (Manipur, Sikkim, West Bengal, Himachal Pradesh, Jammu & Kashmir, Uttarakhand, Odisha, Karnataka, Kerala, Maharashtra, Bihar, Chhattisgarh, Jharkhand, Madhya Pradesh, Punjab, Uttar Pradesh), Nepal, Myanmar, Thailand, Vietnam.

Specimens examined: Gondia district, Tower road, *D.N.Patil 179412* (BSI). Mumbai Suburban district, Andheri, *H.Santapau 7372* (BLAT). Pune district, Khandala, *Z.J.Kapadia 1509* (BLAT). Raigad district, Matheran, *N.A.Irani 4565* (BLAT). Ratnagiri district, Dapoli, *J.S.Jalal 194946* (BSI). Sindhudurg district, Insuli, *S.M.Almeida 3926* (BLAT). Thane district, Mumbra, *K.V.Shenoy 4299* (BLAT).

Habenaria crinifera Lindl., Gen. Sp. Orchid. Pl. 323. 1835. Fig. 6I.

Flowering: July–August.

Life form: Terrestrial.

Habitat: Found in semi-evergreen and evergreen forests between 600–800 m.

Distribution in Maharashtra: Kolhapur and Satara.

General distribution: India (Goa, Karnataka, Kerala, Maharashtra, Tamil Nadu), Sri Lanka.

Specimens examined: Kolhapur district, Chandgad, *J.S.Jalal 195200* (BSI). Satara district, Koyna valley, *Z.J.Kapadia 2893* (BLAT).

Habenaria digitata Lindl., Gen. & Sp. Orchid. Pl. 307. 1835. Fig. 6J.

Flowering: July–September.

Life form: Terrestrial.

Habitat: Found under the shade of moist deciduous and semi-evergreen forests between 400–800 m.

Distribution in Maharashtra: Akola, Kolhapur, Nashik, Pune, Sindhudurg and Thane.

General distribution: India (Assam, Arunachal Pradesh, Sikkim, West Bengal, Himachal Pradesh, Uttarakhand, Andhra Pradesh, Odisha, Gujarat, Karnataka, Kerala, Maharashtra, Tamil Nadu, Jharkhand, Chhattisgarh, Madhya Pradesh, Uttar Pradesh, Rajasthan), Bangladesh, Nepal, Pakistan, Myanmar, Cambodia, Laos.

Specimens examined: Akola district, Narnala fort, *S.Y.Kamble 154073A* (BSI). Kolhapur district, Radhanagari, *197733* (BSI). Nashik district, Markandey hill, *R.D.Pataskar 108822* (BSI). Pune district, Rajmachi, *J.S.Jalal 200576* (BSI). Sindhudurg district, Amboli, *J.S.Jalal 194949* (BSI). Thane district, Malshej Ghat, *J.S.Jalal 200847* (BSI).

Habenaria diphylla (Nimmo) Dalzell in Hooker's, J. Bot. Kew Gard. Misc. 2: 262. 1850. Fig. 6K.

Liparis diphyllos Nimmo in J.Graham, Cat. Pl. Bombay: 252.1839.

Flowering: August–October.

Life form: Terrestrial.

Habit and Habitat: Terrestrials, found in lateritic plateaus growing along with grasses and herbs at lower elevations with clayey soil between 50–700 m.

Distribution in Maharashtra: Kolhapur, Nashik and Sindhudurg.

General distribution: India (Meghalaya, Sikkim, West Bengal, Himachal Pradesh, Uttarakhand, Odisha, Andhra Pradesh, Goa, Karnataka, Kerala, Maharashtra, Tamil Nadu, Bihar, Jharkhand, Chhattisgarh), Bangladesh, Bhutan, Nepal, China, Myanmar, Philippines, Thailand.

Specimens examined: Kolhapur district, Chandgad, *J.S.Jalal 197740* (BSI). Nashik district, Igatpuri, *J.S.Jalal 200871* (BSI). Sindhudurg district, Malvan, *J.S.Jalal 200468* (BSI).

Habenaria elwesii Hook.f., Bot. Mag. 122: t. 7478. 1896.

Flowering: September–October.

Life form: Terrestrial.

Habit and Habitat: Terrestrials, found in edges of semi-evergreen forests at elevation 800 m.

Distribution in Maharashtra: Kolhapur.

General distribution: India (Maharashta, Karnataka, Kerala and Tamil Nadu), **endemic to Western Ghats.**

Note: This species is included based on Bachulkar (2012) who reported it from Kolik in Kolhapur district. The specimen number *20349* deposited at SUK herbarium couldn't be traced.

Habenaria foliosa A. Rich., Ann. Sci. Nat., Bot., 2, 15: 71, t. 3 A. 1841. Fig. 6L.

Habenaria foliosa var. *foetida* (Blatt. & McCann) Bennet, J. Econ. Taxon. Bot. 5: 452. 1984.

Flowering: July–August.

Life form: Terrestrial.

Habitat: Found under the shade and edges of semi-evergreen forests between 400–800 m.

Distribution in Maharashtra: *G*adchiroli, Kolhapur, Nashik, Pune, Raigad, Satara and Thane.

General distribution: India (West Bengal, Goa, Gujarat, Karnataka, Kerala, Maharashtra, Tamil Nadu, Odisha, Chhattisgarh, Madhya Pradesh), **endemic to Western Ghats.**

Specimens examined: Gadchiroli district, R.S.Govekar *0487* (BAMU). Kolhapur district, Radhanagari, *M.M.Sardesai 1455* (SUK). Nashik district, Kasara ghat, *J.S.Jalal 200869* (BSI). Pune district, Nane ghat, *J.S.Jalal 200840* (BSI). Raigad district, Matheran, *N.A.Irani 5036* (BLAT). Satara district, Koyna, *Prajakta Pathare 198885* (BSI). Thane district, Ghodabunder, *Z.J.Kapadia 2103* (BLAT).

Habenaria furcifera Lindl., Gen. & Sp. Orchid Pl.: 319. 1835. Fig. 6M.

Flowering: August–September.

Life form: Terrestrial.

Habitat: Found under the shade of semi-evergreen forests and dry deciduous forests between 400–900 m.

Distribution in Maharashtra: Ahmednagar, Amravati, Kolhapur, Nashik and Sindhudurg.

General distribution: India (Assam, Nagaland, Arunachal Pradesh, Sikkim, West Bengal, Himachal Pradesh, Jammu & Kashmir, Uttarakhand, Kerala, Madhya Pradesh, Odisha, Andhra Pradesh, Tamil Nadu, Maharashtra, Gujarat, Bihar, Jharkhand, Chhattisgarh, Punjab, Uttar Pradesh), Bangladesh, Bhutan, Nepal, China, Myanmar, Thailand.

Specimens examined: Ahmednagar district, Waranghushi forest, *B.M.Wadhwa 128357* (BSI). Amravati district, Semadoh, *M.Y.Ansari 149399* (BSI). Kolhapur district, Kondoshi, *M.M.Sardesai 1553* (SUK). Nashik district, base of Markenday hill, 21.07.2014, *J.S.Jalal 195146* (BSI). Sindhudurg district, Amboli, *S.M.Almeida 5022* (BLAT).

Habenaria gibsonii Hook.f., Fl. Brit. India 6: 135. 1890. Fig. 7A.

Habenaria digitata var. *gibsonii* (Hook.f.) C.E.C.Fisch. in J.S.Gamble, Fl. Madras: 1469. 1928.

Habenaria gibsonii var. foliosa (A.Rich) Santapau & Kapadia, J. Bombay Nat. Hist. Soc. 56: 194. 1959.

Habenaria gibsonii var. foetida Blatt. & McCann, J. Bombay Nat. Hist. Soc. 36: 16. 1932. *Habenaria foliosa* var. *gibsonii* (Hook.f.) Bennet, J. Econ. Taxon. Bot. 5: 452. 1984.

Flowering: July–August.

Life form: Terrestrial.

Habitat: Found under the shade and edges of semi-evergreen forests between 300–800 m.

Distribution in Maharashtra: Akola, Kolhapur, Nandurbar, Nashik, Pune, Raigad, Satara and Thane.

General distribution: India (Gujarat, Karnataka, Maharashtra, Odisha, Chhattisgarh, Madhya Pradesh), **endemic to Peninsular India.**

Specimens examined: Akola district, Narnala fort, *S.Y.Kamble 150456* (BSI). Kolhapur district, Tilari, *J.S.Jalal 197714* (BSI). Nandurbar district, Toranmal, *J.S.Jalal 195122* (BSI). Nashik district, base of Markendey hill, *J.S.Jalal 195143* (BSI). Pune district, Khandala, *B.M.Wadhwa 109972* (BSI). Raigad district, Matheran, *B.M.Wadhwa 109746* (BSI). Satara district, Mahabaleshwar, *B.M.Wadhwa 109642* (BSI). Thane district, Mumbra hill, *K.V.Billore 116608* (BSI).

Habenaria grandifloriformis Blatt. & McCann, J. Bombay Nat. Hist. Soc. 36: 17. 1932. Fig. 7B.

Flowering: May–July.

Life form: Terrestrial.

Habitat: Found in lateritic plateaus, mountain grassy slopes at elevation between 100 m and 1200 m.

Distribution in Maharashtra: Akola, Kolhapur, Nashik, Pune, Raigad, Ratnagiri, Satara, Sindhudurg and Thane.

General distribution: India (Assam, Chhattisgarh, Odisha, Gujarat, Maharashtra, Karnataka, Kerala and Tamil Nadu), **endemic to Peninsular India.**

Specimens examined: Akola district, Narnala fort, *S.Y.Kamble 150473* (BSI). Kolhapur district, Radhanagari, *J.S.Jalal 200534* (BSI). Nashik district, Saturli, *J.S.Jalal 195150* (BSI). Pune district, Nane ghat, *J.S.Jalal 200835* (BSI). Raigad district, Karjat, *G.L.Shah 10771* (BLAT). Ratnagiri district, Rajapur, *J.S.Jalal 200463* (BSI). Satara district, Mahabaleshwar, *J.S.Jalal 200418* (BSI). Sindhudurg district, Sawantwadi, *J.S.Jalal 200472* (BSI). Thane district, Bhiwandi range, *K.V.Billore 116241* (BSI).

Habenaria heyneana Lindl., Gen. Sp. Orchid. Pl. 320. 1835. Fig. 7C.

Flowering: July–September.

Life form: Terrestrial.

Habit and Habitat: Terrestrials, found in lateritic plateaus and open mountain grassy slopes between 500–1200 m.

Distribution in Maharashtra: Kolhapur, Nashik, Pune, Satara and Sindhudurg.

General distribution: India (Andhra Pradesh, Goa, Karnataka, Kerala, Maharashtra, Tamil Nadu), **endemic to Western Ghats.**

Specimens examined: Kolhapur district, Radhanagari, *J.S.Jalal 200533* (BSI). Nashik district, Aryaneri hill, *P.L.Narasimhan 165117* (BSI). Pune district, Karla caves, *J.S.Jalal 200547* (BSI). Satara district, Panchgani, *J.S.Jalal 200445* (BSI). Sindhudurg district, Amboli, *J.S.Jalal 194951* (BSI).

Habenaria hollandiana Santapau, Fl. Purandar 126. 1957.

Habenaria affinis Wight, Icon. Pl. Ind. Orient. 5: t. 1707, 1851, *nom. illeg.*

Flowering: September–October.

Life form: Terrestrial.

Habitat: Found in grassy slopes c. 600 m.

Distribution in Maharashtra: Pune.

General distribution: India (Maharashtra and Karnataka), **endemic to Western Ghats.**

Note: This is a rare orchid in Maharashtra and reported by Woodrow from Purandhar. No subsequent botanist after Woodrow's has been able to locate this plant in Maharashtra. This species has not been found during the recent exploration also.

Habenaria longicorniculata J. Graham, Cat. Bombay, Pl. 202. 1839. Fig. 7D.

Flowering: July–December.

Life form: Terrestrial.

Habit and Habitat: Terrestrials, found in lateritic plateaus and grassy slopes between 100–1200 m.

Distribution in Maharashtra: Akola, Aurangabad, Kolhapur, Nashik, Pune, Raigad, Satara, Sindhudurg and Thane.

General distribution: India (Andhra Pradesh, Odisha, Goa, Gujarat, Karnataka, Kerala, Maharashtra, Tamil Nadu, Jharkhand, Chhattisgarh, Madhya Pradesh, Rajasthan), Sri Lanka.

Specimens examined: Akola district, Narnala fort, *S.Y.Kamble 150475* (BSI). Aurangabad district, Mhaigmal hill, *K.P.Janardhanan 100079* (BSI). Kolhapur district, Gabighat,

J.S.Jalal 200546 (BSI). Nashik district, Igatpuri, *J.S.Jalal 200870* (BSI). Pune district, Khandala, *J.S.Jalal 200551* (BSI). Raigad district, Matheran, *J.S.Jalal 200582* (BSI). Satara district, Kas plateau, *M.P.Bachulkar 5201* (SUK). Sindhudurg district, Amboli, *J.S.Jalal 194953* (BSI). Thane district, Malshej Ghat, *J.S.Jalal 200845* (BSI).

Habenaria marginata Colebr. in Hook., Exot. Fl. 2, 17: t. 136. 1824. Fig. 7E.

Habenaria marginata var. *flavescens* (Hook. f.) T. Cooke, Fl. Bombay 2: 721. 1907.

Flowering: August–October.

Life form: Terrestrial.

Habitat: Found under the shade of bushes in moist deciduous forests and also in open grasslands up to 1200 m.

Distribution in Maharashtra: Ahmednagar, Amravati, Aurangabad, Bhandara, Chandrapur, Gadchiroli, Kolhapur, Mumbai, Nagpur, Nashik, Osmanabad, Pune, Raigad, Ratnagiri, Satara and Sindhudurg.

General distribution: India (Meghalaya, West Bengal, Himachal Pradesh, Jammu & Kashmir, Uttarakhand, Odisha, Andhra Pradesh, Daman & Diu, Goa, Gujarat, Karnataka, Kerala, Maharashtra, Tamil Nadu, Dadara & Nagar Haveli, Jharkhand, Chhattisgarh, Madhya Pradesh, Punjab, Rajasthan), Bangladesh, Bhutan, Nepal, China, Myanmar, Thailand.

Specimens examined: Kolhapur district, Gaganbawda, *B.G.Chowgule 6* (SUK). Mumbai Suburban district, Andheri, *H.Santapau 23323* (BLAT). Nashik district, Katipada, *P.L.Narasimhan 167623* (BSI). Pune district, Khadakvasala, *R.S.Raghavan 64285* (BSI). Raigad district, Chakachaamaal, Phansad, *J.S.Jalal 20088* (BSI). Ratnagiri district, Dapoli, *J.S.Jalal 194947* (BSI). Satara district, Yavteshwar, *M.P.Bachulkar 5200* (SUK). Sindhudurg district, Vengurla, *D.H.Jagdale s.n.* (SUK).

Habenaria multicaudata Sedgw., Rec. Bot. Surv. India 6: 352. 1919. Fig. 7F.

