Documentation of Orchid Resources of Kiphire, Tuensang and Zunheboto Districts of Nagaland and Micropropagation of Two Threatened Species

Submitted By

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THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT OF THE DEGREE OF DOCTOR OF PHILOSOPHY IN BOTANY

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Contents

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DECLARATION

I, Mr. Hutoka Y. Jakha bearing Ph. D. Registration No. 580/2014 dated May 20, 2014 hereby declare that the subject matter of my thesis entitled **'Documentation of Orchid Resources of Kiphire, Tuensang and Zunheboto Districts of Nagaland and Micropropagation of Two Threatened Species'** is the record of original work done by me, and that the contents of this thesis did not form the basis for award of any degree to me or to anybody else to the best of my knowledge. This thesis has not been submitted by me for any Research Degree in any other University/Institute.

This is further certified that the Ph. D. thesis is submitted in compliance with the UGC Regulation 2016 dated May 05, 2016 (Minimum Standard and Procedure for Award of M. Phil./Ph. D. Degree). This thesis is being submitted to the Nagaland University for the degree of 'Doctor of Philosophy in Botany'.

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Ph. D. Coursework Mark sheet and Certificate

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Department of Botany

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The following are the marks secured by Mr/Ms Hutoka Y. Takha

Roll No. 08/13 *of* ***Ph. D Course Work Examination*** *held in 20*13

Subject(s)/Paper(s)	Max. Marks	Minimum Qualifying Marks	Marks Scored
Course No. B. PhD-I Research Methodology	100	35	51
Course No. B. PhD-II Elective/Optional	100	35	51
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Result	Rank/Class/Division	Percentage
Passed		56 %

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This is to certify that Mr/Ms Hutoka Y. Takha

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in the Department of Botany *Nagaland University held in the Year 20*13

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Chapter - 1

Introduction

Orchids are by and large known for their strikingly beautiful flowers of different size range, fascinating shapes and beautiful colors. They belong to a family Orchidaceae, which has outsmarted and outnumbered some other family of flowering plants by evolving higher levels of specialization in its vegetative and reproductive traits. Some of the special characters include intricately nature designed as well as long-lasting bizarre flowers with well developed gynostegium, compound pollen and resupinated ovaries. The long-lived pollen tubes, post-pollination development of ovules, and production of abundant microscopic and non-endospermic seeds with highly reduced embryos, protocorm-like bodies mediated seedling development and specific requirements of fungi and pollinators for continued reproduction in nature. Exhibiting all the characteristics of a group under active speciation, orchids represent the pinnacle of monocot evolution, making various taxonomic categories difficult to delimit (Dressler, 1993; Vij, 2006). The world estimate of orchid species has been usually assessed between 17,000 and 35,000 (Dressler, 1993). Some of the conservative estimates, however, suggest 19,128 species in 800 genera (Atwood, 1986), 18,000 species in 750 genera (Haywood, 1993), and 18,500 species in 778 genera (Mabberley, 1998), 20,000 species (Lawler and Rao, 2002). The family Orchidaceae is one of the largest families of flowering plants accounting for nearly 7% of the total flowering plant species (Pijl and Dodson, 1966). Recent estimates suggests approximately 26, 567 species distributed worldwide (WCSP, 2017). Some of the largest orchid genera are *Pleurothallis,* comprising about 1120 species, *Bulbophyllum* with about 1000 species, and *Dendrobium* with about 900 species (Judd *et al.,* 1999). On the other hand thousands of manmade orchid hybrids are produced each year and their number far exceeds that of the natural species. The family

Orchidaceae is considered to have originated sometime between 40 and 80 million years ago (Dressler, 1974) in Southeast Asia (Garay, 1972). The family has a diverse distribution, reaching almost every corner of the world except the Arctics and the hot deserts. Orchids are adapted to terrestrial, epiphytic, lithophytic, and subterranean life modes, but are mainly concentrated in the tropical and sub-tropical climates where favorable conditions for their growth, i.e., high humidity and thick vegetation prevail (Vij, 1995). Unfortunately, orchids have become victims of their own beauty and utility; the size and frequency of their natural populations have been detrimentally affected by unscrupulous collections for commercial and scientific purposes. The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), in 1975, suggested a complete ban on the export of field collected orchid plants so as to avoid overutilization. The morphological variability of orchids though a boon for commercial growers and hobbyists, poses a challenging situation for orchid taxonomists; it is highly desirable to develop a universally acceptable system of orchid classification. In this connection, the importance of periodic field surveys to analyze nature's changing trends, and identification of additional taxonomic parameters such as anatomical, cytological, embryological, phytochemical, phytogeographical, etc. has been stressed in orchids (Dressler, 1993).

Classification of Family Orchidaceae – A Historical background

The origin of orchids on earth dates back to about 120 million years ago. Available written records however show their origin as early as 4th millennium B.C. only. The first reference of orchids in literature was made by Theophrastus (370-285 B.C.) a Greek philosopher in his book 'Enquiry into Plants'. He used the word 'Orchis' for a group of plants and observed that the roots of these plants were used in traditional Pharmacopoeias of Greece and neighboring Asia minor as antidepressant and as a stimulant. The name 'Orchid' thus originated from the ancient Greek word (*Orchis*), literally meaning 'testicle', because of the shape of the round paired tubers. The term "Orchis" is now used to describe a European genus, and the name of the entire family - Orchidaceae - is also derived from it. Swartz (1800) was the first to bring out a critical review of orchid literature when he presented a classification and also reported the monandrous and diandrous condition in orchids. He described 25 genera and predicted that many more new genera would be created in future. Richard (1817) while working on European orchids introduced the special terminology for orchids that we use today. Brown (1810), du Petit-Thouars (1809, 1822) and Blumn

(1825) while studying tropical orchids in the field refined Swartz's classification and added many new genera. Lindley (1826) divided orchid family into 8 tribes, he later (Lindley, 1840), reduced the number of tribes under the family to 7, and created a new family Apostasiaceae. Bentham (1881) modified Lindley's classification of orchids and in 'Genera Plantarum' validated a total of 5 tribes and 27 subtribes. Pfitzer (1887) bought out a classification by including vegetative features excluding characters of pollinia and proposed 32 tribes with a number of subtribes. Schlechter (1926) divided the family into 2 subfamilies, Diandrae and Monandrae; the former including one tribe (Cypripedieae) and the latter further subdivided into 2 divisions, Bastonae (with one tribe, Ophrydioideae) and Acrotonae (with 2 tribes, Polychondreae and Kerophaereae). Dressler and Dodson (1960) reviewed the classification of Schlechter and made some changes so as to bring it in accordance with International Code of Botanical Nomenclature (ICBN). They divided the family into 2 subfamilies (Cypripediodeae and Orchidoideae); the former with 2 tribes (Apostasieae, Cypripedieae) and no subtribes, and the latter with 3 tribes (Neottieae, Orchideae, Epidendreae) and 40 subtribes. Garay (1960) suggested the division of orchid family into 5 subfamilies; Apostasioideae, Cypripedioideae, Orchidoideae, Neottioideae and Epidendroideae. Vermeulen (1966), proposed 3 families, Apostasiaceae, Cypripediaceae and Orchidaceae under the order Orchidales, and subdivided Orchidaceae into 2 subfamilies (Orchidoideae, Epidendroideae). Dressler in 1981 proposed 6 subfamilies (Apostasioideae, Cypripedioideae, Spiranthoideae, Orchidoideae, Epidendroideae and Vandoideae), 21 tribes and 63 subtribes under the family Orchidaceae. Dressler (1993) then revised this classification on the basis of morphological, palynological, anatomical and cytological data and divided the family into 5 subfamilies (Apostasioideae, Cypripedioideae, Spiranthoideae, Orchidoideae and Epidendroideae), 21 tribes and 69 subtribes. This classification is considered to be the most comprehensive presentation of the hypothesis of orchid phylogeny and systematics presented so far. Szlachetko (1995) accepted the three family scheme of Vermeulen (1966) and is considered the most recent complete classification. He divided two families, Apostasiaceae and Cypripediaceae into 2 tribes with single subtribe under each, while the third family, Orchidaceae was further divided into 8 subfamilies (Thelymitroideae, Orchidiodeae, ropidioideae, Spiranthoideae, Neottioideae, Vanilloideae, Epidendroideae, Vandoideae) including a total of 45 tribes and 134 subtribes. At present there are five broadly recognized orchids

subfamilies: *Apostasioideae* , *Cypripedioideae* (*Cypripedium,Paphiopedilum,Phragmi pedium,exipedilum* and *Selenipedium*), *Vanilloideae* (*Vanilla* orchids), *Epidendroidea e* (the majority of most popular cultivated orchids belong to this group) and *Orchidoideae* (the bulk of European wild orchids belong to this subfamily, as well as cultivated Jewel Orchids). *Vanilloideae, Epidendroideae* and *Orchidoideae* orchids are monandrous orchids (which means that they have only one stamen), and they are more evolutionary progressive than two other subfamilies. The above systems of orchid classification are similar with one another in broader outline, but differ with respect to the systematic position of several taxa mainly due to continuous morphological variability as a result of free flow of genes across groups.

Orchids –Uses and Types

Orchids have been used in different systems of local medicine since the vedic period (Kaushik, 1983; Handa, 1986). The use of orchids in treating different diseases and ailments includes acidity, stomach disorders, diarrhea, blood dysentery, boils, wounds, sores, piles, inflammations, tuberculosis, asthma, malaria, bone fractures, paralysis, chest pain, muscular pain, jaundice, cholera, eczema, menstrual disorder, leucoderma, hepatitis, rheumatism etc. Moreover they are also used as an antibacterial agent and antidotes to snake and insect bites. Some compounds and drugs, both in phytochemical and pharmacological uses have been reported from orchids - *Aerides crispum*, *Agrostophyllum brevipes*, *Agrostophyllum brevipes*, *Agrostophyllum callosum*, *Agrostophyllum callosum*, *Agrostophyllum callosum*, *Arundina graminifolia*, *Cypripedium calceolus pubescens*, *Orchis latifolia*, *Dendrobium macraei*, *Dendrobium nobile*, *Dracula chimaera*, *Eulophia nuda*, *Vanda roxburghii*, *Nidema boothi* and *Scaphyglottis*, *Anoectochilus formosanus*, *Dendrobium moscatum*, *Bulbophyllum gymopus* have been reported to contain alkaloids, triterpenoids, flavonoids and stilbenoids (Singh and Duggal, 2009). Several species including *Acampe praemorsa, Aerides odorata, Coelogyne ovalis, Cymbidium aloifolium, Cypripedium elegans, Dactylorhiza hatagirea, Dendrobium herbaceum, Eulophia dabia, E. epidendraea, Habenaria furcifera, H. intermedia, H. plantaginea, Luisia zeylanica, Malaxis acuminata, M. rheedii, Nervilia aragoana, N. plicata, Pholidota imbricata, Satyrium nepalense, Vanda tessellata* and *V. testacea* are used in curing a variety of human ailments (Vij *et al.,* 1997; Kumar *et al.*, 2000; Rao, 2004a; Reddy *et al.,* 2005). Other species of orchids such as *Dendrobium crumenatum*, *Eulophia campestris*, *Orchis latifolia, Vanda roxburghii* have been documented for their

medicinal value. Deb *et al.* (2009) have documented some of the use of orchids in indigenous system of medicine in Nagaland in which species of orchid and their uses are briefly mentioned. Extract of roots of *Acampe papillosa* is taken orally to get relief from rheumatism. *Calanthe triplicata* roots are used to cure swollen hands, diarrhea, teeth cavities whereas the flower extract is used as a painkiller. Powder from dry pseudobulbs of *Coelogyne punctulata* are applied on burn injuries to relieve pain and healing of wound. Powdery seeds of *Cymbidium aloifolium, Dendrobium chrysanthum, Dendrobium chrysotoxum, Dendrobium densiflorum* & *Dendrobium moschatum* are dried and used as haemostatic. Powdery seeds and root-powder of *Dendrobium nobile* is used to heal wounds and also cures nervous disorders. Extract of pseudobulb of *Malaxis acuminata* is used as tonic and against tuberculosis. Pseudobulbs of *Pholidota imbricata* is made into a paste and plastered on sprains, body pain and rheumatism, the plant decoction is also used to cure skin rash. *Rhynchostylis retusa* leaf juice is used externally on skin as emollient. Decoction of fresh flowers of *Vanda coerulea* is used as an appetizer and a tonic. Paste of roots and leaves of *Vanda tessellata* is applied on sprains, used as antidote for spider and snake bite, the roots are also antibacterial, leaf paste are applied externally on body to reduce high fever, root decoction is used to cure cholera, plant ash with mustard oil is also used in bone fracture. Powder of dry leaves and flowers of *Vanda testaceae* is used in rheumatism. The use of orchids in traditional medicine for the treatment of different disease is not exhaustive and there are even more species with a diversity of medicinal properties documented by different authors. On the other hand the essence 'vanillin' obtained from unripe pods of *Vanilla planifolia* is one of the many examples of sustainable commercialized produce of orchids in confectionary industry.

Orchids also find their use as an important ornamental crop in floriculture industry due to their beautiful foliage (Jewel orchids - *Anoestochilus, Ludisia, Goodyera, Macodes, Sarcoglottis, Malaxis* and many more), vibrant and perfumed flowers, cut flowers (wild and hybrid) that have a long vase life. Moreover their ease of hybridization both within-genera and across genera as compared to other flowering plants has been successfully exploited to raise novel and striking hybrids (Vij, 2002; Deb, 2010). Species of orchids particularly in the genera *Aerides, Arachnis, Ascocentrum, Cymbidium, Dendrobium, Esmeralda, Paphiopedilum, Papilionanthe, Pleione* and *Vanda* have also been used to progenate internationally acclaimed and floriculturally significant hybrids (Bose *et al.,* 1999). Orchids are highly valued both

in the national as well as in the international markets. India was lacking behind and had not been able to make inroads into this multibillion dollar business despite rich natural wealth of orchid diversity (Kumar and Manilal, 1994) unlike its other Asian counterpart especially those of South-east Asia and floriculture industry was only in the hands of a few commercial orchid growers including hobbyist and nurserymen, but now as the Government of India has identified floriculture as a sunrise industry and accorded it 100% export oriented status. The country has exported 22,518.58 MT of floriculture products to the world worth Rs. 479.42 crores in 2015-16 alone (APEDA, 2017) and orchids occupy a significant position in the industry. The major import destinations of Indian floriculture during the same period were the United States, Germany, United Kingdom, Netherlands and United Arab Emirates. Floriculture has thus become one of the important Commercial trades in agriculture and commercial floriculture has emerged as hi-tech activity. Indian floriculture industry has thus been shifted from traditional flowers to cut flowers for export purposes. Moreover the liberalized economy has given a boost to the Indian entrepreneurs for establishing export oriented floriculture units. Maharashtra, Karnataka, Andhra Pradesh, Haryana, Tamil Nadu, Rajasthan, West Bengal have thus emerged as major floriculture centers. North-East in general and Nagaland in particular thus have ample scope owing to its varied climatic conditions and biodiversity richness. Orchid for export mainly consist of cut flowers, pot plants, cut foliage, seeds bulbs and tubers. With emerging technology and rich resource in terms of orchid wealth, this region could boost the country's economy to a larger extent. Meticulous planning and identifying of certain parameters/characters of orchid i.e. attractiveness of flower, spike length and the numbers of flowers/spike, blooming duration/shelf life, scope of improvement through selective/desired breeding (for those species whose flower are attractive but has short blooming duration) are to be adopted though to identify floricultural significant orchid species.

Further classification of orchids is done based on habit and habitat. Terrestrial orchids are the ones which grow in soil and have the same growing conditions and same ecological adaptations as most of other plants (*Bletilla, Calante, Phaius,* some *Paphiopedilums* and *Jewell Orchids*) are terrestrials. Epiphytic orchids grow on other plants and they have thick velamen layer on their roots; some have succulent features such as thick leaves covered with waxy cuticle, and pseudobulbs (*Bulbophyllum, Cattleya, Dendrobiums, Oncidium ,Phalaenopsis, Vandas).*

Litophytes are the orchids which grow on rocks, and they also have thick velamen layer (*Phaius*, *Paphiopedilums*), The velamen layer absorbs water from humid air and provide orchid with water. Aqueous orchids (*Spiranthe*). Based on habit orchids may be monopodial and sympodial. Monopodial orchids have active apical meristem, and they grow upwards from that apical meristem season after season, they activate lateral meristem and produce lateral buds only for generative organs (inflorescences) or if the apical meristem is dead (*Aerides, Phalaenopsis, Rhynchostylis, Vanda*, *Vanilla)* . Sympodial orchids on the other hand terminates the apical meristem when a stem grows to its final size and then activate a lateral meristem after this to produce a new growth, they may or may not have pseudobulbs. Sympodial orchids with pseudobulbs are *Cattleya, Oncidium, Cymbidium*. Sympodial orchids without pseudobulbs are Lady Slipper orchids and *Pleurothallids* (*Masdevallia* and Dracula orchids). Orchids sizes also range from miniature orchids (Some *Bulbophyllum- Bulbophyllum globuliforme, Sophronitis*) to medium, large and giant sized (*Grammatophyllum - Grammatophyllum speciosum, Cymbidium* and *Vanilla orchids.* Many orchid flowers are also of different shapes such as slipper (*Paphiopedilum, Cypripedium*), dancing girl (*Oncidium, Renanthera*), moth (*Phalaenopsis*), spider (*Brassia*), scorpion (*Arachnis*), bee (*Ophrys*), pineapple (*Dendrobium densiflorum*).

Orchid study in India with special reference to North-East India

India with its varied climatic conditions and diverse ecological habitats, ranging from tropical to temperate to arctic, has a very rich resource of wild orchids. The number of species of orchids in India has been estimated between 127-184 genera and 810-1229 species by various workers (Pradhan, 1979; Bose and Bhattacherjee, 1980; Karthikeyan *et al.,* 1989; Kumar and Manilal, 1994; Karthikeyan, 2000). Orchidaceae ranks as the second largest flowering plants family in the country and latest estimates suggests about 1378 species in India (Verma and Lavania, 2014) confining to North-Eastern region and Western Ghats with about 890 species in North-East India (Rao, 2007).