Flowering: August–October.

Life form: Terrestrial.

Habitat: Found under the shade of semi-evergreen forests at elevations between 700–1000 m.

Distribution in Maharashtra: Akola and Kolhapur.

General distribution: India (Maharashtra, Goa, Karnataka, Kerala, Tamil Nadu), **endemic to Western Ghats.**

Specimens examined: Akola district, Narnala fort, *S.Y.Kamble 150973A* (BSI). Kolhapur district, Chandgad, *J.S.Jalal 195181* (BSI).

Habenaria ovalifolia Wight, Icon. Pl. Ind. Orient. 5: t. 1708. 1851. Fig. 7G.

Flowering: August–October.

Life form: Terrestrial.

Habitat: Found under the shade localities and forest edges of semi-evergreen forests between 400–1200 m.

Distribution in Maharashtra: Kolhapur, Mumbai Suburban, Pune, Raigad, Satara and Thane.

General distribution: India (Karnataka, Kerala, Maharashtra, Tamil Nadu), **endemic to Western Ghats.**

Specimens examined: Kolhapur district, Chandgad, *J.S.Jalal 194985* (BSI). Mumbai Suburban district, Borivali, *Z.J.Kapadia 1273* (BLAT). Pune district, Khandala, *J.S.Jalal 200549* (BSI). Raigad district, Phansad, *J.S.Jalal 200878* (BSI). Satara district, Mahabaleshwar, *S.R.Yadav 5792* (SUK). Thane district, Malshej Ghat, *J.S.Jalal 200849* (BSI).

Habenaria panigrahiana S.Misra, Blumea 27: 213.1981.

Flowering: August–October.

Life form: Terrestrial.

Habitat: Found under the shade moist deciduous forests.

Distribution in Maharashtra: Gadchiroli.

General distribution: India (Andhra Pradesh, Maharashtra, Odisha, Tamil Nadu), **endemic to Peninsular India.**

Specimen examined: Gadchiroli district, Amdeli, 09.11.2010, *R.S.Govekar 623* (BAMU).

Habenaria plantaginea Lindl., Gen. & Sp. Orchid. Pl.: 323. 1835. Fig. 7H.

Flowering: August– October.

Life form: Terrestrial.

Habitat: Found under shade of semi-evergreen forests between 100–1200 m.

Distribution in Maharashtra: Ahmednagar, Bhandara, Kolhapur, Nashik, Pune, Raigad and Sindhudurg.

General distribution: India (Assam, Meghalaya, Arunachal Pradesh, Sikkim, West Bengal, Himachal Pradesh, Jammu & Kashmir, Uttarakhand, Andhra Pradesh, Odisha, Karnataka, Kerala, Maharashtra, Tamil Nadu, Chhattisgarh, Jharkhand, Madhya Pradesh, Punjab, Haryana, Uttar Pradesh), Nepal, Sri Lanka, Japan, Vietnam.

Specimens examined: Ahmednagar district, Harischchandragad, *B.M.Wadhwa 127856* (BSI). Bhandara district, Pikagheri forest, *S.K.Malhotra 144880* (BSI). Kolhapur district, Patgaon, *M.M.Sardesai 199* (SUK). Nashik district, Sawarna, *John Cherian 112788* (BSI). Pune district, Bhimashankar, *K.P.Janardhanan 81809* (BSI). Raigad district, Matheran, *J.S.Jalal 200710* (BSI). Satara district, Mahabaleshwar, *P.V.Bole 1200* (BLAT). Sindhudurg district, Amboli Ghat, *R.S.Rao 131568A* (BSI).

Habenaria rariflora A. Rich., Ann. Sci. Nat., Bot. 2, 15: 70, t. 2 D. 1841. Fig. 7I.

Flowering: July–September.

Life form: Terrestrial.

Habitat: Found in higher plateaus and moist rocks near seasonal waterfall between 500–1200 m.

Distribution in Maharashtra: Ahmednagar, Kolhapur, Pune, Raigad, Satara and Sindhudurg.

General distribution: India (Andhra Pradesh, Karnataka, Kerala, Maharashtra, Tamil Nadu), **endemic to Western Ghats.**

Specimens examined: Ahmednagar district, Harischandragarh, *J.S.Jalal s.n.* (BSI). Kolhapur district, Gaganbavada ghat, *J.S.Jalal 200544* (BSI). Pune district, Ambe ghat, Junnar, *J.S.Jalal 200817* (BSI). Raigad district, Matheran, *J.S.Jalal 200592* (BSI). Satara district, Pasarni ghat, *J.S.Jalal 200446* (BSI). Sindhudurg district, Amboli, *J.S.Jalal 200474* (BSI).

Habenaria roxburghii Nicolson in C.J. Saldanha & Nicolson, Fl. Hassan Dist. 834. 1976. Fig. 7J.

Orchis plantaginea Roxb., Pl. Coromandel 1: 32, t.37. 1795.

Habenaria platyphylloides M.R.Almeida, Fl. Maharashtra 5A: 61. 2009, *nom. superfl.*

Flowering: August–December.

Life form: Terrestrial.

Habitat: Found under bushes and rocky crevices in moist deciduous and dry deciduous forests between 500–600 m.

Distribution in Maharashtra: Chandrapur, Osmanabad and Yavatmal.

General distribution: India (Andhra Pradesh, Odisha, Karnataka, Kerala, Maharashtra, Tamil Nadu, Jharkhand Chhattisgarh, Madhya Pradesh), Sri Lanka.

Specimens examined: Chandrapur district, Amborthra, *B.M.Wadhwa 137363* (BSI). Osmanabad district, Udgir, *K.P.Janardhanan 100815* (BSI). Yavatmal district, Bhiwkund, *S.Karthikeyan 156606* (BSI).

Habenaria stenopetala Lindl., Gen. Sp. Orchid. Pl. 319. 1835.

Flowering: August–December.

Life form: Terrestrial.

Habitat: Found under the shade of semi-evergreen forests c. 600 m.

Distribution in Maharashtra: Kolhapur and Satara.

General distribution: India (Assam, Manipur, Mizoram, Nagaland, Arunachal Pradesh, Sikkim, West Bengal Himachal Pradesh, Jammu & Kashmir, Uttarakhand, Andhra Pradesh, Odisha, Karnataka, Maharashtra, Bihar, Jharkhand), Nepal, China, Myanmar, Japan, Philippines, Thailand, Vietnam.

Specimens examined: Kolhapur district, Radhanagari, *A.R.Kulkarni s.n.* (SUK). Satara district, Koyna WLS, *Prajakta Pathare 203073* (BSI).

Habenaria suaveolens Dalzell in Hooker's J. Bot. Kew Gard. Misc. 2: 263. 1850. Fig. 7K.

Habenaria panchganiensis Santapau & Kapadia in J. Bombay Nat. Hist. Soc. 54: 478. 1957.

Flowering: July–September.

Life form: Terrestrial.

Habitat: It prefers to grow on exposed lateritic rocky plateaus.

Distribution in Maharashtra: Kolhapur, Satara and Sindhudurg.

General distribution: India (Goa, Karnataka, Maharashtra), **endemic to Western Ghats**.

Specimens examined: Kolhapur district, Radhanagari, *J.S.Jalal 200545* (BSI). Satara district, Mahabaleshwar, *J.S.Jalal 200442* (BSI). Sindhudurg district, Chokul, *J.S. Jalal 195004* (BSI).

Habenaria viridiflora (Sw.) R. Br. ex Spreng., Syst. Veg. (ed. 16) 3: 691. 1826. *Orchis viridiflora* Rottler *ex* Sw., Kongl. Vetensk. Acad. Nya Handl. 21: 206. 1800.

Flowering: August–September.

Life form: Terrestrial.

Habitat: Reported from lateritic plateau of Malvan c. 50 m.

Distribution in Maharashtra: Sindhudurg.

General distribution: India (Assam, Karnataka, Kerala, Maharashtra, Tamil Nadu), Bangladesh, Sri Lanka, Myanmar, Thailand, Indo-China.

Note: This is reported by Stocks from Konkan and by Dalzell & Gibson from Malvan. No subsequent workers have collected it again. There is no herbarium record available in *BLAT, BSI, SUK, CAL* from Maharashtra.

Liparis Rich.

Liparis odorata (Willd.) Lindl., Gen. Sp. Orchid. Pl.: 26. 1830. Fig. 7L.

Malaxis odorata Willd., Sp. Pl. 4: 91. 1805..

Liparis dalzellii Hook.f., Fl. Brit. India 5: 698. 1890.

Flowering: June–September.

Life form: Terrestrial.

Habitat: Found in semi-evergreen forests at elevations between 100–1200 m.

Distribution in Maharashtra: Kolhapur, Pune, Satara and Sindhudurg.

General distribution: India (Assam, Manipur, Meghalaya, Mizoram, Nagaland, Arunachal Pradesh, Sikkim, West Bengal, Uttarakhand, Odisha, Andhra Pradesh, Goa, Karnataka, Kerala, Maharashtra, Tamil Nadu, Jharkhand), Bhutan, Nepal, China, Myanmar, Japan, Thailand, Laos, Vietnam, Pacific islands.

Specimens examined: Kolhapur district, Radhanagari, *J.S.Jalal 200523* (BSI). Pune district, Saltar dam, Lonavala, *J.S.Jalal 200567* (BSI). Satara district, Mahabaleshwar, *J.S.Jalal 200415* (BSI). Sindhudurg district, Sawantwadi, *J.S.Jalal 195030* (BSI).

Luisia Gaudich.

Luisia tenuifolia Blume in Rumphia 4: 50. 1849.

Luisia birchea Blume, Rumphia 4: 50. 1849.

Luisia evangelinae Blatt. & McCann, J. Bombay Nat. Hist. Soc. 35: 493. 1932.

Luisia tenuifolia var. *evangelinae* (Blatt. & McCann) Santapau & Kapadia in J. Bombay Nat. Hist. Soc. 59: 829. 1962.

Luisia laurifolia M.R.Almeida, Fl. Maharashtra 5A: 66. 2009, *nom. superfl.*

Luisia laurifolia var. *evangelinae* (Blatt. & McCann) M.R.Almeida, Fl. Maharashtra 5A: 66. 2009.

Flowering: March–April.

Life form: Epiphytic.

Habitat: Found in semi-evergreen forests and moist deciduous forests between 100–600 m.

Distribution in Maharashtra: Satara and Thane.

General distribution: India (Goa, Karnatak, Kerala, Maharashtra), Sri Lanka.

Specimens examined: Satara district, Koyna valley, *Z.J.Kapadia 2912* (BLAT). Thane district, Tungar, *N.Y.Das 3218* (BLAT).

Luisia trichorhiza (Hook.) Blume, Rumphia 4: 50. 1849.

Vanda trichorhiza Hook., Exot. Fl. 1: t. 72. 1823.

Flowering: March–April.

Life form: Epiphyte.

Habitat: Found in dry deciduous forests.

Distribution in Maharashtra: Amravati and Gadchiroli.

General distribution: India (Assam, Meghalaya, Nagaland, Arunachal Pradesh, Sikkim, West Bengal, Uttarakhand, Andhra Pradesh, Odisha, Maharashtra, Tamil Nadu, Chhattisgarh, Jharkhand), Bangladesh, Bhutan, Nepal, Myanmar, Thailand.

Specimens examined: Amravati district, Amzari, *G.D.Muratkar 2433* (BAMU). Gadchiroli district, Bhamaragad range, *R.S.Govekar 197* (BAMU).

Luisia zeylanica Lindl., Fol. Orchid. 4: 3. 1853

Flowering: May–June.

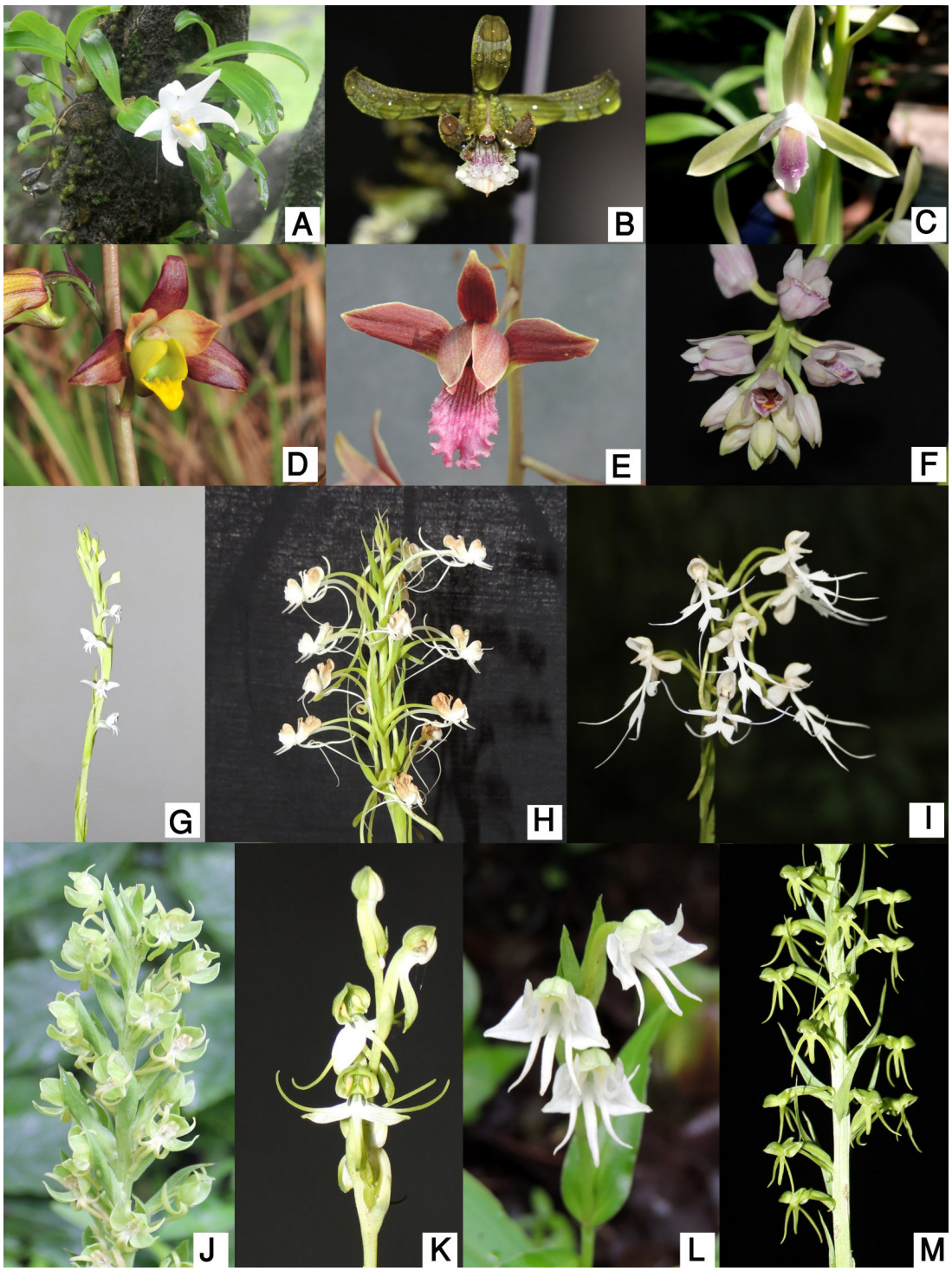

Figure 6. A. *Conchidium reticosum*, B. *Eulophia graminea*, C. *Eulophia herbacea*, D. *Eulophia pratensis*, E. *Eulophia spectabilis*, F. *Geodorum densiflorum*, G. *Habenaria brachyphylla*, H. *Habenaria commelinifolia*, I. *Habenaria crinifera*, J. *Habenaria digitata*, K. *Habenaria diphylla*, L. *Habenaria foliosa*, M. *Habenaria furcifera*.