The use of orchids in India is recorded in 'Charaka Samhita'- a classic ancient Indian medicinal treatise written in Sanskrit (around 100 A.D.), describing the medicinal importance of 'Vanada' - a vandoid taxon. Orchids have been used by Indians for different curative and aphrodisiac properties. When Van Rheede's 12-volume 'Hortus Malabaricus' was published during 1678-1693 describing over 700 species of flowering plants from Malabar, it included descriptions and notes on

medicinal properties of 17 Indian orchids from peninsular region and thus laid the foundation for the first scientific study of Indian orchids. Taxonomic works on Indian orchids were later on carried out by Roxburgh (1832), He recorded 57 species of orchids in 8 genera in "Flora Indica" and proposed many new taxa which were later on transferred to other genera. His collections were mainly from Sylhet district of Assam. Lindley (1830-1840) made use of the collections by J. D. Hooker and G.M. Thomson and later on published "Genera and species of Orchidaceae plants". Lindley (1857a, 1857b) first described 71 species in 21 genera. He later on went to document 331 species belonging to 54 genera studying the genera *Dendrobium, Crytochilus, Acanthephippium and Anthogonium* in detail. Wight (1832) collected and studied the flora of Madras Presidency & he along with G. A.Walker - Arott published their work. In time, Wight (1845-1853) published an illustrated account of Indian plants which contain invaluable information, including a review on the similarities of orchid genera of India & its neighboring countries. Griffith (1851) studied the family orchidaceae intensively and gave a detailed account on their general morphology, methods of pollination, linkage and relation between taxon. The descriptions of floral characters and illustrations of a good number of species are very detailed. He described 147 species of orchids belonging to 49 genera, the treatment of all *Vanilla* spp. in a separate family Vanillaceae was invalidated though. Most of the species were recorded from the Khasi hills and its surrounding area. Some of his described species now belong to the adjacent Asian countries. Drury (1869) listed 275 species of orchids in 74 genera. He recorded a species *Cypripedium druryi* Bedd. now renamed *Paphiopedilum druryi* (Bedd.) Stein. from Augusteer Hill (1500-1800 m) in Travancore Hills. Later, Beddome (1874) provided a very accurate description of this taxon. This endemic species was found in abundance by Beddome on the top of Calicut Hills. In the monumental work of Sir J. D. Hooker (1888-1890) wherein he compiled "Flora of British India" in Kew, London, his account of the family Orchidaceae in Vol.5 & 6 included descriptions of some 1250 species belonging to 117 genera from erstwhile British India. He had extensively collected from Meghalaya, Sikkim, Nepal and Bengal and had thorough knowledge on Indian orchids. Later, Hooker (1895) published an illustrated account on Indian orchids containing descriptions and illustrations of 100 species in "A century of Indian Orchids" in the annals of the Royal Botanical Garden, Calcutta. After Hooker, King and Pantling (1898) published "Orchids of Sikkim Himalayas" describing 448 species

in 91 genera which is considered as the most extensive work on Orchidaceae from the North-eastern region. Duthie (1903a, 1903b) studied on the orchids of NW Himalaya. Regional floras of Shimla (Collett, 1902), Bengal (Prain, 1903), Presidency of Bombay (Cooke, 1901-1908), Nilgiri and Pulney Hilltops (Fyson, 1914), Travancore (Rama Rao, 1914), Presidency of Madras (Fischer, 1928), Kerala (Kumar and Sasidharan, 1986; Kumar and Manilal, 2004), Lahore district (Kashyap, 1936), Bombay (Santapau and Kapadia, 1966), Punjab Plains (Nair, 1978), Kashmir Himalaya (Dhar and Kachroo, 1983), Himachal Pradesh (Chowdhery and Wadhwa, 1984), Haryana (Jain *et al.,* 2000; Kumar, 2001), and Cold Deserts of Western Himalaya (Murti, 2001) all contributed significantly towards the knowledge of orchids in India. Abraham and Vatsala (1981) published an illustrated description of 150 South Indian orchids. Jain and Mehrotra (1984) presented an inventory of Indian orchids, listing about 925 species under 144 genera.. Kumar and Manilal (1994) recorded 1141 species in 166 genera. Sarkar (1995) presented an up-to date census of Indian orchids listing approximately 1100 species in 153 genera. Check-list of orchids of different regions were later brought out as in North West Himalaya (Seidenfaden and Arora, 1982; Deva and Naithani, 1986), Bay Islands (Shiva *et al.,* 2002), Great Nicobar Biosphere Reserve (Gupta *et al.,* 2004), Karnataka (Swamy *et al.,* 2004), and Orissa (Misra, 2004), highlighting the orchid resources of different regions in India. Singh (2001) presented an overview of orchid diversity (1229 species under 184 genera) in India, highlighting its phytogeographical affinities, endemism, economic importance, and conservation status. De and Hajra (2001), and Phukan (2002) presented taxonomic updates of 2 Indian genera, *Tropidia* and *Kingdium* respectively. De and Hajra (2004) presented a taxonomic study of genus *Vanda* describing 16 Indian species. Chowdhery (2004, 2015) and Pradhan (2004) provided detailed notes on Indian Lady's slippers and saprophytic species respectively. Ormerod (2004) commented upon the status of some obscure Indian orchid taxa and proposed a new combination, *Thrixspermum crassilabre* (King and Pantling) Ormerod.

North-East India is known for its megabiodiversity and contains more than one-third of the country's total biodiversity in terms of both flora and fauna. On the other hand it is considered the most important floristic region owing to its rich biodiversity. As of now, the region is among the 18 hottest hotspots of the world, having at least 7, 500 flowering plants out of which approximately 750- 800 are orchids, 58 bamboos, 64 citrus, 28 conifers, 500 mosses, 700 ferns and 728 lichen

species. The region is a meeting point of temperate east Himalayan flora, paleo-arctic flora of Tibetan highland and wet evergreen flora of South East Asia and Yunnan, forming a basin of biodiversity. The region host a number of interesting botanical findings like *Sapria himalayana, Nepenthes khasiana* and saprophytic orchids like species of *Epipogium, Eulophia* and *Galeola* and other primitive angiospermic plants like *Exbucklandia, Manglietia, Holboellia* etc. Reports of the rich presence of ancient plants like *Magnolia, Michelia, Camellia, Rhododendron,* orchids etc. in the region indicates that evolutionary development in wild and cultivated plants are continuously taking place (Chowdhery, 2001). The wide altitudinal variation and topographical features supported by favorable climatic conditions, makes the region rich in floristic biodiversity. Moreover, it is a region having a number of 'sacred groves or forest'. Takhtajan (1969) named the region *"The cradle of flowering plants"* with orchids forming a prominent feature of the vegetation. Estimated reports show that out of 1229 species of orchids known from India, about 750 to 800 species are found in North-East region of the country (Verma and Lavania 2014, Chowdhery, 2009; Deb *et al.,* 2003; Deb and Imchen, 2008; Hynniewta *et al.,* 2000; Kataki, 1986; King and Pantling, 1898; Kumar and Manilal, 1994; Pradhan, 1979). The region has the highest number of monotypic orchid genera.

Arunachal Pradesh is the richest in terms of orchid diversity among North-Eastern states of India. some of the notable works from this region are Hegde (1984) published "Orchids of Arunachal Pradesh" where he recorded 368 species of orchids describing their morphology, distribution, cultivation, Classification and breeding, along with 34 black and white and 84 colour photographs. Chowdhery and Pal (1997) published a checklist of Orchidaceae from Arunachal Pradesh, subsequently Chowdhery (1998) published a book on the "Orchid Flora of Arunachal Pradesh" and recorded 545 species belonging to 123 genera of Orchids. Key to genera and species along with the history of the genus, derivation of its name, distribution, flowering and fruiting times are described. New species of orchids has been reported from the state from time to time some of which includes *Eria connata* Joseph, Hegde *et* Abbareddy (Joseph *et al.,* 1982), *Epipogium sessanum* Hegde *et* Rao (Hegde and Rao, 1982a), *Herminium longilobatum* Hegde *et* Rao (Hegde and Rao, 1982b), *Clesisostoma tricallosum* Hegde *et* Rao (Hegde and Rao, 1983), *Biermannia jainiana* Hegde *et* Nageswara Rao (Hegde and Rao, 1984), *Gastrodia arunachalensis* Hegde *et* Rao (Hegde and Rao, 1985), Two new species of *Cheirostylis* viz. *Cheirostylis sessanica*

Nageswara Rao. and *Cheirostylis munnacampensis* Nageswara Rao (Rao, 1988), *Eria lohitensis* Nageswara Rao, Haridasan *et* Hegde (Rao *et al.*, 1989), *Eria jengingensis* Hegde (Hegde, 1993), *Oberonia katakiana* Nageswara Rao (Rao, 1996), *Cheirostylis gunnarii* Nageswara Rao (Rao, 1998a), *India arunachalensis* (Rao, 1998b), *Rhomboda arunachalensis* Nageswara Rao (Rao, 1998c), *Eria kamlangensis* Nageswara Rao (Rao, 2002), *Porpax seidenfadenii* Nageswara Rao (Rao, 2004b), *Biermannia arunachalensis* Nageswara Rao (Rao, 2006), *Dendrobium arunachalanse* sp. nov (Deori *et al.*, 2006a), *Epigenium arunachalense* Nageswara Rao (Rao, 2009). The latest update on the orchid flora of Arunachal Pradesh (Rao, 2010) have recorded 558 species belonging to 144 genera, 377 epiphytic or lithophytic, 160 terrestrial and 21 are mycotrophs. Among epiphytes *Dendrobium* with 47 species and 1 variety along with *Bulbophyllum* with 47 species and 2 varieties are the most common genus followed by *Oberonia* 22 species, *Coelogyne* 20 species, *Liparis* 16 species and 1 variety. Among terrestrials, *Calanthe* with 16 species, *Goodyera* 12 species, *Zeuxine* 8 species, *Herminium* 7 species, *Cheirostylis* 7 species and 1 variety. Among mycotrophs *Epipogium* with 5 species, *Galeola* 3 species, *Gastrodia* 2 species.

Baruah (1978) started a systematic taxonomical study of orchids of Brahmaputra Valley of Assam and recorded about 114 species and 4 varieties under 50 genera. Prof. S. Chowdhury has carried out extensive and intensive research on orchids of Assam in particular. He has published a number of paper's in National and international journals during the year i.e. 1971, 1976, 1982, 1987 1988, 1990, 1991, 1993a, 1993b, 1996, 2002. Some of the new species of orchids described by him are *Dendrobium assamicum* Chowdhury, *Eulophia kamarupa* Chowdhury, *Zeuxine debrajiana* Chowdhury. He has also published a book entitled "Assam's Flora" (2005) including detailed information regarding the orchids of Assam & their present status. Barua (2001) published the first ever district flora of Kamrup district of Assam & recorded 62 species and 3 varieties under 31 genera. He gave a new report on *Bulbophyllum forrestii* Siedenf. of India (Barua and Barua, 1991). Basumatary (2004) recorded 46 species of orchids under 26 genera from Chirang Reserve Forest under Haltuagaon Forest Division of Kokrajhar District. Sarma *et al.* (2006) reported 287 species belonging to 88 genera from Assam. Dey *et al.* (2007) reported a list of 21 orchid species from Manas National Park including out of which 16 were epiphytes and 5 terrestrial. Gogoi *et al.* (2015) has brought out an annotated checklist of orchids of Assam wherein 398 specific and 6 intraspecific taxa belonging to 102 genera of

orchids is recorded out of which 129 species under 49 genera are terrestrial and 275 specific and intraspecific under 53 genera are epiphytic or lithophytic. *Dendrobium* representing the largest genus with 58 taxa and 51 are monotypic genera. Some of the new records of orchid species for the state are *Thrixspermum acuminatissimum* (Blume) Reichenbach f. (Gogoi, 2011); *Crepidium calophyllum* (Rchb.f.) Szlach., *Eulophia zollingeri* (H.G.Reichb.) J.J. Smith., *Habenaria acuifera* Wallich ex lindl., *Liparis* nervosa (Thunberg) Lindl., *Liparis wightiana* Thw., *Tainia angustifolia* (Lindl.) Benth & Hook.f., (Gogoi, 2012a), *Cymbidium cyperifolium* Wall. ex Lindl. (Gogoi *et al.*, 2013), *Pennilabium struthio* Carr. (Gogoi and Yonzone, 2014a), *Taeniophyllum retrospiculatum* King & Pantling (Gogoi and Yonzone, 2014b); *Bulbophyllum ambrosia* (Hance) Schlechter, *Bulbophyllum gracilipes* King and Pantling (Das *et al.*, 2013). New record of orchid species for India from the state includes *Phalaenopsis malipoensis* Z.J. Liu & S.C. Chen (Gogoi *et al.*, 2012), *Tainia angustifola* (Lindl.) Benth. & Hook. F. (Gogoi, 2012b), *Thrixspermum formasanum* (Hayata) Schltr. (Gogoi and Yonzone, 2015). A new variety *Eria ferruginea* Lindl var. *assamica* (Gogoi and Yonzone, 2014c) is also described.

The state of Manipur was explored by many pioneer European collectors including George Watt (1888) who collected plant species including orchids and most of them are now available at CAL and Kew. J. D. Hooker gave the nomenclature of both *Dendrobium wattii* and *Impatiens wattii*, after studying his collections from Manipur. Charles Baron Clarke, a British botanist explored Manipur in 1885 and made important collections. In 1889, he published a list of 'plants from Kohima and Munneypore' which included *Aerides vandarum* Rchb.f., *Agrostophyllum khasianum* Griff., *Goodyera procera* Lindl., *Liparis longipes* Lindl., *Liparis spathulata* Lindl., *Pholidota calceolata* Lindl., *Saccolabium ampullaceum* Lindl. and *Zeuxine nervosa* Benth. ex Hook. f. from Manipur. Clarke's specimens are at Kew. Alfred Karl Meebold also studied plants of Manipur during 1906-1907. His collections are available at CAL. Norman Loftus Bor was another botanist who visited Manipur several times between 1938 and 1945. His orchid collections were studied by others like Summerhayes *et al.* Francis (Frank) Kingdon-Ward was a British traveller who visited Manipur in 1927, 1946 and 1948 and made a very large collection of orchids, some of his collections are available at CAL. *'Plant Hunter in Manipur*' (1952) is one of his famous works. Summerhayes named *Paphiopedilum wardii* after him. Mukherjee (1953) who explored Manipur along with Kingdon-Ward brought out an

enumeration of orchids of Ukhrul district of Manipur. Deb (1961) made large collections during his stay at Manipur as a teacher. Ghatak and Devi (1986) wrote a book on the "Orchids of Manipur" and reported 250 species of orchids. Mao (1999) reported 64 species of orchids belonging to 27 genera from Senapati district. Chauhan (2001) reported 249 species from 60 genera from Manipur. Updates by Kumar and Kumar (2005) records 280 species in 86 genera. It includes a new genus *Luisiopsis* Sathish & Suresh, one new species of orchid *Bulbophyllum manipurense* Sathish & Suresh, two new records for India – *Bulbophyllum propinquum* Krzl. and *Phalaenopsis fasciata* Rchb.f., one new combination *Luisiopsis inconspicua* (Lindl.) Sathish & Suresh and several new state records. Since then new records and species have been added to the orchid flora of Manipur some of which includes *Ione kipgenii* Kishor, Chowlu and Vij (Kishor *et al.,* 2012), *Dendrobium tamenglongense* R. Kishor, Y. N. Devi, H. B. Sharma, J. Tongbram & S. P. Vij (Kishor *et al.,* 2013), *Oberonia acaulis* Griff. var. *latipetala* (Chowlu *et al.,* 2014), *Oberonia manipurensis* Chowlu, Nanda, A. N. Rao, Angela, Bishwajit & Akimpou (Chowlu *et al.,* 2015)., *Sarcoglyphis manipurensis* A. N. Rao, Vik. Kumar & H. B. Sharma (Kumar *et al.,* 2016)

The state of Meghalaya was explored by Hooker, Thomson and many British naturalists in the 19th century, when it was part of upper Assam. Some of the notable works though includes that of Kataki (1986) who wrote a book entitled "Orchids of Meghalaya". In the book he has recorded 280 species of orchids with their distribution, color photographs with line drawings and Key to the genus & species. The establishment of Eastern Circle of Botanical Survey of India at Shillong enhanced exploration activities in the state as well as neighboring states. Rao (1971) studied the orchids of Khasia and Jaintia Hills, *Trias pusilla*- A new species of orchid from Khasi & Jaintia Hills, Meghalaya. Balakrishnan (1983) published the "Flora of Jowai" wherein 145 species of orchids in 50 genera were described while Deori *et al.* (2006b) has recorded *Dendrobium aurantiacum* Reichb. f from Jowai (Jaintia hills) . Some of the new species reported from the state are *Evardia asraoa* Joseph *et* Abbareddy (Joseph and Abbareddy, 1983), *Bulbophyllum cherrapunjeensis* Barbhuiya & D. Verma (Verma *et al.,* 2014), *Bulbophyllum manabendrae* D.K.Roy, Barbhuiya & A.D.Talukdar (Roy *et al.,* 2014), *Pennilabium labanyaeanum* C.Deori, N.Odyuo & A.A.Mao (Deori *et al.,* 2015).

Chawngthanlluanga (1996) reported 253 species in the book entitled "Orchids of Mizoram, Vol -1". Singh *et al*. (1990) provided a conspectus of orchids of Mizoram. From Murlen national park of Mizoram a total of 32 species of orchids were collected and four species were recorded as new to the orchid flora of the state namely *Bulbophyllum thomsonii* Hook.f., *Epigeneium naviculare* (M.S. Balakr. & S. Chowdhury) Hynn. & Wadhwa, *Oberonia caulescens* Lindl. and *Oberonia mucronata* (D. Don) Ormerod & Seidenf.(Kumar and Singh, 2012). Again Kumar *et al*. (2013) have added fourteen new records from Murlen national park of Mizoram for the state namely *Bulbophyllum crassipes* Hook.f., *Crepidium purpureum* (Lindl.) Szlach., *Dendrobium thyrsiflorum* Rchb.f ex André, *Dendrobium stuposum* Lindl., *Dendrobium wardianum* Warner, *Dendrobium williamsonii* Day & Rchb.f., *Gastrochilus obliquus* (Lindl.) Kuntze, *Habenaria reniformis* (D. Don) Hook.f., *Phreatia elegans* Lidl., *Smitinandia micrantha* (Lindl.) Holtt., *Streochillus hirtus* Lindl., *Sunipia andersonii* (King & Pantl.) P.F. Hunt, *Tainia viridifusca* (Hook.) Benth. Ex Hook.f. and *Vanda pumila* Hook.f. Scientists of Botanical Survey of India, Eastern Circle along with some other orchid enthusiasts have added some new distributional records for the state viz., Panday *et al*. (2014) added three more distributional record for the state *Dendrobium darjeelingensis* Pradhan, *Eria vittata* Lindl., *Trichotosia dasyphylla* (E.C. Parish & Rchb. f.) Kraenzl. Moreover a new record for the flora of north-east India *Nervilia punctata* (Blume) Makino is documented by Sharma *et al*. (2013).

Joseph Dalton Hooker visited Sikkim during 1848 -1849 and collected a large number of plants including orchids from the state which were later studied and presented for his "Flora of British India". Some of his notable orchid collections from Sikkim are *Bulbophyllum kingie* J. D. Hook., *Bulbophyllum thomsonii* J. D. Hook., *Coelogyne treutleri* J. D. Hook. (later renamed *Epigeneium treutleri* (J.D.Hook.) Ormerod), *Habenaria pachycaulon* J. D. Hook., *Liparis gamblei* J.D.Hook., *Zeuxine longifolia* (Benth.) J. D. Hook. George King and Robert Pantling's (1898) book "Orchids of Sikkim Himalaya" records descriptions and illustrations of 448 species in 91 genera and is still considered one of the best available publications till today. They included many new genera such as *Didiciea, Biermannia, Risleya* and also documents several new species. Paulus Johannes Bruhl in 1926 published a book "Guide to the Orchids of Sikkim Himalayan" wherein 461 species belonging to 92 genera were described and a new genus *Cleisocentron* was proposed. Later on more works were

then carried out by J.C. White, W.W. Smith, G.H. Cave, K. Biswas and many others. Rao (1963) have described some species after a tour to the state, Mehra and Vij (1974) on the other hand published an account of ecological adaptations and distribution pattern of Darjeeling and Sikkim Himalayan orchids. Kataki *et al.* (1984) published a book "Threatened & Endemic Orchids of Sikkim and North East India". Book on the "Cultivation of Medicinal plants and Orchids in Sikkim Himalaya" was completed by Sundriyal and Sharma (1995). Panda and Mandal (2013) published the folklore medicinal orchids of Sikkim wherein 36 species have been documented as to having medicinal properties. Lucksom (2011) has written on "The orchid diversity in Sikkim and effect of change of environment on the distribution of native orchids in Sikkim Himalaya, India" recording 557 species (inclusive of sub-species) 523 from Sikkim mentioning 20 monotypic genera and 22 endemic orchids of Sikkim. He has also described 14 new species viz., *Liparis lydiaii* S.Z.Lucksom, *Cleisostoma sikkimensis* S.Z.Lucksom, *Calanthe keshabii* S.Z.Lucksom, *Bulbophyllum pantlingii* S.Z. Lucksom, *Calanthe anjanii* S.Z. Lucksom, *Goodyera dongchenii* S.Z.Lucksom, *Liparis sikkimensis* S.Z.Lucksom, *Cheirostylis pabongnensis* S.Z.Lucksom, *Calanthe yuksomnensis* S.Z.Lucksom, *Liparis dongchenii* S.Z.Lucksom, *Oberonia kingii*. S.Z. Lucksom, *Gastrochilus sonamii* S.Z. Lucksom, *Liparis chungthangnensis* S.Z. Lucksom, *Coelogyne pantlingii* S.Z. Lucksom; 5 rediscovery viz., *Cymbidium whiteae* King & Pantl., *Calanthe whiteana* King & Pantl., *Oberonia obcordata* Lindl., *Cypripedium himalaicum* Rolfe., *Cypripedium elegans* Rchb., 3 new records viz., *Ceologyne barbata* Griff., *Eria pusilla* (Griff), *Zeuxine seidenfadenii* S.Deva and Naithani and 2 new varieties viz., *Cremastra appendiculata* var. *sonamii* S.Z. Lucksom., *Dendrobium eriiflorum* var. sikkimensis. ICAR National Research Centre for Orchids (NRC) located at Pakyong, East Sikkim was established in October 1996 based on recommendations of the Planning Commission keeping in view the export potential of orchids. The centre has since then created infrastructures and facilities for basic and strategic research for orchids and has also deposited about 450 species belonging to 98 genera collected from the North Eastern Region. Hybrids of *Cymbidium*, *Aranda* and *Vanda* have been procured and maintained. In October, 1997, the centre also took over the Darjeeling centre of CPRI, Shimla. The centre has also published a vision document "vision 2050" in 2015.

Deb (1983) reported 33 species of orchids belonging to 22 genera while bringing out the flora of Tripura state. The state of Tripura has the lowest number of

orchids in Northeast India with about 48 species under 33 genera (Tandon and Kumaria, 2010). *Arundina graminifolia* (D. Don) Hochr has been recently reported as a new addition to the flora of Tripura (Debnath *et al.*, 2016).

In Nagaland, floristic studies were carried out as stray collections from workers such as Henry Collet, the Commander Brigade in Burmese war (1826) when he visited Khasi and Naga hills. Since 1837, William Griffith of the East India Company made extensive collections from extremely rough terrained regions in Assam valley, Mishmi hills (now in Arunachal Pradesh), Khasi & Naga hills. From 1885, George Watt made widespread collection of economic plants all over India when he was appointed Reporter of the Economic Products of East India Company and he included orchid species from Nagaland in 1895. When George King was the Superintendent of Royal Botanic Garden (1871 – 1897) Calcutta, David Prain the Curator, Studied plants from different parts of India including Nagaland. N. L. Bor, Frank Kingdon Ward, U.N. Kanjilal, S. R. Srinivasan, C. A. Atonor, G. K. Deka and a number of other workers visited different parts of Nagaland from 1921 to 1946 and their collections of dicots and grasses were incorporated in the book 'Flora of Assam' published in 5 volumes by Kanjilal *et al.* (1934-40), but the work does not include any report on orchids. The first account on the 'Orchidaceae of Nagaland' was through Clarke's (1889) collection wherein he reported 22 species of orchids under 18 genera. Later Hooker (1890) recorded 49 species of orchids under 24 genera including 1 variety from Nagaland, after studying the collections of Collet, Griffith, Clarke and also the earlier collections of Watt and Prain, describing 507 species belonging to 85 genera of orchids from eastern India and 1235 species belonging to 117 genera in the 'Flora of British India' Vols. 5 & 6 (1890). King and Pantling (1898) reported 34 species under 18 genera, Burkill (1924) reported 10 species under 8 genera, Mitra (1958) reported 53 species under 26 genera and 1 variety all of which were based on the collections of C. B. Clarke's, D. Prain's, G. Watt's, H. Collett's, W. Griffith's. Bor (1942) reported 8 species under 5 genera based solely on his own collection. Das and Jain (1978a, 1978b) reported 3 species under 1 genus based on Hynniewta and others' collections from Nagaland. Dr. S. K. Kataki, Dr. C. L. Malhotra and Shri. C. Bahadur of the Botanical Survey of India, Shillong have also made large collections and contributed to our knowledge on the 'Orchidaceae of Nagaland'. Recent work on the orchidaceae of Nagaland includes those of Hynniewta (1984) recording 238 species and 4 varieties of orchids belong to 59 genera from Nagaland. Chankija *et al.*

(1992) recording 360 species under 85 genera, Deorani and Naithani (1995) recording 238 species, Hynniewta *et al* (2000) recording 241 species of 63 genera including one endemic species i.e. *Coelogyne hitendrae* Das & Jain, Deb and Imchen (2008) recording 396 species of 92 genera. Hynniewta's notable work on the orchidaceae of Nagaland includes the rediscovery of *cymbidium tigrinum* Par. Ex Hook. (Hynniewta, 1979) in April 1976 after more than a lapse of 80 years from Tseminyu, he later on went to publish the same in 1979. (Note: The author has also seen the species flowering in the wild but from a different locality in Nagaland). *Sunipia jainii* Hynniewta *et* Malhotra (Hynniewta and Malhotra, 1978) is a new species described by him, moreover many new orchid records for India, Northeast India and several other endemic species has been recorded by him. Phukan and Odyuo (2006) reported *Cleisostoma duplicilobum* (J. J. Sm.) Garay as new addition to orchid flora for Nagaland. Deb *et al*. (2007) has reported *Epipogium indicum* Chowdhery - a new addition to orchid flora of Nagaland."

Latest new species of orchid discovered from the state is *Dendrobium tuensangense* N. Odyuo & C. Deori (Odyuo *et al*., 2017) from Tuensang district of Nagaland. And. The latest findings from the state include 1 species new for north east India, 3 species as new records for the country and several other new records for the state viz., *Arachnis labrosa* var. zhaoi (Z. J. Liu, S. C. Chen & S. P. Lei) S.C. Chen & J.J. Wood – A new record for India (Jakha *et al.*, 2015b), *Coelogyne calcicola* Kerr (Odyuo *et al*., 2016a), *Panisea panchassensis* Subedi (Odyuo *et al.*, 2016b), *Dendrobium regium* Prain – A new record for Northeast India (Deb *et al*., 2015), *Polystachya concreta* (Jacquin) Garay & H.R. Sweet – A new generic record (Deb *et al.*, 2016), *Esmeralda clarkei* Reichenbach f. (Deb *et al*, 2014), *Dendrobium tamenglongense* R. Kishor, Y.N. Devi, H.B. Sharma, J. Tongbram & S.P. Vij (Jakha *et al.*, 2014a), *Arachnis senapatiana* (Phukan & A.A. Mao) Kocyan & Schuiteman (Jakha *et al*., 2014b), *Pendulorchis himalaica* Z.J. Liu, Ke Wei Liu & G.Q. Zhang – A new generic record (Jakha *et al.*, 2015a), *Goodyera fumata* Thwaites; *Phalaenopsis manii* Rchb. f.; *Vanilla parishii* Rchb. f., (Jamir *et al.*, 2015), *Phalaenopsis braceana* (Hooker f.) Christenson (Imchen *et al*., 2015), *Crepidium calophyllum* (Rchb.f.) Szlach.; *Eriodes barbata* (Lindl.) Rolfe and *Erythrodes blumei* (Lindl.) Schltr. (Jakha and Dey, 2017) *Cymbidium bicolor* Lindl. (Deb *et al*., 2017)

Destruction of habitat has driven many rare species of orchids to extinction moreover, a large number of orchid species are also threatened of existence and some

have even reached the point of extremities. Some species such as *Anoectochilus rotundifolius, Aphyllorchis gollanii, Coelogyne treutleri, Paphiopedilum charlesworthii, Paphiopedilum wardii, Pleione lagenaria, Vanda wightii* and *Zeuxine pulchra* have not been recollected during the last several decades (Singh, 2001), on the other hand orchid species such as *Bulbophyllum rothschildianum, Paphiopedilum fairrieanum, Paphiopedilum druryi* (Kumar, 1992), *Dendrobium aurantiacum* (Deori *et al.,* 2006b), *Dendrobium pychnostachyum* (Deori and Phukan, 2004), *Vanda wightii* (Sathish Kumar *et al.,* 2006) has been rediscovered from the country. Hariharan and Balaji (2002), has mentioned that the taxonomic research in India is declining despite the megadiversity status of the country, hence much more additional surveys for proper documentation of diversity, their ecological aspects, and distribution pattern of orchids is the need of the hour. Reprioritizing research in the field of taxonomy and conservation would thus provide a platform for better scope in biosystematics in India and subsequently sustainable utilization of rich bioresources. Since taxonomists employ data from varied fields such as cytology, anatomy, phytochemistry, etc. for identification and classification, particularly, when gross morphological characters prove inadequate, their scopes remain limitless.

Micropropagation, Mass Multiplication and Conservation of Rare and Threatened Orchids

Orchid seeds are microscopic and non-endospermous with undifferentiated embryos. Due to this they require a special fungal association (mycorrhiza) to germinate, and their germination in nature thus depends upon a suitable association with a mycorrhizal fungus to provide an essential physico-chemical stimulus for initiating germination (Harley, 1959). Hence, seed germination in nature is very poor ~0.2-0.3% (Sungkumlong and Deb, 2008) because of their poorly organized as well as the lack of an appropriate metabolic machinery to utilize their own lipidaceous food reserves. Moreover, the rate of vegetative propagation (i.e. keikis, back-bulbs, division of shoots etc.) is very slow in many orchid species. When Knudson (1922) for the first time demonstrated the possibility of bypassing the fungal requirements during germination of *Cattleya* seeds *in vitro* with the supply of appropriate organic carbon in the medium, and subsequently Tsuchiya (1954) discussed the possibility of germinating orchid seeds from immature pods, these two techniques led to the development of 'green pod culture' that enabled to rescue hybrid embryos from desired mating (Sagawa, 1963). The asymbiotic germination potential of fertilized

ovules (seeds) has since then been positively tested in several commercially viable and or threatened Indian taxa (Vij, 2002) and has been accepted as an important tool for propagating orchids. But, not all the orchid species respond well to the same nutrient composition and response of orchid seeds to physio-chemical factors differs from species to species. Later, *In vitro* cloning of *Phalaenopsis* using uni-nodal floral stock cuttings was first developed by Rotor (1949) and Thomale (1957) successfully cultured the shoot tips of *Orchis maculata*, moreover the possibility of using aerial roots for micropropagation was first suggested by Beechey (1970). Whereas, Morel (1960) is credited for mass propagation of virus free *Cymbidium* clones from apical shoot meristem on Knudson 'C' medium. Plant tissue culture techniques have since opened new possibilities in conservation and many orchid species have thus been propagated successfully through this techniques, particularly the threatened orchid species and re-introduced into the wild. However, seeds from different orchid species respond variably on the same nutrient composition and the physio-chemical factors differ from species to species. Devising protocols for asymbiotic seed germination and rapid cloning of native species and their elite hybrids is thus necessitated to aid in conservation and subsequent sustainable utilization.

Regeneration of plants in cultures using different sources of explant viz., shoots, roots, seeds, axillary buds, pseudobulbs, leaf from different orchid species has thus been reported by various workers such as for *Aerides multiflora* Roxb (seeds- Katiyar *et al.*, 1987; foliar segment - Vij and Pathak, 1990; aerial roots - Vij, 1993); *Arachnis labrosa* (seeds- Temjensangba and Deb, 2005a; foliar segments- Deb and Temjensangba, 2007a; aerial roots- Deb and Temjensangba, 2006a); *Cleisostoma racemiferum* (seeds and leaf- Temjensangba and Deb, 2005b, 2005c, 2006; aerial roots- Deb and Temjensangba, 2005); *Dendrobium chrysanthum* Wall. ex Lindl. (seeds- Raghuvanshi *et al.*, 1986); *D. fimbriatum* var. *oculatum* Hk. f (D.Don) (seeds- Devi *et al.,* 1990); *D. nobile* Lindl. (seeds- Raghuvanshi *et al.,* 1986); *D. primulinum* Lindl. (seed- Deb and Sungkumlong, 2009); *Coelogyne porrecta* Lindl. (leaf - Abdul and Hairani, 1990); *Coelogyne suaveolens* Lindl. (seeds- Sungkumlong and Deb, 2008, leaf - Deb and Sungkumlong, 2010); *Cymbidium elegans* Lindl. (seeds- Raghuvanshi *et al.,* 1991); *Eulophia alta* (Linn.) Fawcett & Rendle (seed- Johnson *et al.,* 2007); *E. hormusjii* Duth. (rhizome segments- Vij *et al.,* 1989); *Luisia teretifolia* Gaud. (foliar segments- Vij and Pathak, 1990); *Malaxis khasiana* Soland ex. Swartz (seeds- Deb and Temjensangba, 2006b); *Rhynchostylis gigantea* (immature seeds- Li

and Xu, 2009); *Rhynchostylis retusa* (L.) Bl. (seeds- Nath *et al.*, 1991; aerial roots - Sood and Vij, 1986; foliar segments - Vij and Pathak, 1990); *Taenia latifolia* Lindl. (seed- Deb and Sungkumlong, 2008; 2009, leaf- Deb and Sungkumlong, 2010); *Vanda cristata* Lindl. (foliar segments- Vij and Pathak, 1990.) Plant tissue culture techniques have thus opened new avenues for conservation of threatened/endangered orchids by re-introducing them among their wild relatives and also aiding in their sustainable utilization.

Seed/Embryo Culture

The technique also referred to as ovule/embryo/green pod/green fruit culture (Sagawa, 1963) deals with the sterile isolation and *in vitro* growth of a mature or an immature embryo with an ultimate objective of obtaining a viable plant. Embryo culture in orchids is carried out by removing sexually produced zygotic embryo/seed and placing them on culture medium with proper nutrients in aseptic condition. It ensures better germination frequency and favors the production of virus free seedlings. Asymbiotic/non-symbiotic seed germination is the most commonly used technique in the propagation of tropical orchids as they tend to be easier to grow compared to temperate species. Moreover, the media used for asymbiotic germination is more complex than for symbiotic germination, Since all organic, inorganic nutrients and organic carbon source must be in a form readily available to the orchid without an intermediary fungus (Mc Kendrick, 2000). This technique involves an easier sterilization procedure, ensures better frequency of germination and production of virus free seedlings. It is important though to determine the harvest time of capsule or pod for getting optimal germination since all the seed/embryos are used in a single sowing in this technique; moreover the preferred age at which the embryos can be cultured productively varies across orchid genotype and the local conditions. Very young ovules do not form appropriate explants in orchids because the embryo sac development is a post pollination phenomenon and fertilization is a prerequisite for obtaining seedlings. Since ovules can be used for raising cultures successfully immediately after fertilization, the importance of information on time interval between pollination and fertilization has thus often been stressed (Valmayor and Sagawa, 1967). Yam and Weatherhead (1988) noted that immature embryos germinate better than the mature ones due to their distended testa cells and metabolically awakened embryos; they also lack dormancy or inhibitory factors. Vij (1995) noted that the fruit/capsule developing prominent ridges along the valves and

ceases to grow in diameter could be considered a useful marker for selecting the right stage for embryo culture. Temjensangba and Deb (2005b, 2006) reported *Arachnis labrosa* and *Cleisostoma racemiferum* embryos obtained between 16 and 18, and 16 weeks after pollination respectively (WAP) readily germinate and their germination frequency declines sharply when obtained from beyond this window period. Long *et al* (2010) also reported the germination frequencies from 300 day-old seeds to be lower than those from 200-day-old seeds in *Paphiopedilum villosum* var *densissimum*.