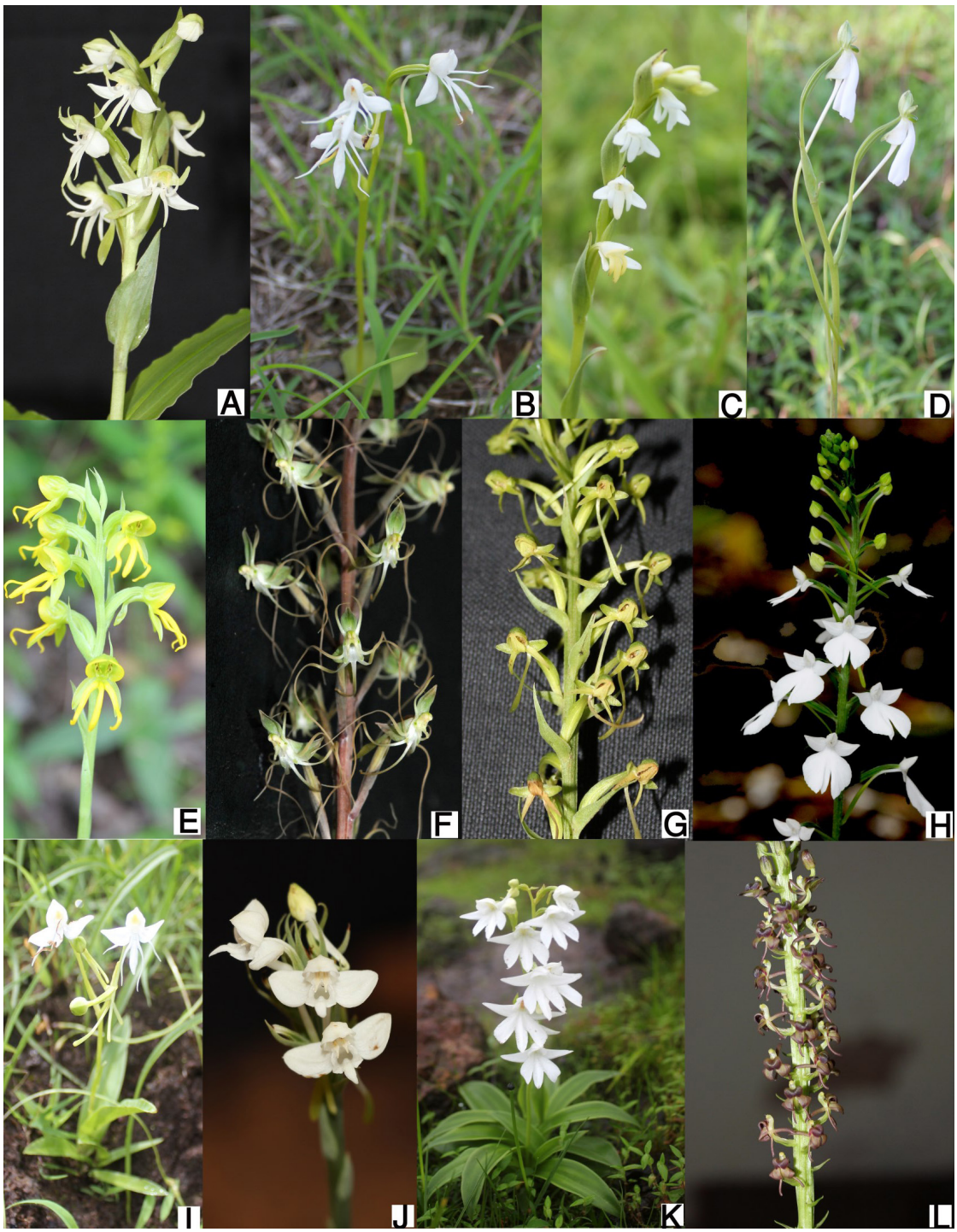

FIGURE 7. A. *Habenaria gibsonii*, B. *Habenaria grandifloriformis*, C. *Habenaria heyneana*, D. *Habenaria longicorniculata*, E. *Habenaria marginata*, F. *Habenaria multicaudata*, G. *Habenaria ovalifolia*, H. *Habenaria plantaginea*, I. *Habenaria rariflora*, J. *Habenaria roxburghii*, K. *Habenaria suaveolens*, L. *Liparis odorata.*

Life form: Epiphyte.

Habitat: Found in dry deciduous forests and moist deciduous forests.

Distribution in Maharashtra: Amravati and Sindhudurg.

General distribution: India (Assam, Meghalaya, Manipur, Nagaland, Arunachal Pradesh, Goa, Karnataka, Maharashtra, Andaman & Nicobar), Nepal, Myanmar, Indonesia, Malaysia, Thailand, Laos, Vietnam.

Specimens examined: Amravati district, Chikhaldara, *J.S.Jalal 200742* (BSI). Sindhudurg district, Sawantwadi, *J.S.Jalal 194992* (BSI).

Malaxis Sol. ex Sw.

Malaxis versicolor (Lindl.) Abeyw., Ceylon J. Sci. Biol. Sci. 2: 247. 1959. Fig. 8A.

Microstylis versicolor Lindl., Gen. Sp. Orchid. Pl. 21. 1830.

Corymborkis versicolor (Lindl.) M.R.Almeida, Fl. Maharashtra 5A: 30. 2009.

Flowering: July–August.

Life form: Terrestrial.

Habitat: Found in shady localities of semi-evergreen forests and evergreen forests.

Distribution in Maharashtra: Kolhapur, Pune, Raigad, Ratnagiri, Satara and Sindhudurg.

General distribution: India (Andhra Pradesh, Odisha, Maharashtra, Goa, Karnataka, Kerala, Tamil Nadu), Sri Lanka.

Specimens examined: Kolhapur district, Ajara, *J.S.Jalal 200498* (BSI). Pune district, Ambavne, *B.Venkata Reddi 99309* (BSI). Raigad district, Matheran, *J.S.Jalal 200583* (BSI). Ratnagiri district, Shivapur, *B.G.Kulkarni 129655* (BSI). Satara district, Mahabaleshwar, *J.S.Jalal 200432* (BSI). Sindhudurg district, Amboli, *J.S.Jalal 200488* (BSI).

Nervilia Comm. *ex* Gaudich.

Nervilia concolor (Blume) Schltr., Bot. Jahrb. Syst. 45: 404. 1911. Fig. 8B.

Cordyla concolor Blume, Bijdr. Fl. Ned. Ind.: 416. 1825.

Nervilia aragoana Gaudich., Voy. Uranie 422, t. 35. 1829.

Flowering: May–August.

Life form: Terrestrial.

Habitat: Found in moist localities under the shade of deciduous forests, dry deciduous forests and semi-evergreen forests.

Distribution in Maharashtra: Kolhapur, Nandurbar, Nashik, Pune, Raigad, Ratnagiri, Sindhudurg and Thane.

General distribution: India (Assam, Meghalaya, Manipur, Nagaland, Sikkim, West Bengal, Himachal Pradesh, Uttarakhand, Andhra Pradesh, Odisha, Goa, Karnataka, Kerala, Tamil Nadu, Jharkhand, Uttar Pradesh, Rajasthan, Andaman & Nicobar), Bangladesh, Bhutan, Nepal, China, Myanmar, Indonesia, Japan, Malaysia, New Guinea, Philippines, Thailand, Laos, Vietnam, Pacific islands, Australia.

Specimens examined: Kolhapur district, Radhanagari, *J.S.Jalal 200535* (BSI). Nandurbar district, Toranmal, 18.07.2014, *J.S.Jalal 195134* (BSI). Nashik district, Near Saputara, *J.S.Jalal 195141* (BSI). Pune district, Nane Ghat, *J.S.Jalal 200838* (BSI). Raigad district, Supegaon, *J.S.Jalal 200892* (BSI). Ratnagiri district, Dapoli, *J.S.Jalal 194929* (BSI). Sindhudurg district, Sawantwadi, *J.S.Jalal 200517* (BSI). Thane district, Tansa, *J.S.Jalal 200858* (BSI).

Nervilia crociformis (Zoll. & Moritzi) Seidenf., Dansk. Bot. Ark. 32: 151, f. 92. 1978. Fig. 8C.

*Bulborchis crociformis*Zoll. & Moritzi, Syst. Verz. 89. 1846.

Nervilia prainiana (King & Pantl.) Seidenf., Dansk Bot. Ark. 32(2): 149. 1978.

Flowering: June–July.

Life form: Terrestrial.

Habitat: Found in moist deciduous forests, dry deciduous forests and semi-evergreen forests.

Distribution in Maharashtra: Kolhapur, Pune, Satara and Sindhudurg.

General distribution: India (Manipur, Arunachal Pradesh, Sikkim, Uttarakhand, Andhra Pradesh, Odisha, Goa, Karnataka, Kerala, Maharashtra, Tamil Nadu, Jharkhand), Nepal, China, Indonesia, Malaysia, Philippines, Thailand, Vietnam, New Guinea, Africa, Australia.

Specimens examined: Kolhapur district, Chandgad,

J.S.Jalal 200974 (BSI). Pune district, Nane Ghat, *J.S.Jalal 200839* (BSI). Satara district, Mahabaleshwar, *J.S.Jalal 200429* (BSI). Sindhudurg district, Amboli, *J.S.Jalal 200497* (BSI).

Nervilia infundibulifolia Blatt. & McCann, J. Bombay Nat. Hist. Soc. 35: 725, t. 3. 1932. Fig. 8D.

Flowering: May–June.

Life form: Terrestrial.

Habitat: Found in moist-shaded and damp places under dense shade.

Distribution in Maharashtra: Pune, Raigad, Thane and Sindhudurg.

General distribution: India (Arunachal Pradesh, Uttarakhand, Odisha, Andhra Pradesh, Maharashtra, Karnataka, Kerala, Tamil Nadu Jharkhand), Myanmar, Indonesia, Malaysia, Thailand, Laos.

Specimens examined: Pune district, Amby valley, *J.S.Jalal 200405* (BSI). Raigad district, Phansad, *J.S.Jalal 200882* (BSI). Thane district, Malshej Ghat, *J.S.Jalal 200846* (BSI). Sindhudurg district, Chaukul, *J.S.Jalal 195003* (BSI).

Nervilia plicata (Andrews) Schltr., Bot. Jahrb. Syst. 45: 403. 1911. Fig. 8E.

Arethusa plicata Andrews, Bot. Repos. 5: 321. 1803.

Pogonia plicata (Andrews) Lindl., Gen. Sp. Orchid. Pl.: 415. 1840.

Nervilia discolor (Blume) Schltr., Bot. Jahrb. Syst. 45: 403. 1911.

Flowering: May–August.

Life form: Terrestrial.

Habitat: Found in moist deciduous forests, semi-evergreen forests.

Distribution in Maharashtra: Kolhapur, Pune, Sindhudurg and Thane.

General distribution: India (Assam, Manipur, Meghalaya, Mizoram, Arunachal Pradesh, Sikkim, West Bengal, Himachal Pradesh, Jammu & Kashmir, Uttarakhand, Odisha, Gujarat, Karnataka, Kerala, Maharashtra, Tamil Nadu, Andaman & Nicobar), Bangladesh, Bhutan, Nepal, China, Myanmar, Indonesia, Malaysia, Philippines, Thailand, Laos, Vietnam, New Guinea, Australia.

Specimens examined: Kolhapur district, Tilari, Chandgad, *J.S.Jalal 197711* (BSI). Pune district, Bhimashanker, *Z.J.Kapadia 1464* (BLAT). Sindhudurg district, Amboli, *J.S.Jalal 200489* (BSI). Thane district, Malshej Ghat, *J.S.Jalal 200848* (BSI).

Oberonia Lindl.

Oberonia bicornis Lindl.,Gen. Sp. Orchid. Pl. 16. 1830.

Flowering: October–November.

Life form: Epiphyte.

Habitat: Found in semi-evergreen forests at higher plateaus.

Distribution in Maharashtra: Sindhudurg.

General distribution: India (Mizoram, Meghalaya, Karnataka, Kerala, Maharashtra, Tamil Nadu), Bangladesh.

Specimen examined: Sindhudurg district, Chaukul, *B.G.Gavade 61* (BLAT).

Oberonia brunoniana Wight, Icon. Pl. Ind. Orient. 5 (1): t. 1662. 1851. Fig. 8F.

Flowering: July–October.

Life form: Epiphyte.

Habitat: Found under the shade of semi-evergreen forests.

Distribution in Maharashtra: Kolhapur and Thane.

General distribution: India (Andhra Pradesh, Goa, Karnataka, Kerala, Maharashtra, Tamil Nadu, Dadara & Nagar Haveli), **endemic to Western Ghats.**

Specimens examined: Satara district, Koyna, *J.S.Jalal 200772* (BSI). Thane district, Kasa, *Yadav & Soman 2600* (Sardar Patel University Herbarium).

Oberonia ensiformis (Sm.) Lindl., Fol. Orchid. 8: 4. 1859.

Malaxis ensiformis Sm. in A.Rees, Cycl. 22: n.º 14. 1812.

Flowering: December–January.

Life form: Epiphyte.

Habitat: Found under the shade of moist deciduous forests.

Distribution in Maharashtra: Thane.

General distribution: India (Manipur, Meghalaya, Mizoram, Nagaland, Arunachal Pradesh, Sikkim,

West Bengal, Uttarakhand, Andhra Pradesh, Odisha, Karnataka, Kerala, Maharashtra, Tamil Nadu, Andaman & Nicobar), Nepal, China, Myanmar, Thailand, Laos, Vietnam.

Specimen examined: Thane district, Usgaon, *N.Y.Das 3203* (BLAT).

Oberonia falconeri Hook. f. in Hooker's Icon. Pl. Ind. Orient. Pl. 18: t. 1780. 1888.

Flowering: August–September.

Life form: Epiphyte.

Habitat: Found in dry deciduous forests and moist deciduous forests.

Distribution in Maharashtra: Thane.

General distribution: India (Assam, Meghalaya, Arunachal Pradesh, Sikkim, West Bengal, Uttarakhand, Odisha, Andhra Pradesh, Karnataka, Maharashtra, Bihar, Jharkhand, Chhattisgarh, Madhya Pradesh), Bangladesh, Nepal, China, Malaysia, Thailand, Laos, Vietnam.