Meristem culture

The embryo culture in orchids produces a great deal of heterozygosity in their progeny due to its out breeding characteristic as a result it is a disadvantage in cut-flower industry where pure lines of desired genotypes are preferred. Hence, the possibility of using excised shoot-meristem for regenerating complete plant from *in vitro* was first initiated by Morel (1960) for *Cymbidiums* and Wimber (1963) formulated, described and published a procedure for the same. This technique of using resident meristem (shoot-tips, axillary bud) thus opened new avenues in orchid micropropagation (Arditti and Ernst, 1993; Deb and Temjensangba 2005, 2006a; Temjensangba and Deb, 2005c). This technique could regenerate upto 200,000 plants from a single resident meristem within a year. However, it had limited utility in monopodial taxa as it involved the sacrifice of the growing tip while endangering the survival of the mother plant. The use of an adventive meristem is advantageous as it does not endanger the survival of mother plant. The regenerative competence or the proliferative potential has been positively reported in many orchid taxa, viz: leaf explants (Vij *et al*., 1984; Mathews and Rao, 1985; Chaturvedi and Sharma, 1986; Seeni, 1988; Vij and Pathak, 1988, 1990; Seeni and Latha, 1992; Temjensangba and Deb, 2005c; Deb and Temjensangba, 2007a; root (Chaturvedi and Sharma, 1986; Sood and Vij, 1986; Vij and Pathak, 1988; Vij, 1993; Deb and Temjensangba, 2005, 2006a), flower stalks (Singh and Prakash, 1984; Kaur and Vij, 1995; Vij *et al*., 1997). The source, genetic constitution and physiological age of the explants are however, some of the important factor for sub-regeneration. The juvenile tissues from green-house grown plants respond better than the mature ones grown outdoors. Generally, the proliferative loci get activated in the sub epidermal cells and soon develop into somatic embryos and or protocorm-like-bodies. Somatic embryogenesis is either direct or callus mediated development, multiplication and differentiation of the PLBs

is influence by the chemical stimulus present in the nutrient pool (Vij and Pathak, 1990; Seeni and Latha, 1992).

Shoot tip culture for *in vitro* propagation

The first production of virus-free dahlias using apical meristem culture was reported by Morel and Martin (1952) and the same technique was applied to produce virus-free *Cymbidium* (Morel, 1960). In addition, the detailed protocol of *in vitro* production of *Cymbidium* from the meristem culture was first reported by Wimber (1963). In fact *Cymbidium* plants could give an indefinite multiplication if the cultured cell is aseptically developed (Steward and Mapes, 1971). In addition, Steward and Mapes (1971) could grow *Cymbidium* suspension cultures in liquid media which contains 2,4-D (5 ppm) and coconut milk (10% v/v) which revolutionized the effective used of shoot tips for the induction of shoot buds and PLBs of many orchids. It may be noted that the introduction of shoot tip culture technique has facilitated in the rapid multiplication of *Vanda coerulea* and the re-introduction of clonal plants (Seeni and Latha, 2000). The success of callus cultures in which the callus can be maintained for a prolonged period is limited to a few orchids (Chang and Chang, 1998; Ishii *et al*., 1998; Roy and Banerjee, 2003). This is because of the difficulty in induction, limited growth and severe necrosis of callus. Roy *et al*. (2007) developed an efficient protocol for callus production which has efficient significance in orchids such as *Dendrobium chrysotoxum* that has tremendous therapeutic potential as an antioxidant, antiangiogenic and antitumour agent. However, shoot tip culture can be used as a more reliable technique for tissue culture of sympodial orchids like *Dendrobium, Cymbidium, Arundina, Phaius* and *Anoectochilus*.

Leaf segment culture

The first leaf tissue culture was carried out by Wimber in 1965 (Wimber, 1965) and he reported on the production of PLBs from *Cymbidium* leaves. However, leaf tissue culture does not require the sacrifice of the mother plant and are easy to obtain in any season. The successful regeneration of multiple plants of the endangered Red Vanda has also been obtained using leaf tissue culture (Seeni and Latha, 1992). Moreover, the competence of regeneration such as frequency of response and number and nature of regenerates in foliar cultures of certain *Vanda* species showed the proportionality of the tissues in terms of size of the donor leaf (Vij *et al*., 1994). There are also reports on the direct somatic embryogenesis from young leaves of *Oncidium*

as early as 20 days after culture in which the initial appearance of the foliar embryos were affected by the stage of the maturity of the leaves (Chen *et al*., 1999). Micropropagation using leaf explants depends on several factors such as nutrient composition, growth hormones, leaf part and source, orientation of the explants and most importantly leaf age. However, the maximum reports on orchid micropropagation have used leaves as the starting material, popular use of leaf explant-mediated mass scale cultivation of commercially important orchid species in industries is restricted because of the time and costs involved in standardizing the above parameters.

Inflorescence axis and flower bud culture

For micropropagating orchids, the inflorescence segment has also been considered as an effective donor organ in which their excision does not require the sacrifice of the complete plant. This method was first reported by Rotor (Rotor, 1949) in which he used *Phalaenopsis* cultures using flower stalks *in vitro*. In fact among the techniques for *in vitro* propagation, the common culturing dormant buds are present in inflorescence's basal part (Griesbach, 1983). The conjugates of indole acetic acid (IAA) and amino acids have also been reported in the *in vitro* propagation of *Phalaenopsis* orchids (Griesbach, 1983). Griesbach added IAA to MS medium and he observed the formation of a large number of shoots from protocorms derived from inflorescence nodal buds of *Phalaenopsis* 'Betty Hausermann'. However, the used of inflorescence stalks for propagation of inflorescence segment explants is not limited to *Phalaenopsis*. Lin (1986) also reported that the developmental stage and age of flower stalk have a direct influence on the frequency of PLBs formed during *in vitro* culture of flower stalk internodes in *Phalaenopsis* and *Doritaenopsis*. However, there are some limitations of these techniques, which have been imposed by difficult sterilization procedures, phenolic exudations and recalcitrance of the tissue.

Rhizome segment culture

Temperature and climatic conditions also play an important role on *in vitro* propagation. *Cymbidiums* species which are mostly confined to the temperate regions of Asia has gained less attention for tissue culture methods because of the rareness and difficulty involved in collecting sufficient amounts of experimental material. In fact, the multiplication rate of the Oriental *cymbidiums* under natural conditions is very low as compared to the tropical or subtropical orchids. Furthermore, the conditions and requirements for the clonal propagation of the orchid species of

temperate regions and their hybrids are much more stringent than for the tropical orchids. Hence, organs such as rhizome have been conventionally used to propagate orchids under field/greenhouse conditions. However, they generate only a limited number of propagules during favourable season (Shimasaki and Uemoto, 1990). Shimasaki and Uemoto also reported an efficient method for the inducting the whole plantlets of *Cymbidium* kanran from the *in vitro* seed derived rhizomes and rhizomes induced directly from the axillary buds using NAA tropical application (Shimasaki and Uemoto, 1990). In addition, there are reports of Auxins, (NAA), known to stimulate rhizome formation and branching in cultures of many orchids such as *C. kanran* and *C. forrestii* (Shimasaki and Uemoto, 1990) (Paek and Yeung, 1991). Therefore, in vitro derived rhizomes serve as readily available source of explants for many terrestrial orchids which provide an effective means for rapid propagation of commercially important rhizomatous orchids.

Root segment culture

There are also reports on bud regeneration in root apices for some orchid species in both natural and *in vitro* conditions (Vaz *et al*., 1998). The first report on the micropropagation of orchids using aerial roots was suggested by Beechey (1970). In fact, the root meristem consists of highly determinate cells which have limited morphogenic competence for bud formation (Peterson, 1975). However, plant hormones such as auxin, cytokinin and other substances like p-coumaric acid interfere with the endogenous IAA oxidase activity that influence the direct conversion of isolated root tip segments of some orchid species like *Catasetum* into PLBs (Colli and Kerbauy, 1993). However, the presence of exogenous auxin in the media drastically reduced the number of PLBs formed; but greatly increased callus formation. Colli and Kerbauy also observed that the presence or absence of growth regulators in the medium, roots of orchids like *C. fimbriatum* still attached to the plantlets and do not convert into shoots (Colli and Kerbauy, 1993). Hence physical isolation of the roots is important for the accumulation of root derived cytokinins sufficient for an IAA/cytokinin ratio adequate for shoot initiation. In addition, Peres and Kerbauy (1999) observed the accumulation of cytokinins during root to shoot conversion, it was also observed that the physiological age of the tissues was detrimental to the formation of buds and PLBs on the root segments apart from the induction of growth hormone, (Vij *et al*., 1989).

Micropropagation via thin cell layer culture

In thin cell layer (TCL) system, it consists of explants which are of a small size excised from different plant organs which is usually a stem, leave, floral inflorescences, flower primordia or floral organs, cotyledons etc. Rout *et al.* (2006) reported that the thin cell layer culture is more efficient compared to the conventional technique of tissue culture. However, Nhut *et al.* (2001) described TCL as a simplified experimental system in which organ interaction is suppressed and a minimum of tissue/cell interaction is maintained. They also reported on the utilization of TCL system, with controlled parameters which is exogenously applied plant growth regulators, light conditions and others directed at defined cell types, the morphogenetic outcome of these tissues may be programmed and controlled.

Different species of orchids exhibits specific needs in respect to nutritional requirement and treatment with plant growth regulators (PGRs) for their growth and development. Hence, no standard media formulation can be prescribed for all the species. Most commonly employed basal medium for orchid tissue culture are Knudson 'C' (1946), Mitra *et al.* (1976), Murashige and Skoog (MS) (1962), Nitsch and Nitsch (1969), Vacin and Went (1949). The use of a-Naphthalene acetic acid (NAA) and cytokinins like benzyladenine (BA) and kinetin (KN) yields a rich crop of PLBs in *Luisia trichorhiza*, *Satyrium nepalense*, *Vanda cristata* and *Vanda testaceae* leaf segment culture (Vij, 1995). Similarly, in *Rhynchostylis retusa*, a synergistic action of KN and indole 3-acetic acid (IAA) or NAA in peptone enriched medium favored enhanced production of PLBs; while yeast extract (YE) is obligatory for regeneration in *Aerides multiflorum*, *Papilionanthe teres* and *Satyrium nepalense* foliar cultures and peptone in those of *Vanda* (Vij, 2002).

Orchid micropropagation has shown spectacular development in recent years but the wide spread use of micropropagation is believed to be still handicapped due to explants isolated from mature plants releasing exudates like phenolics into the medium that become toxic to the cells when oxidized. Moreover, the quick transfer of the explants to fresh media is often preferred to avoid possible inhibitory effects of exudates and as such the addition of activated charcoal and ascorbic acid to the medium have been used often to overcome inhibitory effects of phenolics released into the medium. Moreover, PGRs like TDZ is more effective than other cytokinins but the drawback of using TDZ in regeneration studies often include difficulty in

elongation and rooting of regenerated shoots which may be due to the high cytokinin activity and persistence of TDZ in the tissue compared to adenine-type cytokinins.

A brief Account of the two selected Orchid species for micropropagation

All orchid species are included under Annex B of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and subsequently all *Paphiopedilum* species (Lady's Slippers) are listed under Appendix I of CITES. In India *Paphiopedilum* species are protected by Wildlife Protection Act of India under Schedule VI and hence illegal collection and propagation is banned.

1. *Paphiopedilum villosum* var. ***boxallii*** (Rchb. f.) Pfitzer in Engler, Die naturlichen Pflanz., II, (6): 83. 1888. *Cordula boxallii* (Rchb.f.) Rolfe., Orchid Rev. 20: 2. 1912. *Cypripedium boxallii* Rchb.f., Gard. Chron.,n.s., 7: 367. 1877. *Paphiopedilum boxallii* (Rchb.f.) Pfitzer. Nat. Pflanzenfam. 2(6): 84. 1888. *Cypripedium dilectum* Reichenbach fil. in Gardener's Chronicle, 3rd series, 3: 330-331. 1888.

Taxonomic Description (Figure 1.1)

Plant 25-40cm. *Leaves* 5-8, 13-34 x 2.0-3.6cm, distichous, leaf blade abaxially green and with purple speckles toward base, adaxially uniformly dark green, linear-oblong or lorate, leathery, acute to obtuse and bilobulate at apex. *Inflorescence* 15-23cm long, single flowered, arising from between leaves; Scape sub erect to arching, terminating in a solitary flower; peduncle 10-20 cm, green with more purple and rarely whitish hairs; floral bract 4-5 x 2-3cm, green, elliptic, conduplicate, abaxially purple spotted and hairy toward base. *Flower* 10-12 x 8-10cm; sepals and petals greenish or yellowish with purplish markings, lip yellow and purplish spotted; pedicel and ovary 4-5 cm, with purple or rarely whitish hairs. *Dorsal sepal* 5-6 x 4-5cm, greenish or yellowish white, broadly elliptic to obovate, minutely haired abaxially throughout and with long hairs on midvein and toward base and apex, ciliate, recurved on basal margin, apex obtuse, heavily spotted with large blackish maroon marks; synsepal 4-4.5 x 2-2.5cm, greenish to yellowish white, elliptic-ovate to narrowly ovate. *Petals* 5.5-7 x 3-3.5cm, spathulate-obovate, adaxially purple villous at base, ciliate, obtuse to retuse at apex, deep maroon central stripe, upper side of central stripe pale maroon with deep maroon veins, lower side very pale maroon. *Lip* 4.5-6.5 x 4-4.5 cm, helmet shaped, pouched; staminode 1-1.3 x 0.8-1cm,

obcordate obovate, adaxially with bubblelike papillae and a central umbo, subtruncate at apex. *Pollinia* 1-1.2mm in diameter.

Flowering: February - April

Habitat and Ecology: Epiphytic or lithophytic and found growing on tree trunks in diffused sunlight areas, 1700m

General Distribution: India (Nagaland), China, Myanmar

Specimen examined: Area name Witheld (Tuensang district) bordering Myanmar.

Note: U.C. Pradhan (1976) mentioned this variety without any locality in India and Philip Cribb mentioned this variety as being endemic to Myanmar. The author verifies the variety as the original was encountered flowering in the wild.

The species was described by Reichenbach fil. in Gardener's Chronicle, 2nd series. The plant was probably collected from the Tongku District of Burma. It was named for William Boxall, who discovered it in 1877 while collecting for Messrs.Hugh Low & Co and its Synonyms are *Cypripedium villosum* var. *atratum* Masters and *Cypripedium dilectum* Reichenbach fil. in Gardener's Chronicle, 3rd series (Cribb, 1998). *It is* rare and has only been recorded from China (Yingjiang County, Yunnan), Myanmar and Northeast India. The population of the species is significantly decreasing in recent decades and many of its subpopulations have been ruthlessly removed from the wild by collectors, moreover habitat degradation due to human disturbance, deforestation and mining activities have added to their plight. The estimated area in which the species is found is about 56 km^2 with an estimated continued decline and hence the species has been categorized as Vulnerable (VU) by the the IUCN Red List of threathened species (Kumar and Rankou, 2015a).

2. *Paphiopedilum insigne* (Wall. ex Lindl.) Pfitzer in Pringsh. Jahrb. Wiss. Bot. 19: 159. 188 & in Engler & Prantl, Nat. Pflanzenf. 2(6): 84.1889; U.C. Pradhan, Indian Orchids: Guide to Identif. & Cult. 1: 37. 1976; Nayar & Shastry (ed.), Red Data Book of Indian Plants 1: 268. 1987; Philip Cribb, The Genus Paphiopedilum 231-234. (ed.2) 1987.

Taxonomic Description (Figure 1.2)

Plant 25-30cm. *Leaves* 5-8, 10-18 x1.8-2.6cm, distichous, leaf blade abaxially pale green, adaxially uniformly deep green, narrowly elliptic or linear-oblong, leathery, obtuse and minutely tridenticulate at apex. *Inflorescence* 13-20cm long, single flowered, arising from between leaves; Scape erect, terminating in a solitary flower;

peduncle 10-18 cm, green-purple, densely purple pubescent; floral bract 3-3.5 x 1.8-2.2cm, purple spotted, ovate-elliptic, conduplicate, glabrous. *Flower* 9-12 x 8-10cm; sepals and petals yellowish with white , lip yellowish and faintly purplish markings; pedicel and ovary 4-5 cm, purple pubescent. *Dorsal sepal* 5-5.5 x 4-4.5cm, broadly ovate or ovate-orbicular, abaxially pubescent, apical margin incurved, ciliate, obtuse at apex; synsepal 3.5-4 x 2.8-3.4cm, ovate-elliptic, pubescent abaxially. *Petals* 5-6 x 1.4-2cm, spatulate or oblong-spatulate, adaxially purple villous toward base, margin undulate, apex obtuse or slightly tridenticulate. *Lip* 4.5-5 x 4.5-xx x 5cm, helmet shaped, pouched; staminode 0.8-0.9 x 0.7-0.8cm, obovate, purple puberulent on both surfaces, with a central umbo.

Flowering: -October - December

Habitat and Ecology: Terrestrial and found growing on outcrops near stream of forests, 1800m

General Distribution: India (Meghalaya), China.

Note: The species was described by Wallich ex Lindley in Collectanea Botanica in 1821 (Cribb, 1998). It derived its name from the Latin word *insigne*, meaning 'badge of honor', named for the striking nature of the flower. *Paphiopedilum insigne* is the type species for the genus *Paphiopedilum* and hence holds special importance. Its synonyms are *Cypripedium insigne* Wall. ex Lindl., *Cypripedium chantinii* auct., *Cypripedium maulei* auct. and many more, as a result of which the species has been taxonomically very complex and misleading to orchid experts. *Paphiopedilum insigne* is rare with a restricted distribution area in northeast India and China. The abundance of the species has been further reduced in recent decades (Bangladesh and Thailand) due to ruthless collection for regional and international trade, exploitation for horticultural purposes and habitat degradation. The estimated extent of occurrence and the estimated area of occupancy of the species are 628 km^2 and 8 km^2, respectively, with an estimated continuing decline. This species is thought to be probably extinct from localities in Bangladesh and Thailand and therefore the IUCN Red List of threatened species in 2015 has categorized the species as Endangered (EN) (Kumar and Rankou, 2015b).

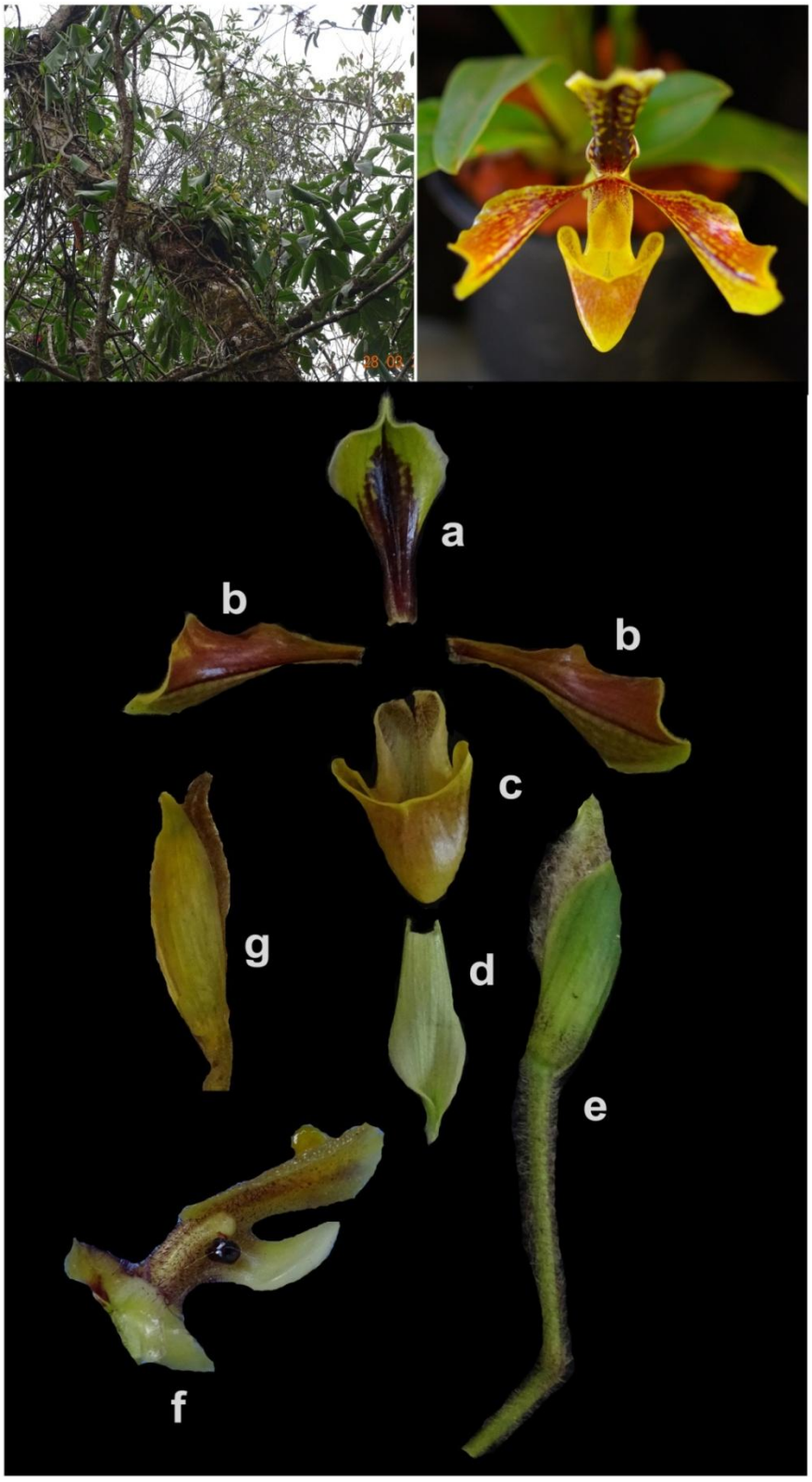


Figure 1.1. *Paphiopedilum villosum* var. *boxallii* Wild Flowering and close up: **a)** Dorsal sepal; **b)** Petals; **c)** Lip; **d)** Synsepal; **e)** Ovary with pedicel and bract; **f)** Column; **g)** Seed pod.

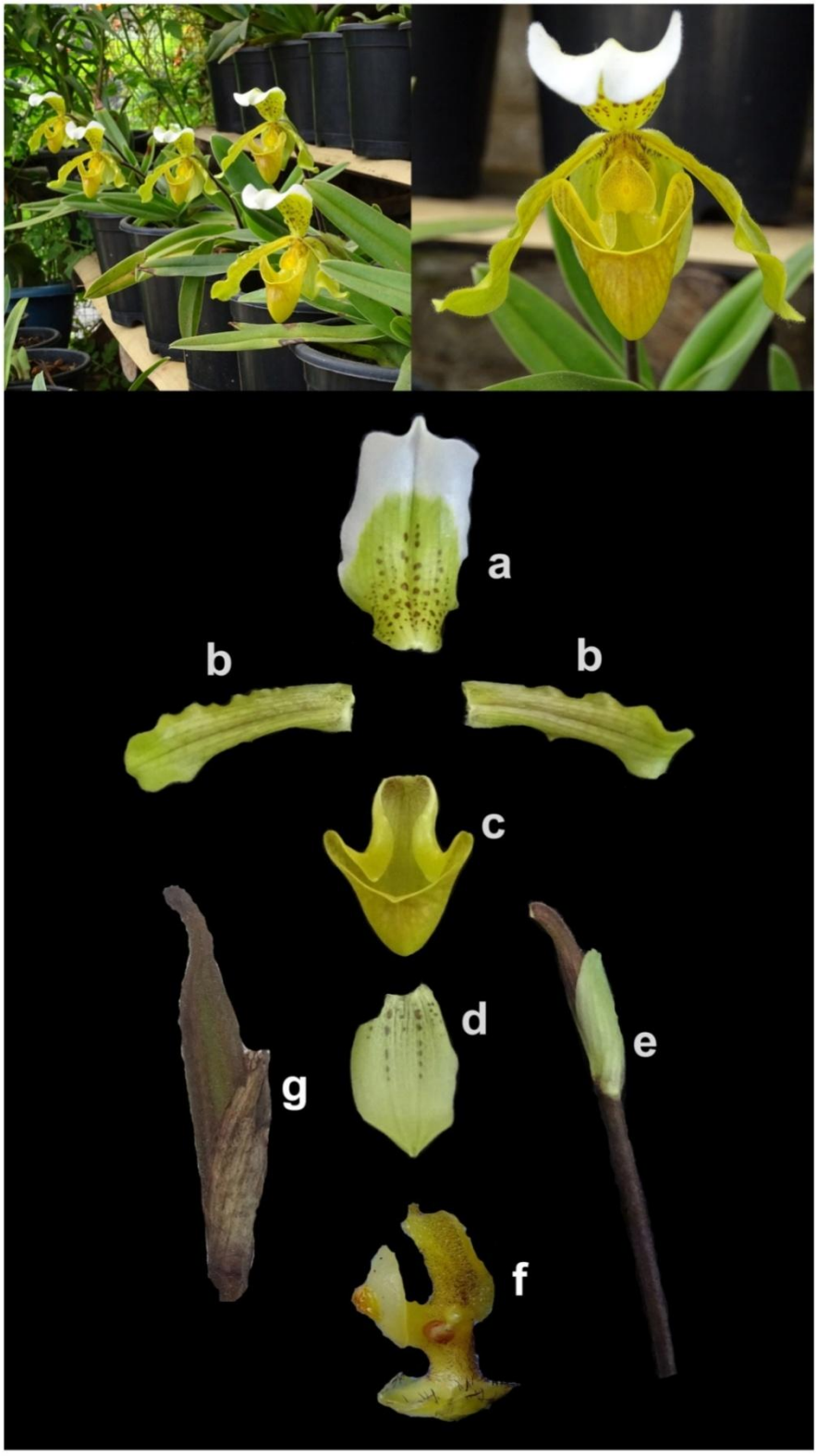


Figure 1.2. *Paphiopedilum insigne* Plants and Close up flower: **a)** Dorsal sepal; **b)** Petals; **c)** Lip; **d)** Synsepal; **e)** Ovary with pedicel and bract; **f)** Column; **g)** Seed pod

Scope and Objectives of the Study

The state of Nagaland formed as the 16th state under the Union of India on 1st December 1963 lies between 25° 60' N and 27° 40' N latitude and 93° 20' E and 95° 15' E longitude, located in the north-eastern part of India having an area of ca 16,579 squares KM. The state is located in the Indo-Burma hotspot belt and bounded in the east by Myanmar (Burma), on the west by Assam, on the north by Arunachal Pradesh and part of Assam and on the south by Manipur. The state comprises of 11 districts, 93 administrative circles, 52 blocks and 1428 villages with an approximate population of 19, 78,502 as of 2015 (Statistical handbook of Nagaland, 2014 and 2015). Based on interpretation of satellite data (Forest Survey of India, 2013) the forests cover in the state was recorded at 13, 044 km^2 comprising

78.68% of the states geographical area of which 1,298 km^2 very dense forest, 4, 931km^2 moderately dense forest and 7,094 km^2 open forest in terms of forest canopy density classes. The forest cover of the state has experienced a decline in the past 2-3 decades due to anthropogenic activities, from 86.8 % of the total geographical area in 1989 to 78.68% in 2013 (8.12%) of which very dense forest cover declined from 6379 km^2 in 1987 to 1,298 km^2 in 2013 (FSI, 2013). Latest estimates however show the forest cover in the state of Nagaland 1,279 km under very dense forest, 4,587 sq km under moderately dense forest and 6, 623 sq km under open forest in terms of forest canopy density classes (FSI, 2015, **Figure 1.3).** The decline in forest area is thus noticeable from statistics and is mainly because of fragmentation of forest by unplanned developmental activities as well as the practice of primitive form of agriculture (Jhum), the primary reasons for loss of forest cover. The loss in biodiversity is thus inherent from the figures and population of many important plant species has declined, including orchids which are most susceptible to small changes in micro-climate before their commercial importance are being realized. Moreover, inadequate work on the proper survey and documentation of orchid resources has been done for the state of Nagaland as compared to other states of India. Hence, scope of a coherent approach involving authentic survey to properly identify and document orchids vis-a-vis use of biotechnological tools for micropropagation of more important species remain limitless for sustainable utilization of this rich bioresource. I had thus proposed to document the orchid resource of three districts of Nagaland i.e., Kiphire, Tuensang and Zunheboto as well as to develop the micropropagation

protocols of two economically important but threatened species of orchids viz., *Paphiopedilum villosum* var. *boxallii* and *Paphiopedilum insigne* for my Ph. D. degree, with the following objectives.

1. Live plant collections of species adding to gene bank in the Orchidarium of Department of Botany, Nagaland University.
2. Preparation of conventional and digital herbarium of species documented from the three districts.
3. Develop micropropagation protocols of selected species i.e., *Paphiopedilum villosum* var. *boxallii* (Reichenbach fil.) Pfitzer & *Paphiopedilum insigne* (Wall. Ex Lindl.) Pfitz.
4. Field establishment of regenerates.

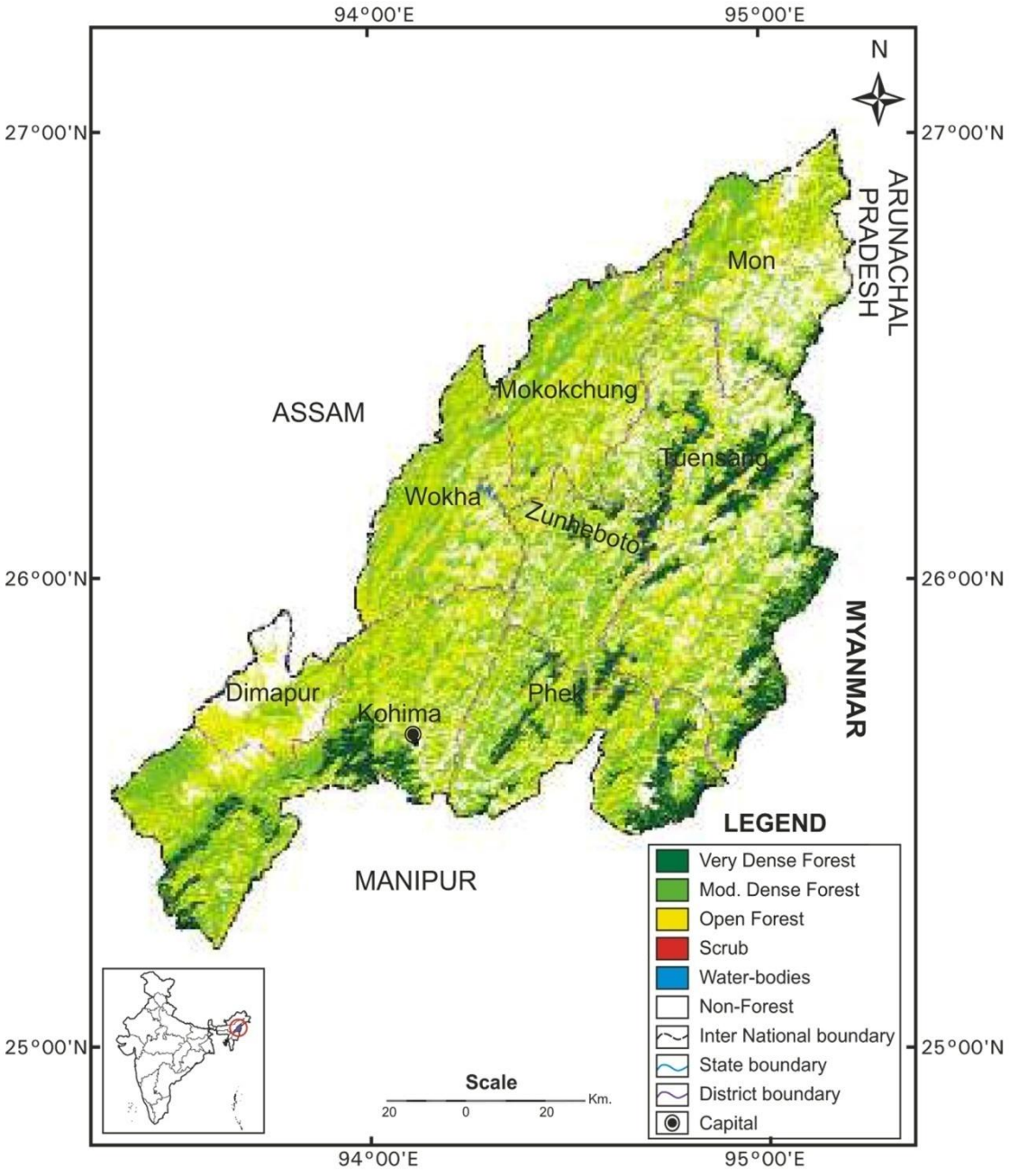


Figure 1.3. Forest Cover Map of Nagaland
(Source: Department of Forest, Ecology, Environment and Wildlife; Nagaland)

Chapter - 2

Documentation of Orchid Resources

2.1 Introduction

The first account on the 'Orchidaceae of Nagaland' was through Clarke's (1889) collection wherein he reported 22 species of orchids under 18 genera. Later Hooker (1890) recorded 49 species of orchids under 24 genera including 1 variety from Nagaland, after studying the collections of Collet, Griffith, Clarke and also the earlier collections of Watt and Prain, describing 507 species belonging to 85 genera of orchids from eastern India and 1235 species belonging to 117 genera in the 'Flora of British India' Vols. 5 & 6 (1890). King and Pantl (1898) reported 34 species under 18 genera, Burkill (1924) reported 10 species under 8 genera, Mitra (1958) reported 53 species under 26 genera and 1 variety all of which were based on the collections of C. B. Clarke's, D. Prain's, G. Watt's, H. Collett's, W. Griffith's. Bor (1942) reported 8 species under 5 genera based solely on his own collection. Das and Jain (1978a, 1978b) reported 3 species under 1 genera based on Hynniewta and others' collections from Nagaland. Dr. S. K. Kataki, Dr. C. L. Malhotra and Shri. C. Bahadur of the Botanical Survey of India, Shillong have also made large collections and contributed to our knowledge on the 'Orchidaceae of Nagaland'. Recent work on the orchidaceae of Nagaland includes those of Hynniewta (1984) recording 238 species and 4 varieties of orchids belong to 59 genera from Nagaland. Chankija *et al.* (1992) recording 360 species under 85 genera, Deorani & Naithani (1995) recording 238 species, Hynniewta *et al*. (2000) recording 241 species of 63 genera including one endemic species i.e. *Coelogyne hitendrae* Das and Jain, Deb and Imchen (2008) recording 396 species of 92 genera. Present study was undertaken to inventorize and documents the

orchid resources of three districts of Nagaland viz., Kiphire, Tuensang and Zunheboto.

2.2 Materials and Methods

2.2.1 Brief account of the study area

Kiphire District

Kiphire district is located in the eastern most part of Nagaland surrounded by Tuensang district in the north, Phek district in the south, Zunheboto in the west and Myanmar in the east. It was part of the 'North Eastern Frontier Agency' (NEFA) under Tuensang district as an administrative sub-division which later bifurcated and was formed as the eleventh district of Nagaland on 24th January, 2004. The total area of the district is about 1255 sq. Kms. The district headquarters Kiphire is located at an elevation of 896.42 (2,940 ft) MSL. The population of the district is 74004 (2011 Census) comprising of 36, 174 female and 37, 830 male. Mount Saramati, the highest peak in Nagaland at 3840 m ((12,602ft.) is located in Pungro Sub-Division of Kiphire district. Other towns of the district are Seyochung, Sitimi, and Kiphire. Kiphire is multi-ethnic in terms of its indigenous population. There are officially three recognized tribes - Sangtam, Yimchunger, and Sumi. Besides these, there are several sub-tribes. The important festivals celebrated in the district are Mongmong (Sangtam), Metemneo (Yimchunger), and Tuluni and Ahuna (Sumi). Fakim Wild Life Sanctuary home to Blyth's Tragopan (*Tragopan blythii*) is located in Pungro circle headquarters. The proposed International Trade Centre is also located at Mimi. The climate is usually humid and hot during summer and cold during winter with minimum and maximum temperature ranging between as low as 2.7° C during winter and a high of 37° C during summer. Monsoon period starts from June up to September. The average rain fall for the district is about 876mm (Statistical handbook of Nagaland, 2016). Some of the important rivers of the district are Züngki and Tizu which flows into the Chindwin in Myannmar. 'Thanamir' village bordering Myanmar in the foothills of Saramati Mountain is known for its 'Apple Festival' wherein apples are grown in abundance. Rhododendrons are also commonly found in Saramati and Jingkhu mountains.