Specimen examined: Thane district, Tansa, *Z.J.Kapadia* 731 (BLAT).

Oberonia mucronata (D.Don) Ormerod & Seidenf. in G.Seidenfaden, Contr. Orchid Fl. Thailand 13: 20. 1997.

Stelis mucronata D.Don, Prodr. Fl. Nepal.: 32. 1825.

Oberonia denticulata Wight, Icon. Pl. Ind. Orient. 5: t. 1625. 1851.

Oberonia iridifolia var. denticulata (Wight) Hook.f., Fl. Brit. India 5: 676. 1890.

Flowering: September–October.

Life form: Epiphyte.

Habitat: Found in moist deciduous forests.

Distribution in Maharashtra: Thane.

General distribution: India (Assam, Manipur, Meghalaya, Mizoram, Nagaland, Arunachal Pradesh, Sikkim, West Bengal, Andhra Pradesh, Odisha, Gujarat, Goa, Kerala, Tamil Nadu, Maharashtra, Chhattisgarh, Andaman & Nicobar), Bangladesh, Bhutan, Nepal, China, Myanmar, Indonesia, Malaysia, Philippines, Laos.

Specimen examined: Thane district, Tansa, *Z.J.Kapadia 1638* (BLAT).

Oberonia recurva Lindl., Edwards's Bot. Reg. 25(Misc.): 14. 1839. Fig. 8G.

Oberonia recurva var. lingmalensis (Blatt. & McCann) Santapau & Kapadia, J. Bombay Nat. Hist. Soc. 57: 259. 1960.

Flowering: October–March.

Life form: Epiphyte.

Habitat: Found in dry deciduous forests, moist deciduous forests and semi-evergreen forests.

Distribution in Maharashtra: Kolhapur, Pune, Ratnagiri, Satara and Sindhudurg.

General distribution: India (Meghalaya, Sikkim, West Bengal, Karnataka, Kerala, Maharashtra), Bhutan, Nepal, Sri Lanka, China, Thailand.

Specimens examined: Kolhapur district, Chandgad, *J.S.Jalal 194986* (BSI). Pune district, Bhimashankar, *J.S.Jalal 200725* (BSI). Ratnagiri district, Mandangad, *J.S.Jalal 200733* (BSI). Satara district, Mahabaleshwar, *J.S.Jalal 200412* (BSI). Sindhudurg district, Khamdadev plateau, *J.S.Jalal 195015* (BSI).

Oberonia verticillata Wight, Icon. Pl. Ind. Orient. 5: t. 1626. 1851.

Flowering: September–October.

Life form: Epiphyte.

Habitat: Found in dry deciduous forest on *Ficus* tree.

Distribution in Maharashtra: Thana.

General distribution: India (Goa, Karnataka, Kerala, Maharashtra, Tamil Nadu), **endemic to Western Ghats.**

Specimen examined: Thana: Kasa, *K.V.S. Badarinath 4021* (Sardar Patel University Herbarium, Gujarat).

Pachystoma Blume

Pachystoma pubescens Blume, Bijdr. 376, t. 3, f. 3. 1825.

Flowering: February–March.

Life form: Terrestrial.

Habitat: Found in semi-evergreen forests in open situation.

Distribution in Maharashtra: Satara.

General distribution: India (Manipur, Meghalaya, Mizoram, Nagaland, Arunachal Pradesh, Sikkim, West Bengal, Himachal Pradesh, Uttarakhand, Odisha, Karnataka, Kerala, Maharashtra, Tamil Nadu, Madhya Pradesh, Punjab, Uttar Pradesh, Andaman & Nicobar),

Bangladesh, Bhutan, Nepal, Myanmar, Indonesia, Malaysia, Philippines, Indo-China, New Guinea, Australia.

Specimen examined: Satara district, Koyna, *Bachulkar 323* (SUK).

Pecteilis Raf.

Pecteilis gigantea (Sm.) Rafin., Fl. Tell. 2: 38. 1837. Fig. 8H.

Orchis gigantea Sm., Exot. Bot. 2: 79. 1806.

Flowering: September–October.

Life form: Terrestrial.

Habitat: Found in open grassy slopes and plateaus of moist deciduous forests, semi-evergreen forests along margins of forests in open and usually on slightly sloping grounds.

Distribution in Maharashtra: Bhandara, Kolhapur, Nashik, Pune, Raigad, Satara, Sindhudurg and Thane.

General distribution: India (Nagaland, Himachal Pradesh, Jammu & Kashmir, Uttarakhand, Andhra Pradesh, Odisha, Goa, Gujarat, Karnataka, Kerala, Maharashtra, Tamil Nadu, Dadara & Nagar Haveli, Madhya Pradesh, Chhattisgarh, Bihar, Jharkhand), Pakistan, Myanmar.

Specimens examined: Bhandara district, Kusumtondi, *S.K.Malhotra 144689* (BSI). Kolhapur district, Radhanagari, *J.S.Jalal 200526* (BSI). Nashik district, Kumbhala, *John Cherian 112620* (BSI). Pune district, Mulshi, *J.S.Jalal 195078* (BSI). Raigad district, Matheran, *J.S.Jalal 200703* (BSI). Satara district, Mahabaleshwar, *J.S.Jalal 200420* (BSI). Sindhudurg district, Kudal, *J.S.Jalal 200513* (BSI). Thane district, Tansa, *J.S.Jalal 200855* (BSI).

Peristylus Blume

Peristylus aristatus Lindl.,Gen. Sp. Orchid. Pl.: 300. 1835. Fig. 8I.

Flowering: July–September.

Life form: Terrestrial.

Habitat: Found under the shade of semi-evergreen forests.

Distribution in Maharashtra: Kolhapur, Satara and Sindhudurg.

General distribution: India (Goa, Karnataka, Kerala, Maharashtra, Tamil Nadu), Nepal, Sri Lanka, Myanmar.

Specimens examined: Kolhapur district, Gajapur, *M.M.Sardesai 201* (SUK). Satara district, Shirshingi, *R.K.Kochhar 153668* (BSI). Sindhudurg district, Amboli, *J.S.Jalal 200479* (BSI).

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

Herminium constrictum Lindl., Edwards's Bot. Reg. 18: t. 1499. 1832.

Flowering: August–September.

Life form: Terrestrial.

Habitat: Found in grassy slopes of dry deciduous forests.

Distribution in Maharashtra: Amravati.

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

Specimen examined: Amravati district, Semadoh, *M.Y.Ansari 149372* (BSI).

Peristylus densus (Lindl.) Santapau & Kapadia in J. Bombay Nat. Hist. Soc. 57: 128. 1960. Fig. 8J.

Coeloglossum densum Lindl., Gen. Sp. Orchid. Pl.: 302. 1835.

Flowering: August–September.

Life form: Terrestrial.

Habitat: Found in high altitude rocky plateaus.

Distribution in Maharashtra: Kolhapur, Pune, Satara, Sindhudurg and Thane.

General distribution: India (Meghalaya, Nagaland, Arunachal Pradesh, Sikkim, Goa, Karnataka, Kerala, Maharashtra, Tamil Nadu), Bangladesh, Nepal, Sri Lanka, China, Myanmar, Thailand, Cambodia, Vietnam.

Specimens examined: Kolhapur district, Chandgad, *J.S.Jalal 194977* (BSI). Pune district, Mulshi, *B.Venkata Reddi 99065* (BSI). Satara district, Mahabaleshwar, *M.Y.Ansari 67726* (BSI). Sindhudurg district, Jalvadi-Chokul, *J.S.Jalal 195006* (BSI). Thane district, Tokavada range, *K.V.Billore 115809* (BSI).

Peristylus lawii Wight, Icon. Pl. Ind. Orient. 5: t. 1695. 1851.

Flowering: July–September.

Habit and Habitat: Terrestrials, found under the shade of moist deciduous forests and dry deciduous forests between 200–500 m.

Distribution in Maharashtra: Thane and Yavatmal.

General distribution: India (Uttarakhand, Odisha, Gujarat, Karnataka, Kerala, Maharashtra, Tamil Nadu, Bihar, Jharkhand, Madhya Pradesh), Nepal, Myanmar.

Specimens examined: Thane district, Tansa, *J.S.Jalal 200861* (BSI). Yavatmal district, Patan Bori Range, *S. Karthikeyan 160088* (BSI).

Peristylus plantagineus (Lindl.) Lindl., Gen. Sp. Orchid. Pl.: 300. 1835.

Herminium plantagineum Lindl., Edwards's Bot. Reg. 18: t. 1499. 1832.

Flowering: August–October.

Life form: Terrestrial.

Habitat: Found in dry deciduous forests, moist deciduous forests, semi-evergreen forests.

Distribution in Maharashtra: Chandrapur, Gadchiroli, Kolhapur, Pune, Raigad, Satara, and Sindhudurg.

General distribution: India (West Bengal, Odisha, Andhra Pradesh, Goa, Gujarat, Karnataka, Kerala, Maharashtra, Tamil Nadu, Chhattisgarh, Madhya Pradesh), Sri Lanka.

Specimens examined: Chandrapur district, Amborthra, *B.M.Wadhwa 137363A* (BSI). Gadchiroli district, *R.S.Govekar 1284* (BAMU). Kolhapur district, Chandgad, *J.S.Jalal 194984* (BSI). Pune district, Nane Ghat, *J.S.Jalal 200841* (BSI). Raigad district, Matheran, *J.S.Jalal 200701* (BSI). Sindhudurg district, Amboli, *J.S.Jalal 200482* (BSI).

Peristylus stocksii (Hook.f.) Kraenzl., Orchid. Gen. Sp. 1: 513. 1898. Fig. 8K.

Habenaria stocksii Hook.f., Fl. Brit. India 6: 158. 1890.

Flowering: July–September.

Life form: Terrestrial.

Habitat: Found in dry deciduous forests, moist deciduous forests and semi-evergreen forests.

Distribution in Maharashtra: Amravati, Kolhapur, Nashik, Pune, Raigad, Ratnagiri and Thane.

General distribution: India (Goa, Gujarat, Karnataka, Maharashtra, Tamil Nadu, Bihar, Madhya Pradesh), **endemic to India.**

Specimens examined: Amravati district, Melghat, *M.Y.Ansari 149371* (BSI). Kolhapur district, Chandgad, *J.S.Jalal 194983* (BSI). Nashik district, Kasara ghat, *J.S.Jalal 200873* (BSI). Pune district, Rajmachi, *J.S.Jalal 200577* (BSI). Raigad district, Matheran, *J.S.Jalal 200597* (BSI). Ratnagiri district, Phonda ghat, *R.S.Rao 129680* (BSI). Thane district, Malshej ghat, *J.S.Jalal 200844* (BSI).

Pholidota Lindl.

Pholidota imbricata Lindl. in W.J.Hooker, Exot. Fl. 2: t. 138. 1825.

Flowering: July–September.

Life form: Epiphyte.

Habitat: Found in semi-evergreen forests.

Distribution in Maharashtra: Gadchiroli, Kolhapur and Sindhudurg.

General distribution: India (Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura, Arunachal Pradesh, Sikkim, West Bengal, Uttarakhand, Andhra Pradesh, Odisha, Goa, Karnataka, Kerala, Maharashtra, Tamil Nadu, Jharkhand, Chhattisgarh, Madhya Pradesh, Andaman & Nicobar), Bangladesh, Bhutan, Nepal, Pakistan, Sri Lanka, China, Myanmar, Indonesia, Malaysia, Thailand, New Guinea, Pacific islands, Australia.

Specimens examined: Gadchiroli district, Binagunda, *R.S.Govekar 1703* (BAMU). Kolhapur district, Patgaon, *M.M.Sardesai 2043* (SUK). Sindhudurg district, Virdi, Sawantwadi, *S.M.Almeida 4895* (BLAT).

Pinalia Lindl.

Pinalia mysorensis (Lindl.) Kuntze, Revis. Gen. Pl. 2: 679. 1891.

Eria mysorensis Lindl., J. Proc. Linn. Soc., Bot. 3: 54. 1858.

Flowering: July–October.

Life form: Epiphyte.

Habitat: Found in semi-evergreen forests.

Distribution in Maharashtra: Satara.

General distribution: India (Karnataka, Kerala, Maharashtra, Tamil Nadu), **endemic to Western Ghats.**

Specimen examined: Satara district, Mahabaleshwar, 16.08.1883, *J.M.Woodrow s.n.* (CAL acc.n. 453115).

Note: This species was collected by J.M.Woodrow from Mahabaleshwar in 1883. After that it was not collected by any subsequent workers from Mahabaleshwar or any other area from Maharashtra.

Pinalia polystachya (A.Rich.) Kuntze, Revis. Gen. Pl. 2: 679. 1891.

Eria polystachya A.Rich., Ann. Sci. Nat., Bot., sér. 2, 15: 20. 1841.

Flowering: July–October.

Life form: Epiphyte.

Habitat: Found in semi-evergreen forests.

Distribution in Maharashtra: Satara.

General distribution: India (Karnataka, Kerala, Maharashtra, Tamil Nadu), **endemic to Western Ghats**.

Specimen examined: Satara district, Koyna valley, July 1892. *Herb. Cooke no. 447* (BSI).

Note: This species is endemic to Western Ghats. It was reported from Koyna valley in 1892. Only single specimen of this taxon is available in herbarium *BSI*.

Plectoglossa (Hook.f.) K. Prasad &Venu

Plectoglossa perrottetiana (A. Rich.) K. Prasad & Venu, Rheedea 88. 2015.

Habenaria perrottetiana A. Rich. in Ann. Sci. Nat., Bot., 2,15:74, t. 4 B. 1841.

Flowering: August–October.

Habitat and ecology: Terrestrials, found in open grassy slopes of higher plateaus.

Distribution in Maharashtra: Kolhapur.

General distribution: India (Karnataka, Kerala, Maharashtra, Tamil Nadu), **endemic to Western Ghats.**

Specimen examined: Kolhapur district, Amba, *M.M.Sardesai 4341* (SUK).

Porpax Lindl.

Porpax jerdoniana (Wight) Rolfe, Orchid Rev. 16: 8. 1908.

Lichenora jerdoniana Wight, Icon. Pl. Ind. Orient. 5: t. 1738. 1851.

Flowering: June–July.

Life form: Epiphyte.

Habitat: Found in moist deciduous and semi-evergreen forests.

Distribution in Maharashtra: Kolhapur, Thane, Ratnagiri and Sindhdurg.

General distribution: India (Goa, Maharashtra, Karnataka, Kerala, Tamil Nadu, Andaman & Nicobar), **endemic to India.**

Specimens examined: Kolhapur district, Tilari, *J.S.Jalal 197746* (BSI). Ratnagiri district, Kudavale, *J.S.Jalal 194921* (BSI). Thane district, Usgaon, *N.Y.Das 1704* (BLAT). Sindhudurg district, Amboli, *M.R.Almeida 334* (BLAT).

Porpax reticulata Lindl., Edwards's Bot. Reg. 31(Misc.): 62. 1845. Fig. 8L.

Flowering: April–June.

Life form: Epiphyte.

Habitat: Found in moist deciduous forests and semi-evergreen forests.

Distribution in Maharashtra: Kolhapur, Pune, Raigad, Ratnagiri and Sindhudurg.

General distribution: India (Goa, Maharashtra, Karnataka, Kerala, Tamil Nadu), Thailand, Laos, Vietnam.

Specimens examined: Kolhapur district, Chandgad, *J.S.Jalal 194970* (BSI). Pune district, Khandala, *H.Santapau 743* (BLAT). Raigad district, Matheran, *N.A.Irani 4314* (BLAT). Ratnagiri district, Kudavale, *J.S.Jalal 194922* (BSI). Sindhudurg district, Amboli, *J.S.Jalal 200477* (BSI).

Rhynchostylis Blume

Rhynchostylis retusa (L.) Blume, Bijdr. 286. 1825.

Epidendrum retusum L., Sp. Pl.: 953. 1753.

Flowering: June–July.

Life form: Epiphyte.

Habitat: Found in dry deciduous forests and moist deciduous forests.

Distribution in Maharashtra: Amravati, Gadchiroli, Kolhapur, Nashik, Mumbai Suburban, Pune, Raigad, Ratnagiri and Thane.

General distribution: India (Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura, Arunachal Pradesh, Sikkim, West Bengal, Himachal Pradesh, Jammu & Kashmir, Uttarakhand, Andhra Pradesh, Odisha, Goa, Gujarat, Karnataka, Kerala, Maharashtra, Tamil Nadu, Jharkhand, Chhattisgarh, Haryana, Madhya Pradesh, Andaman & Nicobar), Bangladesh, Bhutan, Nepal, Sri Lanka, China, Myanmar, Indonesia, Malaysia, Philippines, Thailand, Indo-China.

Specimens examined: Amravati district, Semadoah, *J.S.Jalal 200753* (BSI). Gadchiroli district, *R.S.Govekar s.n.* (BAMU). Kolhapur district, Patgaon, *M.M.Sardesai 1310* (SUK). Mumbai Suburban district, Malad, *G.L.Shah 4626* (BLAT). Nashik district, Umberthan, *P.L.Narasimhan 165454* (BSI). Pune district, Khandala, *J.S.Jalal 195041* (BSI). Raigad district, Karjat, *J.S.Jalal 195049* (BSI). Ratnagiri district, Dapoli, *J.S.Jalal 194937* (BSI). Thane district, Tansa, *J.S.Jalal 200864* (BSI).

Smithsonia C.J.Saldanha

Smithsonia maculata (Dalzell) C.J.Saldanha, J. Bombay Nat. Hist. Soc. 71: 74. 1974.

Micropera maculata Dalzell, Hooker's J. Bot. Kew Gard. Misc. 3: 282. 1851.

Flowering: May–June.

Life form: Epiphyte.

Distribution in Maharashtra: Sindhudurg.

General distribution: India (Maharashtra, Karnataka, Kerala and Tamil Nadu), **endemic to Western Ghats.**

Note: T. Cooke has reported this species from 'Phondaghat' (in Kankavli taluka) based on the collection by Ritchie. There is no herbarium record in BSI, CAL and BLAT of this species. We have not seen any wild population of this plant in Maharashtra.

Smithsonia straminea C.J.Saldanha, J. Bombay Nat. Hist. Soc. 71: 73. 1974.

Flowering: May–June.

Life form: Epiphyte.

Habitat: Found in semi-evergreen forests.

Distribution in Maharashtra: Ratnagiri.

General distribution: India (Goa, Karnataka, Kerala, Maharashtra), **endemic to Western Ghats.**

Specimens examined: Ratnagiri district, Vigavani, *J.S.Jalal 194912* (BSI).

Smithsonia viridiflora (Dalzell) C.J.Saldanha, J. Bombay Nat. Hist. Soc. 71: 75. 1974. Fig. 8M.

Micropera viridiflora Dalzell, Hooker's J. Bot. Kew Gard. Misc. 3: 282. 1851.

Aerides dalzelliana (Santapau) Garay, Bot. Mus. Leafl. 23: 158. 1972.

Flowering: May–June.

Life form: Epiphyte.

Habitat: Found in semi-evergreen and evergreen forests.

Distribution in Maharashtra: Kolhapur, Pune, Satara and Sindhudurg.

General distribution: India (Goa, Karnataka, Kerala, Maharashtra), **endemic to Western Ghats.**

Specimens examined: Kolhapur district, Amba, *R.K.Bhide s.n.* (*BSI*). Pune district, Dudhivare khind, *J.S.Jalal 195071* (*BSI*). Satara district, Koyna, *J.S.Jalal 200796* (BSI). Sindhudurg district, Amboli, *J.S.Jalal 200403* (BSI).

Spiranthes Rich.

Spiranthes sinensis (Pers.) Ames, Orchidaceae 2: 53. 1908.

Neottia sinensis Pers., Syn. Pl. 2: 511. 1807.

Spiranthes lancea (Thunb. ex Sw.) Bakh.f. & Steenis, Blumea 6: 361. 1950.

Flowering: March – September.

Life form: Terrestrial.

Distribution in Maharashtra: Satara.

General distribution: India (Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura, Arunachal Pradesh, Sikkim, West Bengal, Himachal Pradesh, Jammu & Kashmir, Uttarakhand, Odisha, Punjab, Karnataka, Kerala), Afghanistan, Bangladesh, Bhutan, Nepal, China, Myanmar, Japan, Kashmir, Korea, Malaysia, Mongolia, Philippines, Thailand, Vietnam, Pacific islands, Russia, Australia.

Note: This species is included based on Santapau and Kapadia (1966). They discovered it by an accident. Mrs. Rukminibai collected a group of lily bulbs from Panchgani and planted in St. Xavier's College terrace garden. In the subsequent year during the month of March it was flowering along with lilies plants. The specimen number 1916 by Kapadia (BLAT) couldn't be traced in BLAT Harbarium. It was also reported by Stocks from Konkan region.

Thunia Rchb.f.

Thunia alba (Lindl.) Rchb.f. var. ***bracteata*** (Roxb.) N.Pearce & P.J.Cribb in Edinb. J. Bot. 58: 116. 2001. *Limodorum bracteatum* Roxb., Fl. Ind., ed. 1832, 3: 466. 1832.

Thunia venosa Rolfe, Orchid Rev. 12: 206. 1905.

Flowering: August–September.

Life form: Epiphyte.

Habitat: Found in semi evergreen forests.

Distribution in Maharashtra: Kolhapur, Pune and Satara.

Genaral distribution: India (Meghalaya, Arunachal Pradesh, Sikkim, West Bengal, Himachal Pradesh, Uttarakhand, Andhra Pradesh, Odisha, Kerala, Maharashtra), Bhutan, Nepal.

Specimens examined: Kolhapur district, Chandgad, *J.S.Jalal 194971* (BSI). Pune district, Ambavne, *B.Venkata Reddi 99020* (BSI). Satara district, Mahabaleshwar, *M.M.Sardesai 1422* (SUK).

Vanda Jones ex R. Br.

Vanda tessellata (Roxb.) Hook. ex G.Don in J.C.Loudon, Hort. Brit.: 372. 1830. Fig. 8N.

Epidendrum tessellatum Roxb., Pl. Coromandel 1: 34. 1795.

Flowering: March–June.

Life form: Epiphyte.

Habitat: Epiphytes, found in moist deciduous forests and dry deciduous forests.

Distribution in Maharashtra: Amravati, Bhandara, Chandrapur, Gadchiroli, Nandurbar and Yavatmal.

General distribution: India (Assam, Nagaland, Tripura, Arunachal Pradesh, Sikkim, West Bengal, Uttarakhand, Andhra Pradesh, Odisha, Goa, Gujarat, Karnataka, Kerala, Maharashtra, Tamil Nadu, Dadara & Nagar Haveli, Bihar, Jharkhand, Madhya Pradesh, Chhattisgarh, Uttar Pradesh, Rajasthan), Bangladesh, Nepal, Sri Lanka, Myanmar.

Specimens examined: Amravati district, Tarubanda, *J.S.Jalal 200771* (BSI). Bhandara district, Nagzira, *S.K.Malhotra 145137* (BSI). Chandrapur district, Bhawragarh, *S.R.Rolla 96586* (BSI). Gadchiroli district, *R.S.Govekar 0001* (BAMU). Nandurbar district, Toranmal, *J.S.Jalal 195117* (BSI). Yavatmal district, Kharbi range, *S. Karthikeyan 156720* (BSI).

Vanda testacea (Lindl.) Rchb. f., Gard Chron.2: 166.1877.

Aerides testacea Lindl., Gen. Sp. Orchid. Pl.: 238. 1833.

Aerides wightiana Lindl., Gen. Sp. Orchid. Pl.: 238. 1833.

Vanda testacea var. parviflora (Lindl.) M.R.Almeida, Fl. Maharashtra 5A: 90. 2009.

Flowering: May–June.

Life form: Epiphyte.

Habitat: Found in moist deciduous forests and dry deciduous forests.

Distribution in Maharashtra: Amravati, Gadchiroli, Thane, Nandurbar, Nashik, Raigad and Ratnagiri.

General distribution: India (Assam, Manipur, Mizoram, Nagaland, Arunachal Pradesh, Sikkim, West Bengal, Himachal Pradesh, Uttarakhand, Andhra Pradesh, Odisha, Goa, Karnataka, Kerala, Maharashtra, Tamil Nadu, Jharkhand, Madhya Pradesh, Chhattisgarh, Uttar Pradesh, Rajasthan), Nepal, Sri Lanka, Myanmar.

Specimens examined: Amravati district, Melghat, *J.S.Jalal 200747* (BSI). Gadchiroli district, *R.S.Govekar 1691* (BAMU). Thane district, Tansa, *J.S.Jalal 200864* (BSI). Nandurbar district, Toranmal, *J.S.Jalal 195120* (BSI). Nashik district, Pimpalsonda, *P.L.Narasimhan 166395* (BSI). Raigad district, Talerwarphata, *J.S.Jalal 194902* (BSI). Ratnagiri district, Dapoli, *J.S.Jalal 194934* (BSI).

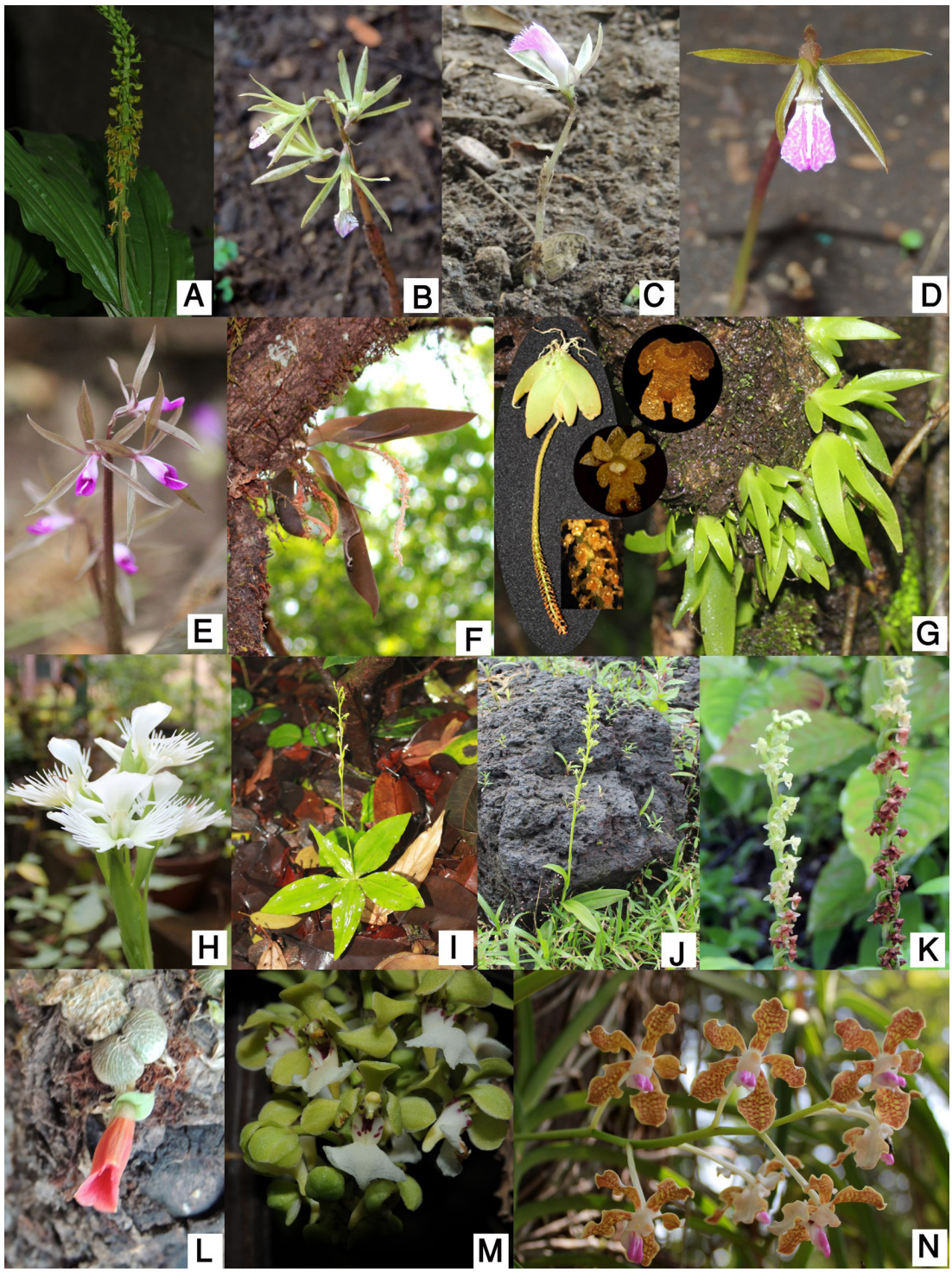

Figure 8. A. *Malaxis versicolor,* B. *Nervilia concolor*, C. *Nervilia crociformis*, D. *Nervilia infundibulifolia*, E. *Nervilia plicata*, F. *Oberonia brunoniana*, G. *Oberonia recurva*, H. *Pecteilis gigantea*, I. *Peristylus aristatus*, J. *Peristylus densus*, K. *Peristylus stocksii*, L. *Porpax reticulata*, M. *Smithsonia viridiflora*, N. *Vanda tessellata*.

Zeuxine Lindl.

Zeuxine gracilis (Breda) Blume, Coll. Orchid.: 69. 1858.

Psychechilos gracilis Breda, Gen. Sp. Orchid. Asclep. 2: t. 9. 1829.

Flowering: February–March.

Life form: Terrestrial.

Habitat: Found in semi-evergreen forests.

Distribution in Maharashtra: Kolhapur.

General distribution: India (Meghalaya, Nagaland, Arunachal Pradesh, Odisha, Karnataka, Kerala, Maharashtra, Tamil Nadu), Indonesia, Malaysia, Thailand, Vietnam.

Specimen examined: Kolhapur district, Dajipur, *M.M.Sardesai 2045* (SUK).