Tuensang District

Tuensang is located in the eastern part of Nagaland surrounded by Mon and Longleng Districts in the north, Mokokchung in the northwest, Zunheboto in the

southwest, Kiphire in the south, and Myanmar in the east. The district has an area of about 1,728 sq.km. The area of Tuensang (including the present Mon, Longleng and Kiphire Districts) was part of the North East Frontier Agency (NEFA) as the Tuensang Frontier Division. Later Tuensang was bifurcated into two Districts – Tuensang and Mon. Tuensang was further divided in 2004, when Longleng and Kiphire were declared as full-fledged districts. At present the district population records 1, 96, 596 comprising 1, 01, 933 males and 94, 663 females according to Census, 2011 (Statistical handbook of Nagaland, 2016). The District is inhabited by four predominant tribes namely the Changs, the Yimchungers, the Khiamniungans and the Sangtams and other minor sub-tribes. The main festivals of these tribes are Poang Lum, Kundang lum and Naknyu lum (Chang), Metemneo (Yimchunger), Tsokum Sumai, Khaotzao Sey Hok-ah sumai (Khiamniungan), Mongmong (Sangtam), Wild mithun (*Bos frontalis*) is reared in the more remote areas of the district. The climate of the district ranges from sub-tropical to temperate.

Zunheboto District

Zunheboto district is located in the heart of Nagaland and is bordered on the north by Mokokchung district, Kohima district and Wokha district on the west, Phek district in the south, and Tuensang district and Kiphire district in the east. The district has an area of about 1, 255 sq. km. The district Headquarters is at Zunheboto. According to the 2011 census, Zunheboto district has a population of 1, 40, 757 comprising of 71, 217 male and 69540 female. The dominant tribe of the district Zunheboto is Sumi Nagas, a warrior tribe of Nagaland. Tuluni and Ahuna are the important festivals celebrated by the sumi tribe. Tizu and Langki are the important rivers of the district. Shifting cultivation is mainly practiced in the district and terrace cultivation by the people living on the bank of Tizu river. Ghosu Bird sanctuary located at Satakha sub-division is a paradise for ornithologists and bird-watchers. Satoi Range, consisting of 11 villages is the only area where undisturbed forest of the district can be witnessed owing to bad connectivity and is home to endangered species like Blythi Tragopan (*Tragopan blythii*), the more common Kalij Pheasant (*Lophura leucomelanos*) and Eurasian hoopoe (*Upupa epops*).

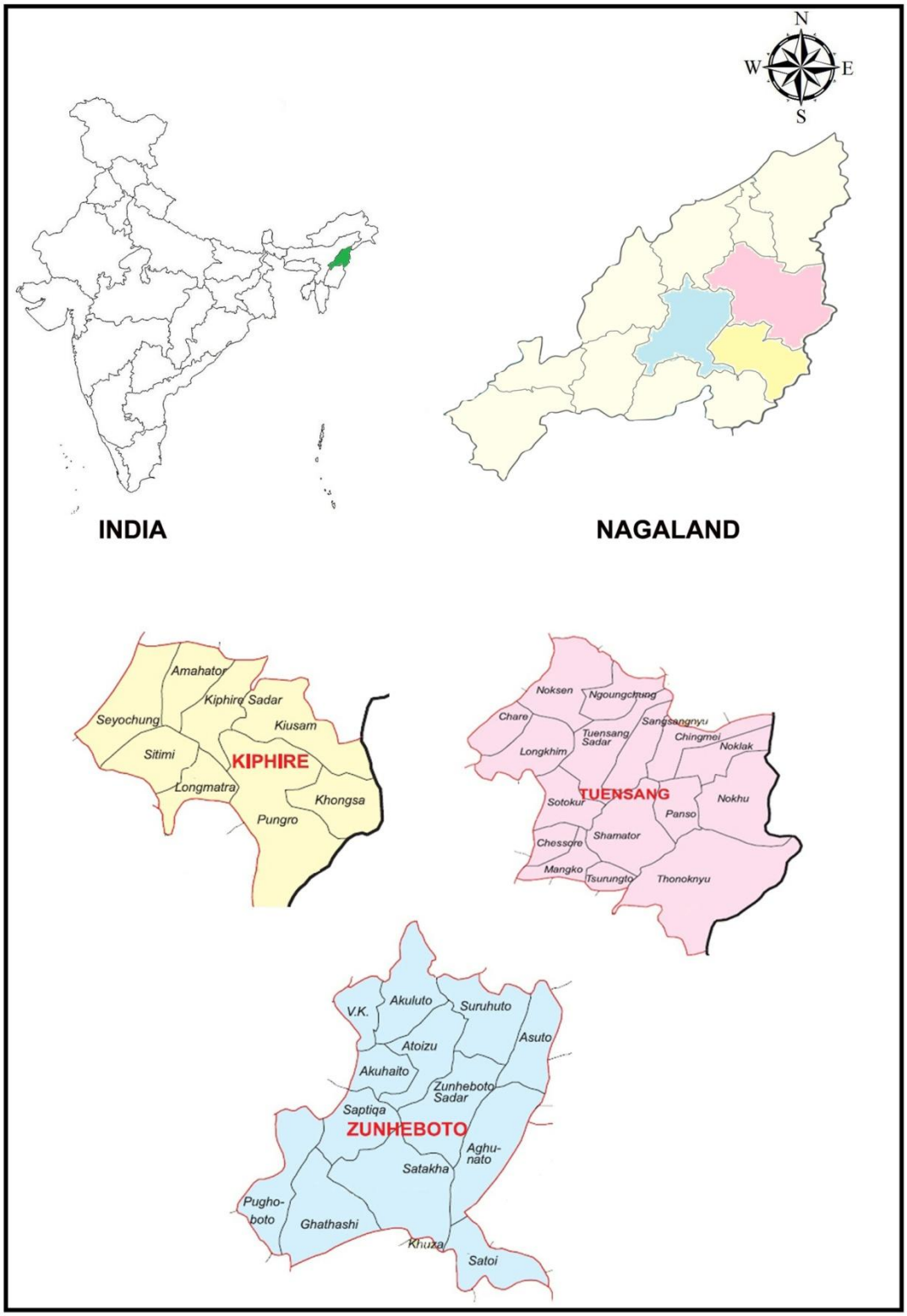


Figure 2.1. Map of Study area (Not to scale)

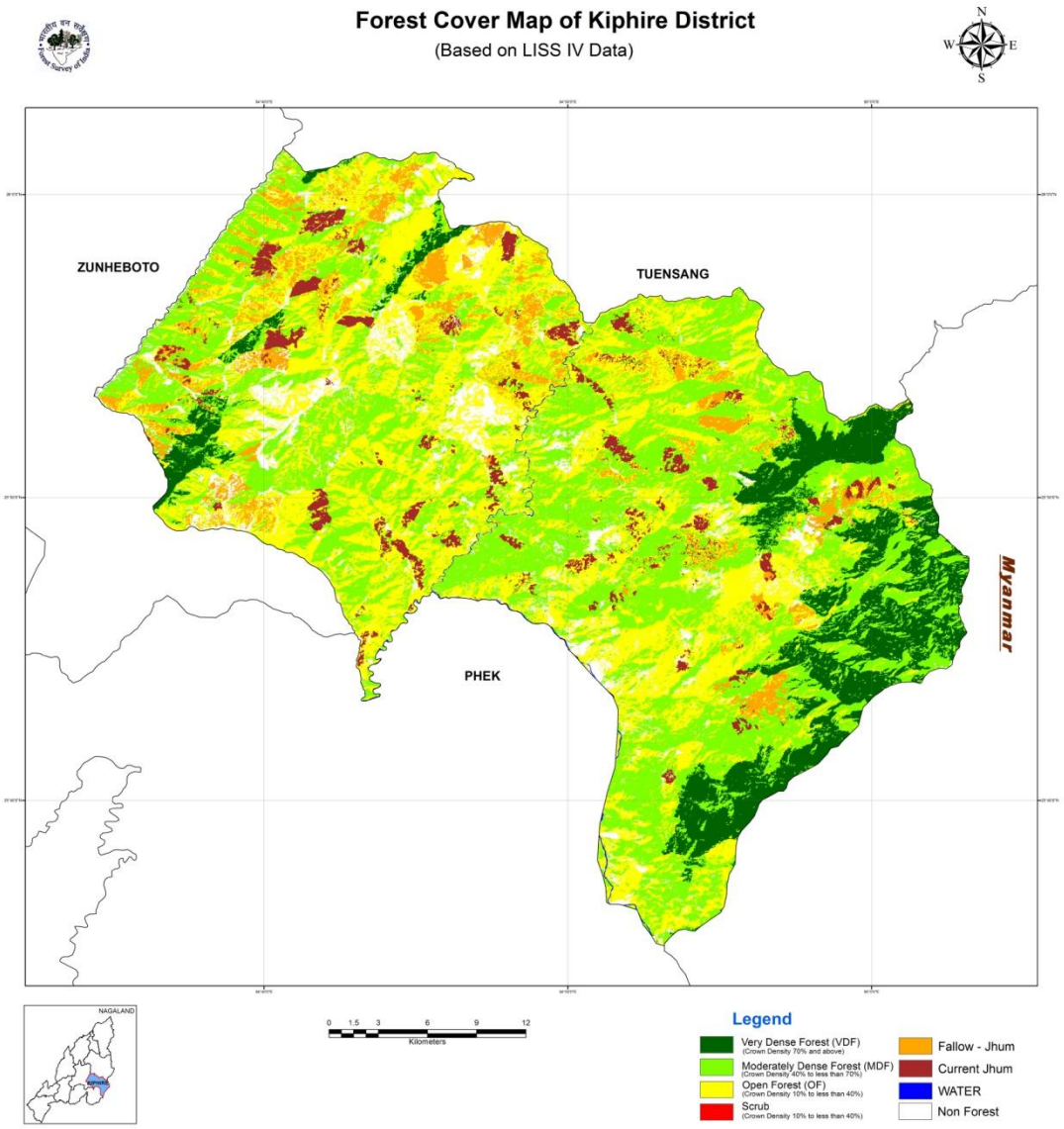


Figure 2.2. Forest Cover Map of Kiphire District, Nagaland

(Source:- Department of Forest, Ecology, Environment and Wildlife, Nagaland)

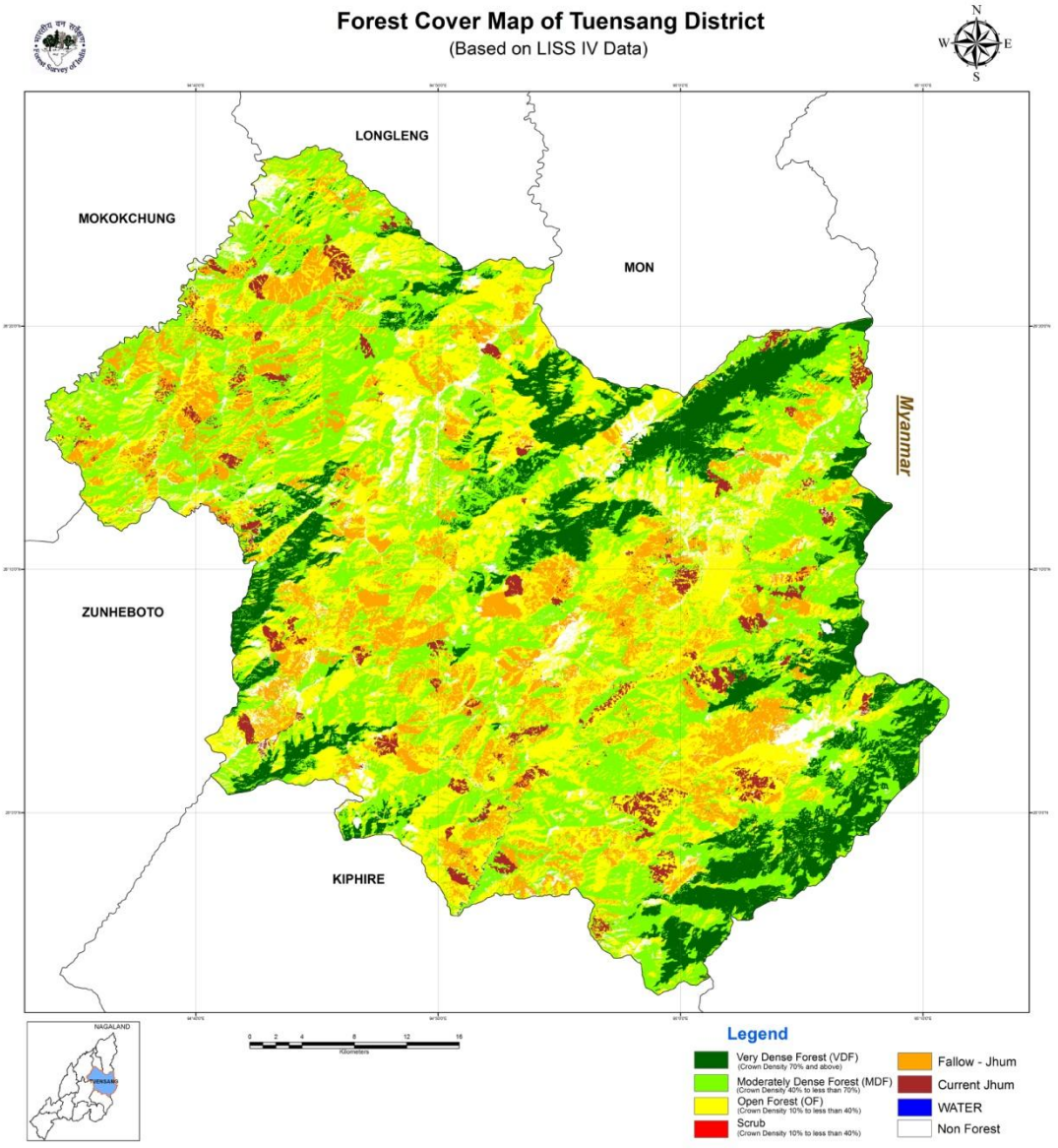


Figure 2.3. Forest Cover Map of Tuensang District, Nagaland

(Source :-Department of Forest, Ecology, Environment and Wildlife, Nagaland)

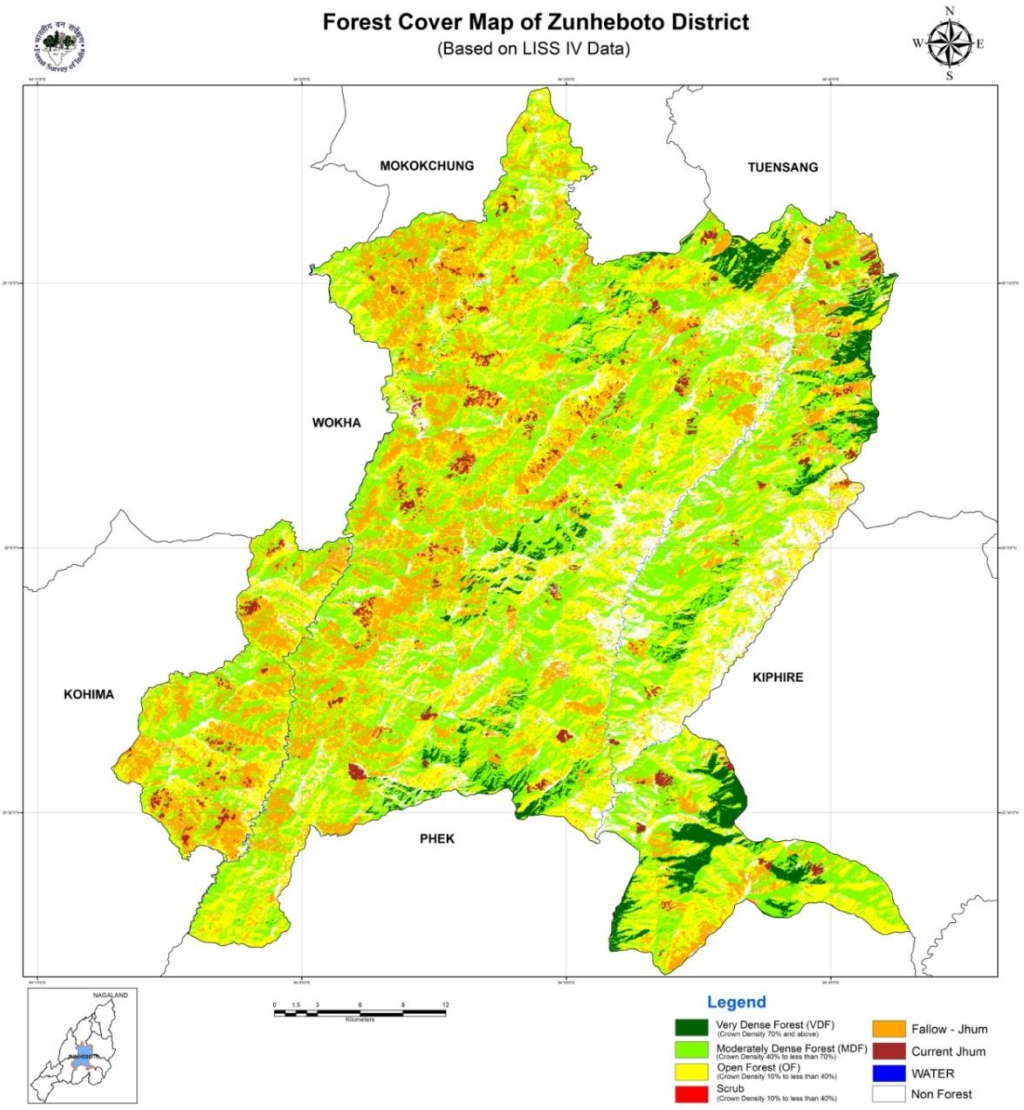


Figure 2.4. Forest Cover Map of Zunheboto District, Nagaland

(Source :-Department of Forest, Ecology, Environment and Wildlife, Nagaland)

2.2..2 Survey

Extensive field survey was carried out at various village forest areas of Kiphire, Tuensang and Zunheboto districts of Nagaland **(Table.1.1, Figure 2.1)** from year 2013 – 2017 covering all the seasons of the year to gather comprehensive information on the diversity of orchid species. Since the forest is mostly owned by the community, due permission from the village Gaonbura/ chairman were obtained to enter forest areas of the particular village. Intensive field survey of the orchid flora of Kiphire, Tuensang and Zunheboto districts of Nagaland and collection of specimen with GPS location and photographs (for wild flowering sightings) were done.

2.2.3 Method of collection

Random collection in village forest areas were carried out after referring to the forest cover map of the three districts viz. Kiphire, Tuensang and Zunheboto **(Figure 2.2-2.4)**. Efforts were made to visit the more dense forest areas which were relatively undisturbed. Photographs of plants in flowering were taken along with GPS. The collected plant specimen were then carried in polythene bags and brought to the base camp.