Zeuxine longilabris (Lindl.) Trimen, Syst. Cat. Fl. Pl. Ceylon: 90. 1885.

Monochilus longilabris Lindl., Gen. Sp. Orchid. Pl.: 487. 1840.

Flowering: February.

Life form: Terrestrial.

Habitat: Found in semi-evergreen forests and evergreen forests.

Distribution in Maharashtra: Kolhapur and Sindhudurg.

General distribution: India (Assam, Tripura, Arunachal Pradesh, West Bengal, Odisha, Goa, Karnataka, Kerala, Maharashtra, Tamil Nadu, Bihar), Bangladesh, Nepal, Sri Lanka, Myanmar, Malaysia, Thailand, Cambodia.

Specimens examined: Kolhapur district, Pargad road, *J.S.Jalal 195197* (BSI). Sindhudurg district, Amboli, *J.S.Jalal 194948* (BSI).

Zeuxine strateumatica (L.) Schltr., Bot. Jahrb. 45: 394. 1911.

Orchis strateumatica L. Sp. Pl. 2: 943. 1753.

Flowering: January–March.

Life form: Terrestrial.

Habitat: Found in marshy and sandy localities especially along river banks among the grasses.

Distribution in Maharashtra: Ahmednagar, Akola, Kolhapur, Pune and Solapur.

General distribution: India (Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura, Arunachal Pradesh, Sikkim, West Bengal, Himachal Pradesh, Uttarakhand, Odisha, Andhra Pradesh, Gujarat, Karnataka, Kerala, Maharashtra, Tamil Nadu, Bihar, Jharkhand, Delhi, Madhya Pradesh, Punjab, Rajasthan, Uttar Pradesh, Andaman & Nicobar), Afghanistan, Bangladesh, Bhutan, Nepal, Pakistan, Sri lanka, China, Myanmar, Indonesia, Japan, Philippines, Malaysia, Thailand, Indo-China, West Asia, New Guinea, Africa, America.

Specimens examined: Ahmednagar district, Khandgaon, *R.Shinde 735* (BLAT). Akola district, Patur, *S.Y.Kamble 152782* (BSI). Kolhapur district, Shivaji University campus, *J.S.Jalal 200732* (BSI). Pune district, Mulshi, *R.V.Kammathy 78359* (BSI). Solapur district, Ujani, *S.K. Das Das 179635* (BSI).

Imperfectly known species

Habenaria caranjensis Dalzell has uncertain identity and status. There is no specimen in any herbaria and it was not collected by any other botanist after Dalzell (Dalzell & Gibson 1861). Santapau and Kapadia (1966) stated that the original locality given by Dalzell is the islands of 'Carunja near Bombay'. Carunja is a place near the Bombay coast and not an island. Moreover, at present the area belongs to Indian Navy and converted for Navy operations with port and township. Hence, existence of this species is doubtful.

Excluded Taxa

These species have been reported from Maharashtra by previous workers but are not included in our Checklist for the reasons given.

Acampe rigida (Buch.-Ham. ex Sm.) P.F.Hunt was reported by Singh & Dawre (1983) based on collection numbers *R.D.Pataekar 102001* (BSI) and *H.P.Paranjape s.n.* (*BSI*), which has been re-identified as *Acampe praemorsa* (Roxb.) Blatt. & McCann.

Diplocentrum congestum Wight was included by Barbhuiya and Salunkhe (2016) in orchids of Maharashtra based on collection number S.M.Almeida *601* (*BLAT*), which was reidentified as *Smithsonia straminea* C.J.Saldanha.

Liparis dalzellii Hook.f.was included by Barbhuiya and Salunkhe (2016) in his list orchids of

Maharashtra citing collection number *Dalzell 47* (K-000387793). However, the Dalzell's specimen is identified as *Liparis odorata*.

Liparis nervosa (Thunb.) Lindl. was included by Almeida (2009) in Flora of Maharashtra and Barbhuiya and Salunkhe (2016) in his list orchids of Maharashtra citing the collection numbers *S.M.Almeida 515* (*BLAT*), *Gavade 1475* (*BLAT*), which was reidentified as *Liparis odorata.*

Liparis viridiflora (Blume) Lindl. was included by Barbhuiya and Salunkhe (2016) in Orchids of Maharashtra based on collection number *Rao 95193* (*CAL*). After examining that specimen it was found that the distribution locality is from Karnataka.

Malaxis densiflora (A. Rich.) Kuntze was included by Almeida (2009) in Flora of Maharashtra and Barbhuiya and Salunkhe (2016) in Orchids of Maharashtra citing the collection number *B.G.Gavade 441* (*BLAT*), which was reidentified as *Malaxis versicolor.*

Peristylus affinis (D.Don) Seidenf. was included by Almeida (2009) in Flora of Maharashtra and Barbhuiya and Salunkhe (2016) in Orchids of Maharashtra citing the collection number *S.M.Almeida 4959* (*BLAT*), which was reidentified as *Habenaria marginata.*

Peristylus gardneri (Hook.f.) Kraenzl. was included by Almeida (2009) in Flora of Maharashtra and Barbhuiya and Salunkhe (2016) in Orchids of Maharashtra citing the collection number *S.M.Almeida 3150* (*BLAT*), which was reidentified as *Peristylus densus.*

Peristylus richardianus Wight was included by Almeida (2009) in Flora of Maharashtra and Barbhuiya and Salunkhe (2016) in Orchids of Maharashtra citing the collection number *M.R.Almeida 334* (*BLAT*), which was reidentified as *Peristylus densus.*

Pholidota pallida Lindl. was included by Almeida (2009) in Flora of Maharashtra and Barbhuiya and Salunkhe (2016) in Orchids of Maharashtra citing the collection number *S.M.Almeida 4895* (BLAT), which was reidentified as *Pholidota imbricata.*

Polystachya concreta (Jacq.) Garay & H.R.Sweet was included by Barbhuiya and Salunkhe (2016) in Orchids of Maharashtra based on Gammie (1908). However Gammie (1908) had clearly mentioned that this has not been recorded from Bombay but from the nearby ghats of forest of Belgaum and North Kanara, which are in Karnataka state.

Pteroceras viridiflorum (Thwaites) Holttum was included by Almeida (2009) in Flora of Maharashtra and Barbhuiya and Salunkhe (2016) in Orchids of Maharashtra citing the collection number *M.R.Almeida 1621* (*BLAT*), which was reidentified as *Smithsonia viridiflora.*

Satyrium nepalense D.Don was included by Almeida (2009) in Flora of Maharashtra and Barbhuiya and Salunkhe (2016) in Orchids of Maharashtra citing the collection number *S.M.Almeida 2483* (*BLAT*), which was reidentified as *Peristylus plantagineus.*

Doubtful Taxa

Diplocentrum recurvum Lindl. was included by Lakshminarasimhan *et al*. (1996) based on *L.D.Garade's 257* (BSI) dated 27.05.1902 locality College garden, Poona. There is no other specimen to prove its occurrence in wild in Maharashtra. It requires further intensive survey to confirm its presence.

Peristylus spiralis A.Rich. is based on a collection by Law said to be from the Konkan region. There is no specimen in any herbaria and it was not collected by any other botanist.

Cultivated taxa

Twenty-two species viz., *Coelogyne flaccida*, *C. nitida, Cymbidium eburneum*, *Dendrobium albosanguineum, D. aphyllum, D. cretaceum*, *D. densiflorum, D. farmeri, D. fimbriatum, D. formosum, D. hookerianum, D. lindleyi, D. heterocarpum, D. nobile, D. parishii, D. pulchellum, Epidendrum ellipticum, E. secundum, Phaius mishmensis, P. tankervilleae, Spathoglottis plicata* and *Vanilla planifolia* have been reported by the previous workers from cultivated sources. Six species viz., *Arundina graminifolia, Chiloschista lunifera, Goodyera procera*, *Malaxis acuminata, M. intermedia* and *M. latifolia* were included by Almeida (2009) based on Karthikeyan *et al*. (1998). However, all these species have no wild record and herbarium specimens to confirm their occurrence in Maharashtra.

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A NEW SPECIES OF *CYRTOCHILUM* (ORCHIDACEAE: ONCIDIINAE) FROM THE EASTERN CORDILLERA OF COLOMBIA

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Abstract. A new species of *Cyrtochilum* from the Eastern Cordillera of Colombia is described and illustrated. The new species is most similar to the pink-flowered *Cyrtochilum distans* but is distinguished by its white and yellow-green flowers with spreading sepals and a pink lip with a basally yellow and apically white callus consisting of two parallel keels (vs. pink lateral sepals that are fused to about half or more of their length and a white callus consisting of two basal and two apical spreading keels).

Key words: eastern Colombia, new *Cyrtochilum*, Oncidiinae, Orchidaceae

Introduction. The circumscription of *Cyrtochilum* Kunth, with over 180–190 currently accepted species, has been contentious, along with the circumscription of related genera including *Odontoglossum* Kunth and *Oncidium* Sw. (Dalström 2012). As presently circumscribed, *Cyrtochilum* is mainly characterized by having ovoid pseudobulbs, conduplicate leaves, large and flexuous, branched inflorescences, resupinate flowers with mostly free sepals and petals, generally with an ovate to triangular lip with a more or less complex callus, consisting of keels and knobs in various shapes, a straight to sigmoid column with a large stigmatic cavity and two elongate pyriform cleft pollinia.

The species currently attributed to *Cyrtochilum* are distributed mainly in South America from Venezuela to Bolivia at 1500–3500 m in elevation, with only one species, *Cyrtochilum meirax* (Rchb.f.) Dalström occurring in the Caribbean. The largest number of species are found in the Andes where usually occur as epiphytes or lithophytes in cloud forests. In Colombia about 70–85 species are reported (Ortiz Valdivieso & Uribe Vélez 2007, Bernal *et al*. 2015). Here we describe a new species of *Cyrtochilum* from the Eastern Cordillera in Colombia.

Materials and methods. Plant material was prepared at the herbarium of the Jardín Botánico José Celestino Mutis (JBB) in Bogotá. Photographs of the detailed and dissected species were taken with a Canon EOS T3 camera fitted with a macro lens (EF-S 60 mm f/2.8). A Lankester Compose Digital Plate (LCDP) was prepared and diagrammed with Adobe Photoshop 5.0. Sketches were traced from the LCDP using a Wacom Bamboo CTH-460 and printed on smooth Fabriano paper of 240 gr. and repainted with a Shinhan Touch Liner 0.05 and 0.1 mm.

Taxonomic treatment

Cyrtochilum albovirens N. Gutiérrez & P. Harding ***sp. nov.*** (Fig. 1–3, 5, 6F).

TYPE: Colombia. Santander: Vélez Province, Municipo de La Belleza, Vereda Vistahermosa, Finca Moravia, 5 51 54.14 N 73 55 46.79 W, 2381 m, July 2016, *David E. Granados (DEG) 555* (holotype: JBB).

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Diagnosis.*Cyrtochilum albovirens* is vegetatively similar to *Cyrtochilum distans* (Rchb.f.) Kraenzl. with similar leaves, pseudobulbs and inflorescence, but distinguished mainly by having yellow-green and free lateral sepals and a basally yellow and apically white lip callus terminating in two parallel keels (*vs.* pink lateral sepals that are fused for half or more of their length, and a white lip callus consisting of two basal and two apical spreading keels for *C. distans*).

Epiphytic, caespitose *herb*. *Pseudobulbs* ovoid and slightly flattened, glossy green with brown markings at the base when exposed to sun, becoming orange-brown with age, bifoliate, surrounded basally by 3 to 4 foliaceous and deciduous, distichous sheaths, 8–11 × 2–4 cm. *Leaves* conduplicate, sessile, obovate-ligulate, obtuse, 25–56 × 3–4 cm. *Inflorescence* axillary from the uppermost sheath, an erect to arching panicle with multiple few-flowered side-branches, *ca*. 120 cm long. *Bracts* appressed, scale-like, *ca*. 1–2 cm. *Pedicel with ovary* to 3 cm long. *Flowers* stellate.*Dorsal sepal* yellow-green, basally shortly spathulate, then broadly elliptic, acute, apically involute, 1.2–1.6 × 0.4–0.5 cm. *Lateral sepals* similar in color and shape, free and spreading, slightly oblique, 1.5 × 0.3 cm. *Petals* whitish green, broadly unguiculate to almost sessile, then elliptic and indistinctly oblique, acute, 1.2–1.3 × 0.5–0.6 cm. *Lip* basally white, suffused with pink from the base of the callus towards the margins and apex and with a slightly darker midvein, rigidly fused to the column basally through a short ventral, longitudinal keel, elongated rhomboid with indistinct lateral lobes and an obtuse front-lobe, reflexed at 1/4 of its length, 1.0–1.2 × 0.5–0.6 cm; callus basally yellow, turning light pink to white apically, consisting of a swollen, two-ridged and hump-like basal part, emerging *ca.* 2 mm from the base of the lip, turning into a pair of parallel digitate keels extending to about half the length of the lip lamina. *Column* basally white and apically pale purplish, straight, stout, ventrally shallowly canaliculated, *ca*. 0.7 cm long. *Anther cap* white suffused with purple, globular and campanulate, *ca*. 2 mm broad. *Pollinarium ca*. 1.5 mm long, of two pyriform cleft/folded pollinia on a *ca*. 0.5 mm long almost diamond-shaped involute stipe, on a pulvinate viscidium.

Additional material studied. Colombia. Boyacá, in the canyon of the Pómeca river in Arabuco, 5 48 44.6 N 73 28 37.8 W, *Ortiz-Valdivieso & Uribe-Vélez s.n.* (*Cyrtochilum* sp. 05 in Ortiz-Valdivieso & Uribe-Vélez 2007, photo, drawing) (Fig. 3). Plants were observed by one of the authors (PH) in Bolivar, Santander, along the road to El Peñón, 6 02 56.7 N 74 11 47.1 W, at 2600 m elevation, July of 2016. Additional plants have been seen in private collections and shows in Bogotá. The American Orchid Society awarded a plant at the Bogotá show in 2015 (No. 20151928).

Distribution. *Cyrtochilum albovirens* is only known from the Eastern Cordillera of the Colombian Andes, in the departments of Santander and Boyacá (Fig. 4). The type plant was found in La Belleza growing next to plants of *Odontoglossum lindleyanum* Rchb.f. & Warsz., *Cyrtochilum mandibulare* (Linden & Rchb.f.) Kraenzl. and *Ornithidium ruberrimum* (Lindl.) Rchb.f. on a tree of the Verbenaceae family growing in pasture close to a relict forest. The plant that became the holotype was growing epiphytically *ca.* 6 m above the ground. These pastures are part of a family dairy farm called Moravia, whose owners are concerned about the conservation of the biodiversity.

Etymology. From the Latin "*albus*", white and "*virens*", green. In allusion to the white-green sepals and green-yellow petals.

Cyrtochilum albovirens (Fig. 5F) with its white and yellow-green flowers is easily recognized by the rhomboid pink lip, basally yellow and apically white callus that terminates in a pair of parallel digitate keels. The new species is easily distinguished in a fresh state due to the combination of yellow-green sepals and the bi-colored lip callus. In a dried state, it may superficially resemble other small-flowered *Cyrtochilum* species, such as *Cyrtochilum confertum* (Rchb.f.) Dalström (Fig. 5A), *Cyrtochilum distans* (Rchb.f.) Kraenzl. (Fig. 5B), *Cyrtochilum funis* (F.Lehm. & Kraenzl.) Kraenzl. (Fig. 5C), *Cyrtochilum longifolium* (Lindl.) Kraenzl. (Fig. 5D), and *Cyrtochilum myanthum* (Lindl.) Kraenzl. (Fig. 5E) but can be distinguished from all by the raised and hump-like base of the callus, which extends in a rather straight direction down from the column in a *ca*. 45º angle. In other words, the callus does not curve and follow the

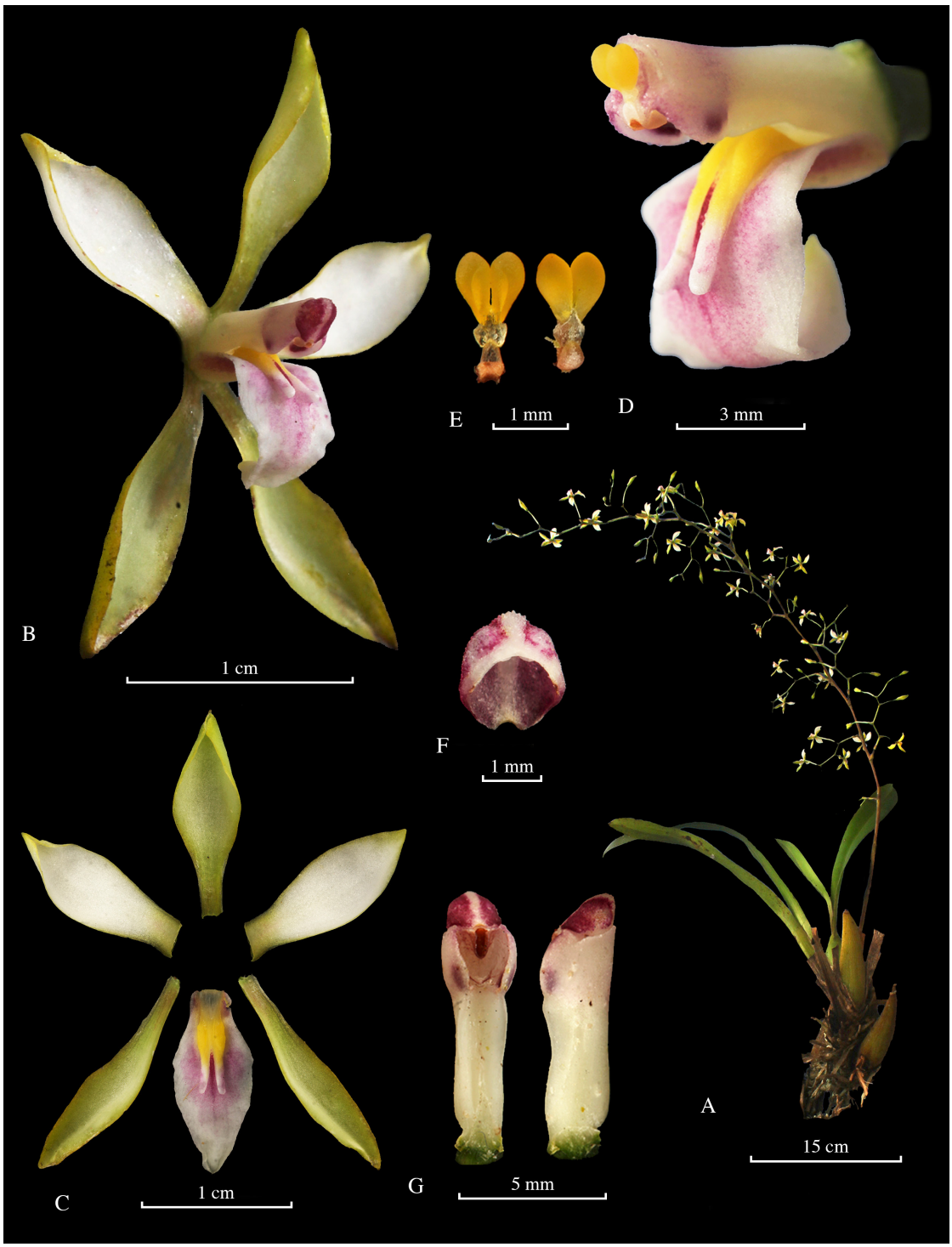

Figure 1. *Cyrtochilum albovirens*. A. Plant habit. B. Flower. C. Dissected perianth. D. Column and lip. E. Pollinarium, front and back views. F. Anther cap. G. Column lateral and ventral views. Photographs by Nicolás Gutiérrez Morales, from the plant that served as type.

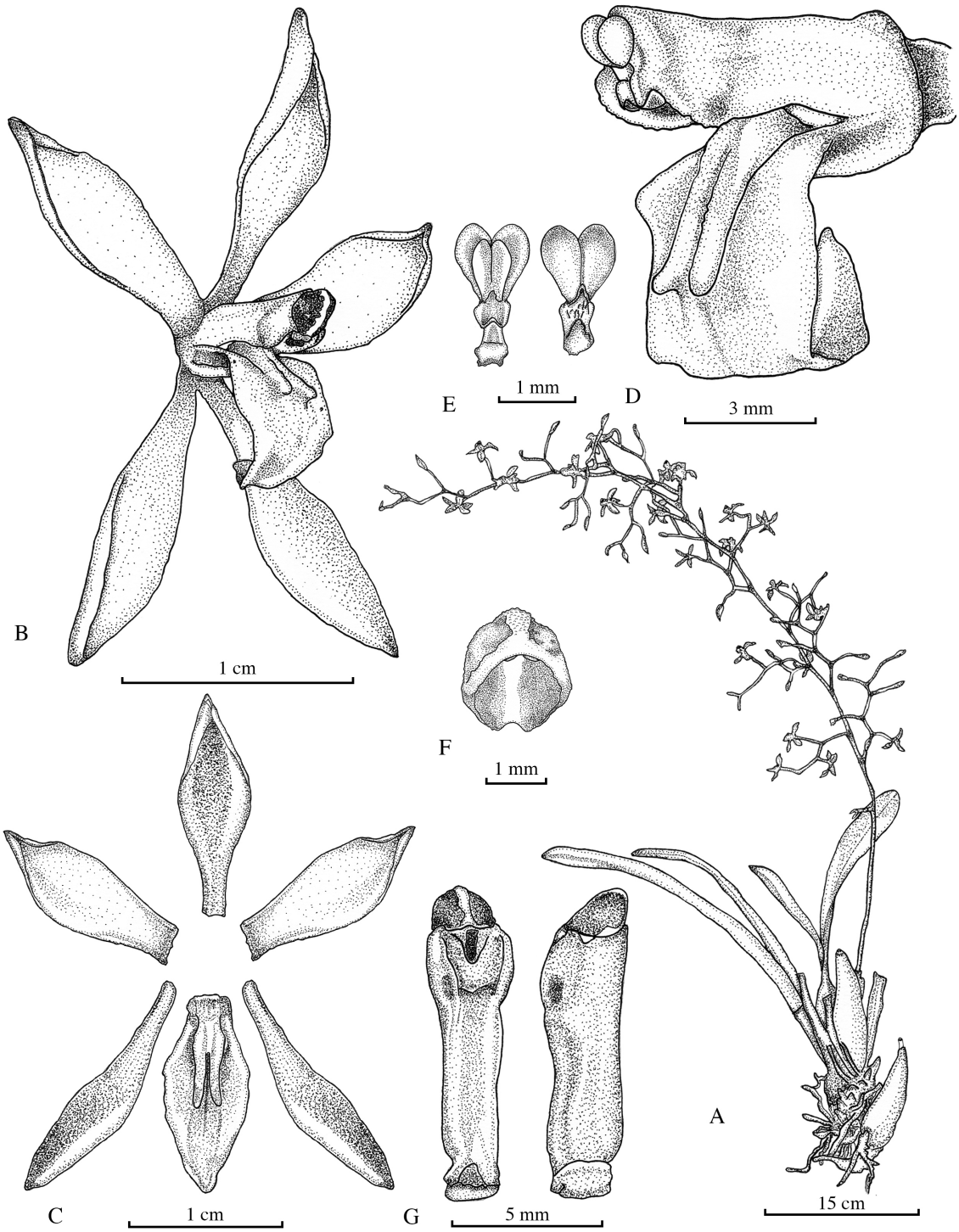

Figure 2. Illustration of *Cyrtochilum albovirens*. A. Habit. B. Flower. C. Dissected perianth. D. Column and lip. E. Pollinia. F. Anther. G. Column, dorsal and ventral view. Drawing by Juan Sebastián Moreno, from the plant that served as type.

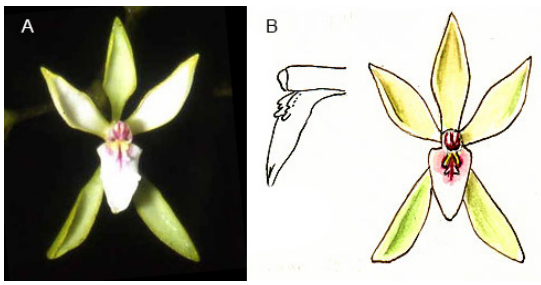

Figure 3. Additional material studied of *Cyrtochilum albovirens*. A. Photograph. B. Drawing. Photograph and illustration by Padre Ortiz-Valdivieso, from Ortiz-Valdivieso & Uribe-Vélez (2007).

more or less reflexed lamina of the lip. In addition, all of these here mentioned superficially similar species have distinct ventral column lobes that clasp the sides of the lip callus. *Cyrtochilum albovirens* does not have any ventral column lobes and actually appears more similar to larger-flowered species, such as *C. auropurpureum* (Rchb.f.) Dalström and *C. revolutum* (Lindl.) Dalström in that aspect. *Cyrtochilum albovirens* may look like a differently colored form of *Cyrtochilum distans* but the callus differences described above will easily tell the species apart.

Acknowledgements. The research presented here would not have been possible without the collaboration of the staff at Jardín Botánico José Celestino Mutis. We also thank Guido Deburghgraeve for lending us his stunning photographs of the most similar species and Steve Beckendorf for his help with the species general corrections on the manuscript. Finally, we especially thank Adam P. Karremans for his help with the species description and comments on the manuscript.

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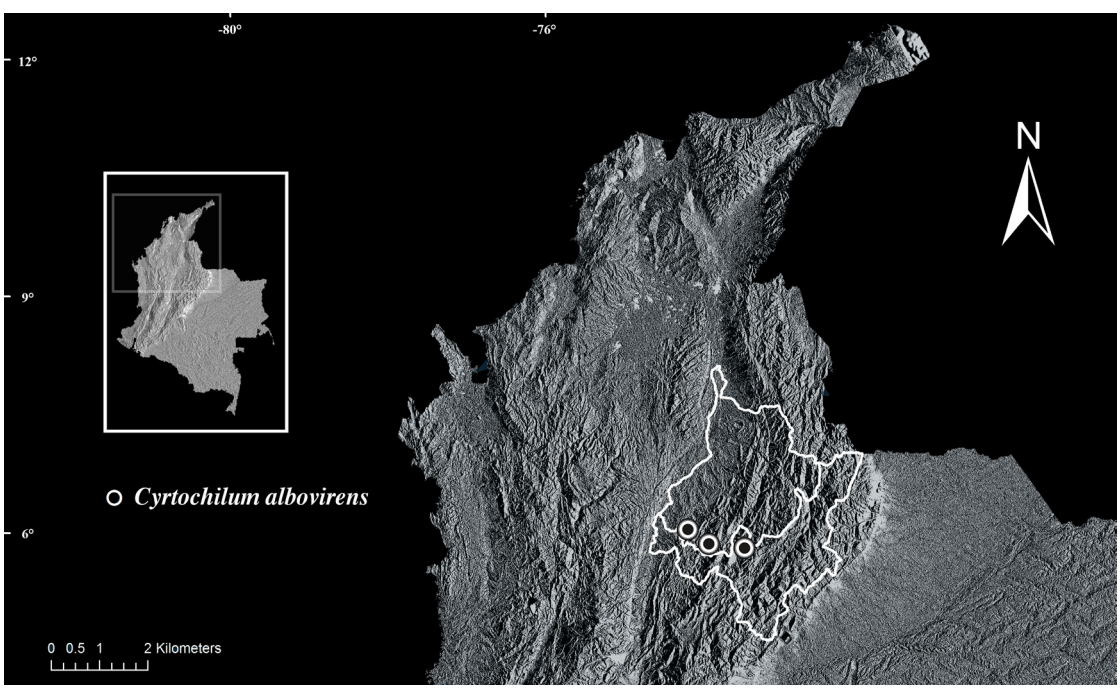

Figure 4. Distribution map of *Cyrtochilum albovirens*, distributed in La Belleza and Bolivar, Santander and Arcabuco, Boyacá in Colombia. The specimens presented in Bolivar and Arcabuco are from unvouchered observations.

FIGURE 5. *Cyrtochilum albovirens* and morphologically similar species. A. *C. confertum*. B. *C. distans*. C. *C. funis*. D. *C. longifolium*. E. *C. myanthum*. F. *C. albovirens*. Scale bars: 5 mm. Photographs by Guido Deburghgraeve (A, B, D & E) Juan Sebastián Moreno (C) and Nicolás Gutierréz Morales (F).

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PELATANTHERIA WOONCHENGII, A NEW ADDITION FOR THE ORCHID FLORA OF VIETNAM

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ABSTRACT. *Pelatantheria woonchengii* is a new record for the orchid flora of Vietnam. This species was previously misidentified as *Pelatantheria ctenoglossum*, as both species are present in Vietnam. The illustration, description, distribution and comparison with the closest species in Vietnam are included. An updated identification key for all Vietnamese members of the genus *Pelatantheria* is presented.

KEY WORDS: new record, Orchidaceae, *Pelatantheria woonchengii*, Vietnam

The genus *Pelatantheria* Ridl. includes eight accepted species (Govaerts *et al.* 2017). In Vietnam four species are recorded by Seidenfaden (1992), and Averyanov and Averyanova (2003): *Pelatantheria ctenoglossum* Ridl., *P. eakroensis* Haager, *P. insectifera* (Rchb.f.) Ridl., and *P. rivesii* (Guillaumin) Tang & F.T.Wang. The first author had the opportunity to study some specimens of *P. ctenoglossum* that he collected, and other Vietnamese specimens from his own collection. After closely examining these specimens, he realized that they present some morphological differences from the typical *P. ctenoglossum*. According to O'Byrne (2009), *P. woonchengii* P.O'Byrne, previously unrecorded for the flora of Vietnam, is a closely related species that looks very similar to *P. ctenoglossum*. The main differences between the two taxa are described below. With the inclusion of *P. woonchengii*, the number of *Pelatantheria* species recorded in Vietnam increased to five.