2.2.4 Herbarium Preparation

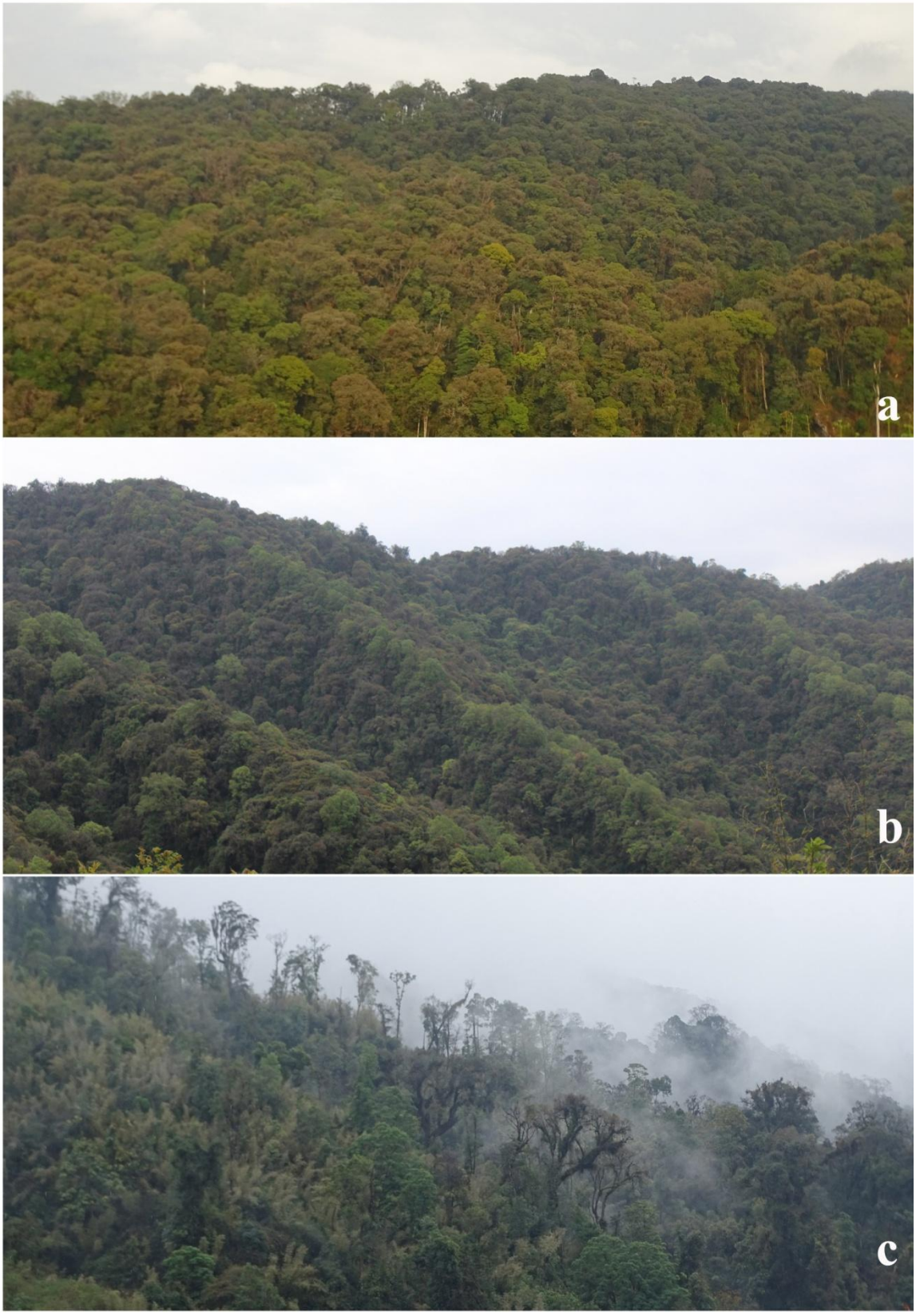
a. Pressing and drying

The collected specimens were then noted with collection no., date, area and general characteristics noted down in field notebook. The Specimen were then treated with chemical formaldehyde (10%) or alcohol and then pressed in wooden frames in between sheets of blotting paper and newspaper. The blotting paper/ newspaper were continuously changed until the specimens dried. Fragile parts of plants such as flowers were also preserved and pickled in chemical formaldehyde (10%) or alcohol for later dissection.

b. Herbarium sheet preparation

Dried specimens were then poisoned by dipping in saturated solution of mercuric chloride following (Jain and Rao, 1977) and again pressed in blotting paper. The specimens were then mounted on herbarium sheets of standard size (42cm x 28cm) using adhesives and then subsequently stitched. The herbarium sheets were then labeled with details that include the collection No., Date of collection, Family, Name of species, Locality of collection, Habitat, General description, and Name of the collector on the lower right hand corner. All the Herbarium sheets have been deposited in the herbarium of Department of Botany, Nagaland University, Lumami.

Panoramic view of mountains and rivers (a) Rhododendron forest, Tsutoho village, Zunheboto; **b)** River during peak monsoon Pughoboto, Zunheboto; **c)** Three capped mountain range at chingmai village, Tuensang



Panoromic view of Reserved forest and village forest: a) Reserve forest, Thanamir village, Kiphire; **b)** Satoi village forest, Zunheboto; **c)** Helipong Range forest, Tuensang

Sub Alpine/Alpine Vegetation: a) Saramati Mountain Range, Kiphire spotted with various species *Gaultheria sp.*; **b)** *Rhododendron macabeanum*; **c)** *Rhododendron arboreum*; **d)** *Rhododendron wattii.*

2.2.5 Live specimen

Live plant specimens were also brought and transplanted in the Orchidarium of Department of Botany, Nagaland University for further observation of flowering and other characteristics.

2.2.6 Identification

Identification of plants were carried out by referring the published regional and national flora, help of protologues, taxonomic revisions, monographs, latest published literature. Later, the identities of the species were confirmed by consulting the herbaria of Botanical Survey of India, Eastern regional circle, Shillong (ASSAM!) and Central National Herbarium (CAL!).

2.2.7 Photographs

Photographs of the plant species in flowering/fruiting were taken using Sony DSC HX 400V & Pentax DSLR. Efforts were made as much as possible to photograph the plants flowering/fruiting in the wild. Photographs of habit and vegetative parts were taken against a black cloth with scale in field itself for later help in identification.

2.2.8 Digital Herbarium

Conventional herbarium sheets were then digitized and has been stored for further reference.

Table 2.1: G.P.S points of the areas and localities of the three districts visited during field survey

Sl. No	Area	District	Position with approx. altitude	Localities visited (villages)
1.	Pungro	Kiphire	25°50’07.1” N 94°51’25.2”E, 1343 m	Chomi, Iponger, khongkha, Moya, Mimi, Fakim
2.	Khongsa (Saramati)	Kiphire	25°45‘13” N 94°59’24.5”E, 2705m	Khong, Penkim, Salomi, Thanamer, Sangtsung
3.	Longmatra	Kiphire	25°50‘08” N 94°51’25.6”E, 1343m	Ngoromi, Sangphure, Sangtsoze, Tethuze
4.	Seyochung	Kiphire	-	Lukhami, Yangzitong, Yingphire, Thsinger
5.	Sitimi	Kiphire	25°47’18.6” N & 94°44’44.7”E, 1282m	Honito, Kiyezhe, Thazuvi, Nikiye, Nitoi, Shishimi, Xuvishe
6.	Amahotor	Kiphire	-	Hutanger, hurong, kisetong, Purur
7.	Longkhim	Tuensang	26°12 ’24.3”N 94°39’09.7”E, 1585m	Angangba, Chimonger, Mangakhi, New Sangsamong, Sangsamong

8.	Sotokur	Tuensang	26°12 ’11.1”N 94°44’44.3”E, 2200 m	Helipong, Sipongsang, Kuthur
9.	Chare	Tuensang	26°16’20.7”N 94°36’04.3”E, 959m	Alisophur, Chare village, Thronger, Tsadang (Old and New), Kiding
10.	Chingmei	Tuensang	26°14’00.4”N 94°56’39.2”E, 1438 m	Chendang saddle village, Waoshu, Chingmei village, Yimpang
11.	Noklak	Tuensang	26°15’26.8”N 95°06’59.3”E, 1969m	Dan village, Pangsha (Old and New), Wansoi, Nokyan, Noklak
12.	Shamator	Tuensang	26°06’07.6”N 94°50’23.1”E, 2153m	Meliankiur, Shiponger, Waphur,Yakor
13.	Satoi	Zunheboto	25°49 ’10.3”N 94°35’ 42.3 E, 2324m	Hokiye, Khuvuxu, Satoi village, Tsutoho
14.	Ghathashi	Zunheboto	25°39 ’25.3”N 94°21’35.3 E, 432m, 25°53 ’18.3” N 94°22’44.0” E. 886m	Mukalimi, Chishilimi, Chisholimi, Khughutomi, Kilomi
15.	Atoizu	Zunheboto	26°06 ’31.6” N 94°30’56.4” E. 1806m	Naghuto (Old and New), Atoizu village, Litsami, Emlomi
16.	Pughoboto	Zunheboto	25°51' 12.0"N & 94°19' 19.4"E, 835m	Mishilimi, Lazami, Natsumi, Ghokimi, Tsaphimi
17.	V.K. Area village	Zunheboto	26°06 ’47.7” N 94°23’24.8” E. 401m	Mukhami, Izheto
18.	Akuluto	Zunheboto	26°12 ’11.4” N 94°29’21.0”E.971m	Lumami, Alaphumi, Sema settsu, Sutemi, Zaphumi, Lumithsami
19.	Saptiqa	Zunheboto	25°58 ’40” N 94°24’22.2”E. 901m	Ustomi,
20.	Zunheboto sadar	Zunheboto	26°05 ’27.3” N 94°32’46.9”E. 1936m	Asukhomi, Sukhalu, Lochomi
21.	Aghunato	Zunheboto	-	Aquba (Old and New), Lukhuyi, Thokihi
22.	Satakha	Zunheboto	25°57 ’58.9” N 94°24’25.5”.920m	Nunumi, Zhekiye, Khukiye, Sukhai, Shoipu

2.2.9 Plan of Presentation of Flora

For convenience alphabetical order has been followed in the arrangement of genera and species. The most recent nomenclature has been adopted as much as possible based as per International Code of Nomenclature for algae, fungi, and plants, Melbourne code, 2012 (McNeil, J. *et al.*2012) as well as in accordance to the latest taxonomic literature, recent floras, monographs and floristic revisions. Dichotomous

bracketed type keys to genera and species have been provided for easy identification of genera, species and variety. For each species, correct name is followed by citation of important literature. The accepted name (in bold letters) with citation is followed by the basionym and synonyms (in italics). Detailed description of species is then done based on my collections. Habit, Habitat and ecology, distribution within the country as well as outside has been mentioned based on latest revision of flora. Exact location wherein the plant specimens were collected has also been given along with the Herbarium No. Flowering months mentioned in the text is based on my own observations in the field.

Measurements are made in metric scale i.e. m: metre, cm: centimeter and mm: millimeter. Simple measurements without range have been provided in certain cases and compound measurements *viz.* 6-9 x 3-5 cm represents 6-9 cm range in length and 3-5 cm range breadth unless otherwise specified.

2.2.10 Taxonomic Description

Key to genera

1. Plants mycotrophic ……..……...…. 2
- Plants not mycotrophic …….……...……..... 4
2. Pollinia hard, not sectile, usually 2 ……..… *Eulophia* (*E. zollingeri*)
- Pollinia soft or mealy, sectile ……..……..... 3
3. Root distinctly coralloid-tuberolous, lip spurred, flowers resupinate or non-resupinate ……..……..…….. *Epipogium*

   Root rhizomatous, flowers in axillary racemes or a terminal panicle .. *Galeola*
4. Anthers 2 ……..…….…… *Paphiopedilum*
- Anthers 1 …… 5
5. Anther firmly attached with column at its base, pollinia strictly sectile ……6
- Anther freely (movably) attached to column on apex (with a connective), pollinia may or may not be sectile ……7
6. Anther wilth a broad connective, canals elongate, spur of lip long ….. *Pecteilis*
- Anther with narrow connective, canals short; spur of lip short …. *Habenaria*
7. Pollinia granular, rarely mealy ……..……...…... 8
- Pollinia waxy or cartilaginous ……..…. 10
8. Plants tall, flowers large and showy, Anther incumbent at top of column…*Arundinea*

- Plants relatively smaller, flowers very small, stem decumbent and rooting at nodes, anther erect on back of column ……..... 9

9. Lip hypochile hairy within ……..……..…….. *Goodyera*

- Lip lacking hairs within …….…….. *Erythrodes*

10. Plant sympodial ……..……..…… 11

- Plant monopodial ……..… 38

11. Plants terrestrial or lithophytic, pollinia 4 or 8 ……..... 12

- Plants epiphytic, sometimes lithophytic, pollinia 2, 4 or 8 ……..……. 22

12. Pollinia 4 ……..... 13

- Pollinia 8 …… 17

13. Pollinia lacking a caudicle or stipe and viscidium ……..…… 14

- Pollinia with a caudicle or stipe and viscidium …… 16

14. Flowers usually resupinate …….…… *Liparis*

- Flowers usually not resupinate, rarely resupinate …… 15

15. Lip entire to obscurely lobed without transverse callus at base ….....*Crepidium*

- Lip prominently 3-lobed, with a transverse callus at base ..... *Dienia*

16. Sepals connate into a slender tube, Pollinia mealy and soft …… *Anthogonium*

- Sepals free, pollinia firm or hard ……..……. *Cremastra*

17. Sepals connate to form a broad fleshy cup ……..……. *Acanthephippium*

- Sepals free …… 18

18. Stem with one leaf …….…….. *Tainia*

- Stem with 2 or more leaves ……..…...… 19

19. Inflorescence densely pubescent, column with a prominent foot …….. *Eriodes*

- Inflorescence not densely pubescent, column lacking a prominent foot …. 20

20. Column distinctly winged ……...….. *Spathoglottis*

- Column not distinctly winged ……... 21

21. Column connate with lip base ……...… *Calanthe*

- Column attached to lip at base only ……..….. *Phaius*

22. Pollinia 2 ……..……..… *Cymbidium*

- Pollinia 4 or 8 ……...……..... 23

23. Pollinia 4 ……..……. 24

- Pollinia 8 ……..……..…… 35

24. Pollinia naked, with no caudicles or stipes ……...… 25

- Pollinia with caudicles or stipe…...……..…. 28

25. Inflorescence terminal, flowers lacking a distinct column foot, mentum or spur ……...…… *Oberonia*

- Inflorescence subterminal, lateral or arising from rhizome, flowers with a distinct column foot, lateral sepals forming a mentum ……...…… 26

26. Lip mobile, movably hinged to column foot, mentum saccate … *Bulbophyllum*

- Lip not mobile, not hinged at base, mentum spur-like ……..27

27. Pseudobulbs short, ovoid and erect, arising from a creeping rhizome, flowers solitary from between leaves …….. *Epigenium*

- Pseudobulbs ovate, elongate or clavate, often tufted, inflorescence racemose, flowers showy…….....……..…… *Dendrobium*

28. Leaves distichous, stems thick fleshy, not pseudobulbous ……...….. *Thunia*

- Leaves not distichous, stems pseudobulbous ……...…… 29

29. Lip without a spur or saccate base ……...…….. 30

- Lip with a spur, or saccate at base ……..……...… 33

30. Lip sigmoidally curved at base …….……. 31

- Lip not sigmoidally curved at base ……...…… 32

31. Lateral sepals free ……...….……. *Panisea*

- Lateral sepals adnate to column foot forming a mentum …….… *Polystachya*

32. Lip convolute around the column, entire to obscurely lobed, inflorescence 1- or 2-flowered, leaves deciduous, pseudobulbs annual ……..…… *Pleione*

- Lip not convolute around the column, 3-lobed, inflorescence more than 2 flowered, leaves not deciduous, pseudobulbs perennial ……..…. *Coelogyne*

33. Pseudobulbs forming singly from a creeping rhizome ……. *Bulleyia*

- Pseudobulbs forming a chain, usually jointed ……..…. 34

34. Column long, floral bracts deciduous ……..……...…….. *Otochilus*

- Column short, floral bracts persistent ……...……...….. *Pholidota*

35. Sepals connate to form a tube ……...…… *Cryptochilus*

- Sepals free ……..…… 36

36. Sac shaped hypochile separtated from epichile by a trasverse ridge …. ……...……..… *Agrostophyllum*

- Lip with no transverse ridge …….……... 37

37. Demarcating line between the foot and the lip clearly visible ……...….. *Eria*

- No demarcation line between column-foot and lip……..….. *Pinalia*

38. Pollinia strictly 4 …… 39

- Pollinia 2, rarely 4 ……. 49

39. Column with a distinctive foot ……..…...…… 40

- Column without a distinctive foot ……..……...…… 42

40. Lip with a spur ……...…… *Cleisocentron*

- Lip without a spur ……..…… 41

41. Plants without leaves/leafless …...……...…….. *Chiloschista*

- Plants with leaves ……..……...…….. *Thrixspermum*

42. Lip adnate to column and not freely movable/ mobile …….. 43

- Lip adnate to column and freely movable/mobile ……..…….…… 48

43. Lip without a spur at base ……...…….. *Vandopsis*

- Lip with distinct spur or sac at base …… 44

44. Spur with a longitudinal septum ……...… *Cleisostoma*

- Spur without a longitudinal septum ……..……. 45

45. Lip base without a transverse ridge or callus at entrance to spur …. ……...…… *Schoenorchis*

- Lip base with a transverse ridge or callus at entrance to spur ……..... 46

46. Lateral sepals much broader than dorsal sepal and petals ……..… *Renanthera*

- Lateral sepals usually similiar to dorsal sepal ……...…… 47

47. Spur pubescent inside, plant large …….……..…..... *Acampe*

- Spur not pubescent inside, plant relatively smaller …….……. *Smitinandia*

48. Sepals and petals thinner, less fleshy, lip with a spur-like protrusion …. ……..…..…… *Arachnis*

- Sepals and petals broadly ovate, fleshier, lip without a spur –like protrusion ... …….*Esmeralda*

49. Pollinia cleft or split ……. 50

- Pollinia cleft and porate ……..…… 56

50. Column without a foot ……...…….…….. 51

- Column with a distinctive foot …….…….……. 54

51. Stipes short and broad …… 52

- Stipes linear ……...…… 53

52. Pollinia 2 ……..…….…….…….*Vanda*

- Pollinia 4 in 2 pairs …….……*Hygrochilus*

53. Apex of stipes curved and S-shaped ……...……. *Uncifera*

- Apex of stipes simple .,…….…..…..…… *Rhynchostylis*

54. Leaves terete ……..…….....…. *Papilionanthe*

- Leaves not terete ……..…. 55

55. Inflorescence densely many flowered, pollinia 2 ……. *Aerides*

- Inflorescence laxly few-flowered, pollinia 2 sometimes 4 …… *Phalaenopsis*

56. Leaves flattened, lip with a spur or sac ……..…… *Gastrochilus*

- Leaves terete, lip with or without a spur .....…… …… 57

57. Lip with a long distinct spur ……..…… *Pendulorchis*

- Lip lacking a spur …… *Luisia*

ACAMPE Lindl.