Materials and methods. The description presented hereafter is based on Vietnamese material found in Khanh Son district, Khanh Hoa province, supplemented with other specimens from the senior author's private collection, originally collected in the Daklak province, Vietnam. The measurements and description were prepared from living plants. Herbarium material was preserved in 70% ethanol and stored at VNM herbarium. All the photos were taken with a Canon 600D fitted with a EF–S 60mm f/2.8 Macro USM lens. Terminology for the morphological description follows Beentje (2012).

TAXONOMIC TREATMENT

Pelatantheria woonchengii P.O'Byrne, *Malayan Orchid Rev*. 43: 98. 2009 (Figure 1).

TYPE: Thailand. Cult. at Woon Leng Nursery (Singapore), *O'Byrne PX450* (SING!)

Creeping epiphyte *herb*. Aerial *roots*, occasionally branched, produced along stem. *Stem* to over 30 cm long, slightly compressed. *Leaves* distichous, thick, elliptic, concave, obtuse, slightly unequally bilobed, channeled along the midvein, 2.0–2.5 × 0.9–1.0 cm. *Inflorescence* axillary along the stem, *ca*. 1 cm long, peduncle short, slightly compressed, *ca*. 2 mm long, covered by 3 tubular bracts; rachis thicker than peduncle 7–8 mm long, 1–2 flowered; floral bract triangular, acute, *ca*. 2 mm long. *Flower* spreading, yellow striped with red on petals and sepals, the labellum yellow, the spur greenish-yellow. *Dorsal sepal* ovate, obtuse, *ca*. 4–5 × 3 mm. *Lateral sepals* oblique, elliptic, sub–acute, *ca*. 6–7 × 3 mm, with a distinct abaxial keel along the midvein. *Petals* thinner

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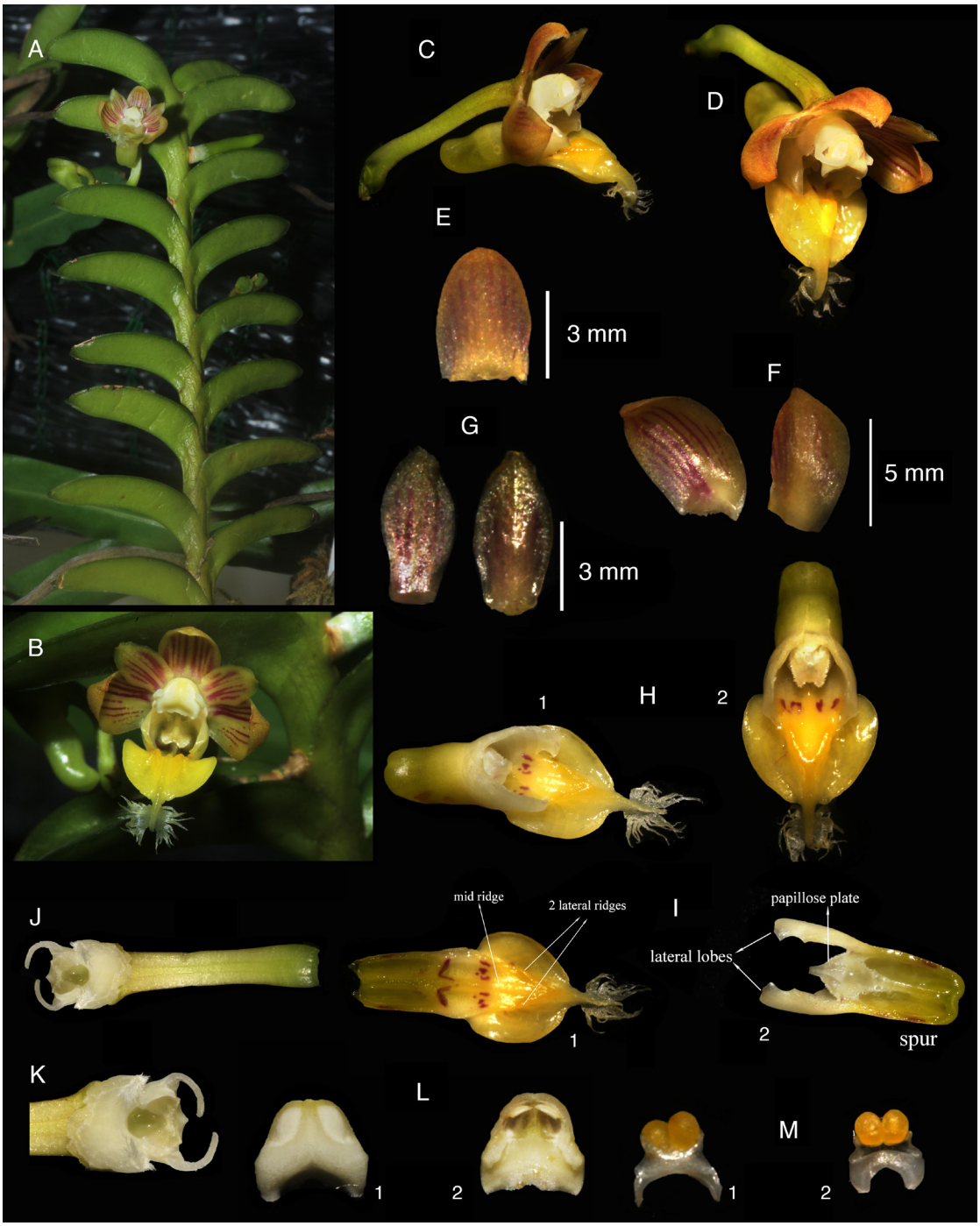


FIGURE 1. *Pelatantheria woonchengii.* A, habit. B, flower in frontal view. C, flower in side view. D, flower in upper view. E, dorsal sepal. F, lateral sepals. G, petals (abaxial and adaxial views). H, labellum with spur in adaxial (1) and frontal (2) views. I, mid lobe with spur, the lateral lobes removed (1) and present (2). J, column and pedicel. K, column. L, anther cap in frontal (1) and dorsal (2) views. M, pollinarium in frontal (1) and dorsal (2) views. Photo and drawing by Truong Ba Vuong from *BV 300*.

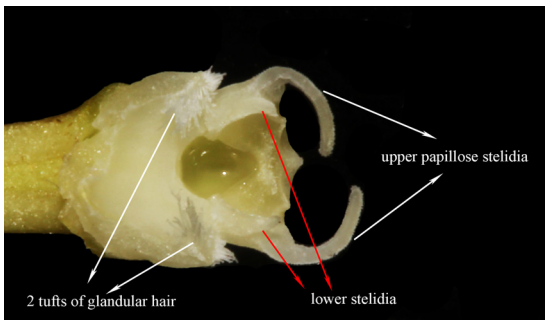
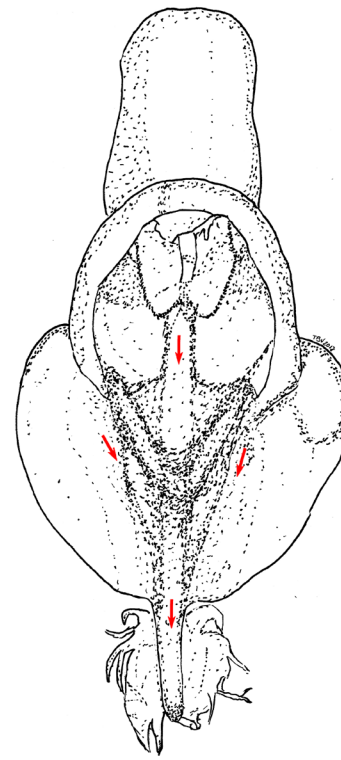


FIGURE 2. *Pelatantheria woonchengii* , detail of the column. Photo and drawing by Truong Ba Vuong from *BV 300.*



Right, FIGURE 3. Ridges on labellum of *Pelatantheria woochengii*. Drawn by Truong Ba Vuong from *BV 300.*

than sepals, narrowly elliptic, sub-acute ca. 5 × 2 mm. *Labellum* 3 lobed, spurred, immobile, *ca*. 12 mm long (from tip of spur to tip of mid lobe); spur *ca*. 4 mm long, apex rounded, truncate, emarginate, slightly curved forward; lateral lobes erect, triangular, *ca*. 3 × 2 mm; mid lobe broadly ovate to suborbicular, rounded, the margins slightly curved forward, 6–7 × 5 mm wide, the apex with an appendage 2 mm long and tufts of white hairs on the sides of apex; provided with 3 keels continuous from the ridge of spur septum, the central one lower than the lateral keels, fused on the middle of mid lobe into one narrower keel connecting with the apical appendage; spur provided on the floor with a median ridge, create the septum of spur and dividing it into 2 halves; the sidewall callus and the callus on the floor forming a backwall, laminar, ovate, papillose, T–shaped callus *ca*. 1.5 mm long. *Column* stout, *ca*. 2 mm long, provided at the base with 2 tufts of white glandular hair on each side, the apex with 2 pairs of lateral stelidia, the upper two incurved, papillose, embracing the anther cap, the other two shorter, oblique. *Anther cap* triangular. *Pollinia* 4, in two pairs, subglobose. *Ovary* (with pedicel) 1.1 cm long, the ovary straight, the pedicel slightly up curved. *Capsule* not seen. (Fig. 2–3).

FLOWERING TIME: From mid-October to late November.

DISTRIBUTION: Khanh Son district (Khanh Hoa province), Daklak, Ninh Thuan. Peninsular Malaysia (Pahang), Thailand.

SPECIMEN EXAMINED: Khanh Son District (Khanh Hoa province) *BV 239* (VNM). Daklak province, flowered in the private collection of the senior author, *BV 300* (VNM). Without specific locality, *Nguyen Van Khang s.n.* (Photo).

TABLE 1. Comparison of the main differences between *Pelatantheria woonchengii* and similar to *P. ctenoglossum.*

	Pelatantheria ctenoglossum	*Pelatantheria woonchengii*
Callus on midlobe	Labellum with 3 keels, mid keel lower than 2 side keels, 3 keels jointed to form a high keel in middle of mid lobe and then compress into single narrow keel connecting with labellum apex.	"Mid lobe with large yellow callus…", according to Seidenfaden (1992); "…disk thickened and cushion–like centrally, waxy", according to Chen, & Wood (2009).
Column foot	Two tufts of hairs for each side	One tuft of hairs for each side

FIGURE 4. Species of *Pelatantheria*. A. *P. ctenoglossum* Ridl. (Photo by Chu Xuan Canh) and B. *P. woochengii* P.O'Byrne (photo by Truong Ba Vuong).

Pelatantheria woonchengii looks very similar to *P. ctenoglossum* and is misidentified in Vietnam. Below is the comparison of the two species (Table 1, Fig, 4).

There are 2 flower forms of *P. woochengii* found in Vietnam. The first one is described above. Another form (observed in the collection of the second author) is striped with red and has a lower number of stripes (Figure 5).

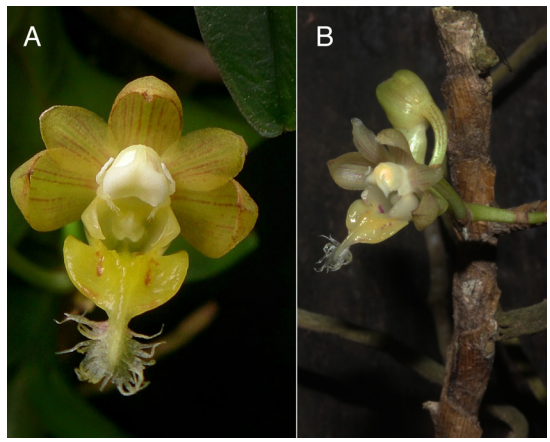


FIGURE 5. Specimens of *Pelatantheria woonchengii* with fewer reddish stripes. A, photo from theprivate collection of Nguyen Van Khang; B, photo of *BV 239*, collected by the senior author in Khanh Son district (Khanh Hoa province). Photo by Truong Ba Vuong.

Pelantantheria woochengii has recently been sold through the Internet in the Vietnamese market of wild orchids, at a very cheap price. Many populations of the species were destroyed by overcollection.

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ARTIFICIAL IDENTIFICATION KEY TO THE VIETNAMESE SPECIES OF *PELATANTHERIA**

1a. Pollinia 2, without hairs on column, short and thin appendage without projection on labellum apex ..... *P. eakroensis*
1b. Pollina 4 2
2a. Midlobe of labellum smooth, without projection on midlobe apex 3
3a. Midlobe with unclear central thickening, without or unclear hairs on column ..... *P. insectifera*
3b. Midlobe with single mid ridge, dense white glandular hairs on column apex ..... *P. rivesii*
2b. Midlobe of labellum with prominent yellow calli or warty cushion callus, with projection on midlobe apex 4
4a. Midlobe of labellum with 3 yellow calli, 2 tufts of hairs on each side of column ..... *P. woochengii*
4b. A broad warty yellow callus nearly covered midlobe, 1 tuft of hairs on each side of colum ..... *P. ctenoglossum*

* Based on data from Seidenfaden (1992), Haager (1993), Averyanov (1994), O'Byrne (2009), Chen and Wood (2009).

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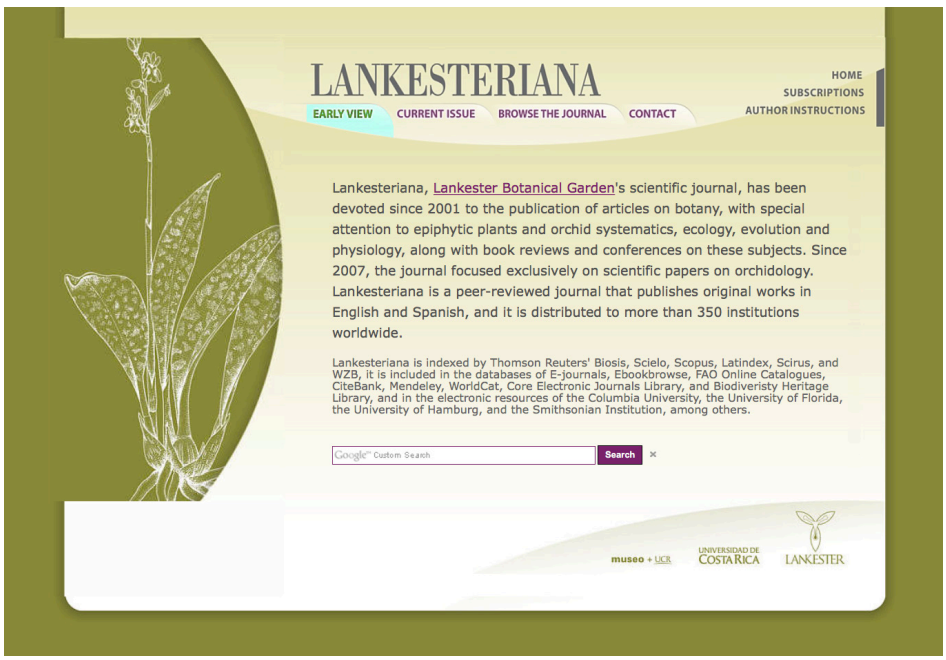

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