Fol.Orch. 4. 1853.

The genus was described by John Lindley in 1853. The generic name is derived from the Greek word 'akampes' (rigid) as the flowers in the genus Acampe are small and brittle. About 10 species in India, China, S.E Asia and tropical Africa. 6 species in India, 5 in Nagaland and 3 species recorded by the author

Key to species

1. Lip epichile rugose, margin not wavy ……..……... *A. rigida*

- Lip epichile coarsely warty, margin wavy…… 2

2. Inflorescence paniculate, 8-15 cm; lateral lobes of lip protruding; column with two short, distinct horns.....…….....*A. ochracea*

- Inflorescence subumbellate, 1–4 cm, lateral lobes of lip not protruding; column lacking distinct horns.....…….... *A. praemorsa*

1. Acampe ochracea (Lindl.) Hochr. In Bull. New York Bot. Gard. 6:270. 1910; Hook. f., Fl. Brit. India 6:62. 1890; King & Pantl. in Ann. Roy. Bot. Gard. Calcutta 8: 219, t. 292. 1898; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 39. Fig. 11. 1998; Hynniewta, Kataki & Wadhwa. Orch. Nagaland (BSI), 27. 2000; Sant. & Kapad, Orch. Bombay, 234. 1966. *Saccolabium ochraceum* Lindl. in Bot. Reg. Misc. 2. 1842. *Acampe dentata* Lindl., Fol. Orchid. Acampe 4:3, no. 8. 1853. *Acampe griffithi* Rchb. f., in Flora 55 : 277. 1872.

Stems upto 90 cm long and 8 mm thick, covered by sheaths, internodes 1.5–1.8 cm long. *Roots* arising from nodes, long and fleshy. *Leaves* many, 10–24 x 1.8–2.8 cm, distichous, oblong, obtuse, fleshy, keeled, unequally and obtusely 2-lobed at

apex. *Inflorescence* 8–15 cm long, many flowered, paniculate, leaf-opposed, sub – erect; peduncle 1–1.5 mm thick, slender, branched, glabrous, sheathed at base. *Flowers* 0.8–1.2 cm across; sepals and petals yellow with ochre with irregular brown markings, lip 2-6 mm long, mid-lobe yellowish, brown spotted, spur yellow, brown spotted; pedicel and ovary slender, sparsely pubescent. *Dorsal sepal* 5–6 x 1.5–1.8 mm long, broadly oblanceolate, obtuse; lateral sepals 4–5 x 1.6–2.3 mm, oblong, weakly falcate, obtuse. *Petals* 4–4.4 x 1.4–1.8 mm, spathulate, obtuse. *Lip* 3–4 x 1.6–2 mm, 3-lobed; lateral lobes protruding, subtriangular, erect, dentate below; mid-lobe fleshy, deflexed, broadly oblong, obtuse, surface warty, margins wavy and undulate; *spur* 3–4 mm long, cylindric, hirsute within. *Column* ca 1.5 mm, thick, dentate, with 2 short distinct horns; anther cap dome shaped, beaked; pollinia 0.1 – 0.2 mm long; caudicle clavate, 1 mm long. *Fruit* 2–2.5 x 0.4–0.6 cm fusiform - ovoid, subsessile.

Colour Plate 1

Flowering: January- February

Habitat and Ecology: Epiphytic and growing on the main tree trunk exposed to full or diffused sunlight along with *Pholidota* sp. 800 – 1000 m

Distribution: India (Arunachal, Assam, Manipur, Meghalaya, Nagaland, Sikkim, South India); Bhutan, Myanmar, Nepal, Vietnam.

Specimens examined: Tsuyi riverbank Mukalimi village (Zunheboto district) HYJ173 (NU), Sikimi village (Kiphiri district) HYJ177 (NU).

2. Acampe praemorsa (Roxb.) Blatt. & Mc Cann, J. Bombay Nat. Hist. Soc. 35: 495 .1932; Kumar et. Monilal, Cat. Ind. Orch. 63 (1994); Misra, Orch. India. 280 (2007). (Figs: 4, 5, 6). *Acampe papillosa* (Lindl.) Lindl., Fol. Orchid. Acampe 4:2, no.5. 1853; Pradhan, Indian Orchid 2:41. Fig. 12; Hegde, Orchids of Arunachal Pradesh, 70. Fig. 94. 1984; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh 524. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland 28. 2000. *Saccolabium papillosum* Lindl. in Bot. Reg. t. 1552. 1841; Hook. f., Fl. Brit. India 6:63. 1890: King & Pantl., in Ann. Roy Bot. Gard. Calcutta. 8: 219. T. 290. 1898. *Gastrochilus papillosus* (Lindl.) O. Ktez., Rev. Gen. Pl. 2: 661. 1891.

Stems 25-30 cm, erect, stout and rigid. *Leaves* 7-14 x 1-1.3 cm, linear with obliquely notched and bifid apex, coriaceous, curved, conduplicate, sheathing at base. *Inflorescence* leaf opposed, 2-3cm long, many flowered, sub-umbellate. *Flowers* ca 1 cm across, yellowish with brown stripes. *Dorsal sepal* ca 6 x 3 mm, oblong, subacute

apex spreading. Lateral sepals 6 x 2.5 mm, oblong, sub-acute apex, slightly falcate. *Petals* 6 x ca 2mm, oblong sub-spathulate. *Lip* 10 x 3 mm, ovate-oblong, longer than sepals and petals, adnate to base of column, white with orange boundary or margins in the mid-portion with rose purple–transverse base in the centre, apical portion decurved, lateral lobes of lip not protruding. *Spur* cylindrical, hairy within. *Column* 3.5 mm long, lacking distinct horns. Pollinia 2, sub-acute.

Colour Plate 1

Flowering: December - January

Habitat and Ecology: Epiphytic and growing on the main tree trunk exposed to diffused sunlight

Distribution: India (Arunachal, Assam, Manipur, Meghalaya, Nagaland, Sikkim, South India); Bhutan, Myanmar.

Specimens examined: Tsaphimi village (Zunheboto district) HYJ175 (NU)

3. Acampe rigida (Buch.-Ham. ex Sm.) P.F.Hunt in Kew Bull. 24:98. 1970; Hook. f., Fl. Brit. India 6:62. 1890; King & Pantl. in Ann. Roy. Bot. Gard. Calcutta 8: 220, t. 292. 1898; Pradhan, Indian Orchid-II. 524. 1979; Kumar & Manilal, Cat. Ind. Orch. 63. 1994; Kataki, Orch. Meghalaya, 182. 1986; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh 41. Figs. 7, 8, 9. 1998; Hynniewta, Kataki & Wadhwa. Orch. Nagaland (BSI), 28. 2000. *Aerides rigida* Buch.-Ham. ex Sm. in A.Rees, Cycl. 39: 12. 1818. *Vanda multiflora* Lindl., Coll. Bot.: t. 38. 1826. Vanda longifolia Lindl., Gen. Sp. Orchid. Pl.: 215. 1833. *Acampe* longifolia (Lindl.) Lindl., Fol. Orchid. 4: 1. 1853. *Acampe multiflora* (Lindl.) Lindl., Fol. Orchid. 4: 1. 1853. *Saccolabium longifolium* (Lindl.) Hook.f., Fl. Brit. India 6: 62. 1890.

Stems up to 90 cm long, 9 mm thick, stout, unbranched, internodes 2 - 3 cm with distichous leaves. *Leaves* 16-38 x 3–4.6 cm ascending, lorate, fleshy, sheathing at base, apex obtuse and unequally bilobed. *Inflorescence* 7–12 cm, many flowered, axillary or leaf opposite, suberect. *Flowers* slightly fragrant, yellow with purplish brown transverse stripes, lip creamish white, with purplish brown longitudinal stripes. *Dorsal Sepals* 1-1.2 x 0.5–0.6 cm, obtuse, oblong; lateral sepals similar. *Petals* 0.9–1 x ca. 0.4 cm, narrowly obovate, obtuse. *Lip* 0.5–0.6 x 0.3-0.4 cm, thickly fleshy, 3-lobed, epichile rugose; lateral lobes subquadrate; mid-lobe suberect, ovateligulate, margin slightly undulate and irregularly incised, apex obtuse, slightly recurved; spur

conic, inside densely hairy, apex obtuse. *Column* ca 2mm thick, stout. *Fruit* suberect, cylindric or narrowly fusiform. **Colour Plate 1**

Flowering: August - October

Habitat and Ecology: Epiphytic and growing on tree branch exposed to full or diffused sunlight by the side of stream, 900-1000 m

Distribution: India (Arunachal, Assam, Meghalaya, Nagaland, Sikkim, South India); Southern and east Africa, Sri Lanka, Burma, China, Taiwan, Thailand, Cambodia, Vietnam, Peninsular Malaysia.

Specimens examined: Khashito village (Zunheboto district) HYJ174 (NUH), Chiang mai village (Tuensang district) HYJ176 (NUH)

ACANTHEPHIPPIUM Bl.

Bijdr. 353. 1825

The genus was described by K. L. Blume. In 1825. The generic name is derived from a combination of two Greek words, "akanthe" meaning spur or thorn, and "ephippion" meaning saddle referring to the shape and structure of the blade of the lip. Total about 13 species. 2 species found in India, 1 sp. in Nagaland and recorded by the author.

1. Acanthephippium striatum Lindl. in Bot. Reg. 24:41. 1838; Hook. f., Fl. Brit. India 5:816.1890; King & Pantl. in Ann. Roy. Bot. Gard. Calcutta 8: 112. T. 133. 1898; Hynniewta, Kataki & Wadhwa. Orch. Nagaland (BSI), 29. 2000.

Plants upto 50 cm tall. *Roots* 6-10 x 1-2.5 cm, densely pubescent. *Pseudobulb* 3- or 4-noded, narrowly ovoid with membranous sheaths. *Leaf* 1, rarely 2-leaved. 18-25 x 7-11 cm, 5-veined usually, elliptic to oblong, apex acute; petiole-like base ca 3cm, sheathing. *Inflorescence* 10-12 cm with several scalelike membranous sheaths; rachis densely 4-6-flowered; floral bracts 2.5-3cm, ovate-oblong, cymbiform, apex acute. *Flowers* tubular, 2-2.5cm across, creamy white with parallel red venation. *Dorsal sepal* 2-2.4 x 1-1.3 cm, 7-veined, elliptic, apex obtuse; lateral sepals 2.6-3.2 x 1.5-2 cm, 5-7-veined, oblong-triangular, slightly oblique, base adnate to column foot, apex subacute and recurved. *Petals* 2-2.5 x 1-1.2 cm 7-veined, oblong-obovate, fleshy, apex obtuse or acute. *Lip* 1.4-1.6cm across, adnate to apex of column foot, membranous, 3-lobed; lateral lobes 0.8-1cm, erect, falcate-triangular; mid-lobe ca 0.8

cm with red spots or blotches, ovate-triangular, small, margin slightly undulate, apex acute, recurved; disk with a solitary broad yellow ridge; mentum formed by bases of lateral sepals and column foot, conic and spurlike, tapering toward apex, longer than column. *Column* 1-1.4 cm; foot 2.8-3.5 cm, adnate to base of lateral sepals. anther cap ca 0.3 cm; pollinia ca 1.5 - 2mm. *Fruit* ca 3- 5cm long. **Colour Plate 1**

Flowering: May - June

Habitat and Ecology: Terrestrial and found on side of streams, 1500 – 1800m

Distribution: India (Arunachal, Assam, Manipur, Meghalaya, Nagaland, Sikkim), China, Indonesia, Malaysia, Nepal, Thailand, Vietnam.

Specimens examined: Hokiye village, Asukhomi village (Zunheboto district) HYJ198 (NUH), Chare village (Tuensang district) HYJ214 (NUH)

AERIDES Lour.

Fl.Cochinch. 525. 1790.

The genus was described in 1790 by Juan Lourerio. The generic name is derieved from the Greek word 'aer' and 'eides' (resembling), literally meaning 'childred of the air'.

About 10 species is found in India, 3 in Nagaland, and 2 sp. recorded by the author.

Key to species

1. Lip mid-lobe heart shaped and emarginated ……...…… *A. multiflora*
- Lip with well developed spur, greenish pink in colour…….....… *A. odorata*

1. Aerides multiflora Roxb., Coromandel. Pl. 3: 67. t. 271. 1820; Fl. Ind. 3: 475. 1832; Hook. f., Fl. Brit. India 6: 45. 1890; King & Pantl. in Ann. Roy. Bot. Gard. Calc. 8 : 212. t. 283. 1898. Pradhan, Indian Orch. 2: 546. 1979; Hegde, Orchids of Arunachal Pradesh, 70. Fig. 95. 1984; Kataki, Orch. Meghalaya 173. Pl. 61(3a&3b) & A(iii). 1986; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh 49. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI). 30. 2000. *Aerides affine* Lindl., Gen. & Sp. Orch. 239.1833. *Epidendrum geniculatum sensu* Buchanan-Hamilton ex Hook.f., Fl. Brit. India 6(1): 45. 1890.

Plant Erect to pendent. *Roots* 3–5 mm thick, fleshy, fibrous. *Stems* 9–14 cm long, many leaved, leaf sheaths persistent. *Leaves*, 6-10, 14-26 x 2-2.5 cm, linear oblong coriaceous; apex unequally and obtusely 2-lobed, weakly curved, channeled above and keeled beneath. *Inflorescecence* racemose or paniculate, arising from within

leaf sheath, densely many flowered; peduncle 8–12 cm long, sheathed, glabrous; heaths tubular, semi circular, 5 – 8 mm long; rachis 15 – 26 cm long, glabrous; floral bracts triangular-ovate, 2–4 mm long. *Flowers* 2 – 3.3 cm across, fragrant; sepals and petals white to pinkish purple, apex spotted with darker purple, lip light purple, column white; pedicel and ovary 4–6 mm long. *Sepals* similar, oblong, elliptic-oblong to orbicular, rounded, 0.8–1.5 x 0.4–1 cm; lateral sepals decurrent on the column foot. *Petals* 0.8–1.5 x 0.7–1 cm, oblong, elliptic - oblong to orbicular. *Lip* 1.3–1.4 x 0.8–1.1 cm, clawed, geniculate, 3-lobed, convex, margins recurved; lateral lobes erect, semi – circular; mid-lobe heart-shaped, cordate to hastate-ovate, rounded, slightly convex above; callus at base of mid-lobe, fleshy, incurved, 2-lobed; *spur* straight, compressed, 0.3 – 0.5 cm long. *Column* apex beaked, 2–3 mm long, beak 2.5–3.4 mm long; foot with 2-rounded auricles; stipe glandular-pubescent, ca 2.5 mm long; viscidium subquadrate; pollinia 0.6 – 0.8 mm across. *Fruit* stalked, ovoid, 1.5 x 0.6 – 0.8 cm.

Colour Plate 1

Flowering: April - June

Habitat and Ecology: Epiphytic and growing on the main tree trunk exposed to diffused sunlight, 300 – 600 m.

Distribution: India (Arunachal, Assam, Meghalaya, Nagaland, , Sikkim, Andaman & Nicobar Islands, Tamil Nadu, Orissa, West Bengal) Bhutan, Myanmar, Cambodia, Java, Laos, , Malaya, Thailand, Vietnam.

Specimen examined: Chare village (Tuensang district) HYJ224 (NUH)

2. Aerides odorata Lour., Fl. Cochinch. 2: 525. 1790; Lindl. in Bot. Mag. t. 4139.1845; Hook. f., Fl. Brit. India 6: 47. 1890; King & Pantl. in Ann. Roy. Bot Gard. Calcutta 8: 212. t. 282. 1898; Pradhan, Indian Orch. 2: 549. 1979; Hegde, Orchids of Arunachal Pradesh, 70. Fig. 96. 1984; Hegde in Jour. Bombay Nat. History Soc. 82(2): 117. 1985; H.J. Chowdhery, Orchid Fl. Arunachal Pradesh 49. Fig. 17. 1997; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI) 30. 2000. *Epidendrum odoratum* (Lour.) Poiret in Lamarck, Encycl. Suppl. 1:385. 1810. *Aerides cornutum* Roxb., Fl. Ind. 3: 472. 1832.

Plant erect to pendant. *Stems* 10–32 cm long, drooping, stout, branched, leaf sheaths persistent. *Roots* 3-6 mm thick. *Leaves* many, 13-22 × 2.2-4.2 cm, thickly leathery, apex round-unequally bilobed, obtuse, leaf blade broadly lorate.

Inflorescence 15-25 cm, pendent, numerous, racemose, densely 25-30 flowered; peduncle 4–6 mm long, stout, glabrous, sheathed, sheaths broadly ovate, obtuse, distant; rachis glabrous, stout, 20 cm long; floral bracts 4–8 mm long, lanceolate, acute. *Flowers* 2–2.5 cm across, fragrant, pale pink to almost white, often tipped and spotted purple, spur apex greenish yellow; pedicel and ovary 1.3–2.5 cm across, slender. *Dorsal sepal* 1.1–1.2 x 0.6–0.8 cm, oblong, obtuse; *lateral sepals* 1–1.3 x 0.6–1.0 cm, narrowly triangular-lanceolate, decurrent on the column foot. *Petals* 1.1–1.2 x 0.6–0.8 cm, narrowly oblong, obtuse. *Lip* ca 1.5 cm, immovable, spurred, 3-lobed, almost enclosing column, spurred, fleshy; lateral lobes ca 15×10 mm, erect, obovate-cuneate, erect, weakly wedge-shaped to subquadrate, margins entire to dentate, irregularly toothed, apex obtuse-rounded; mid-lobe short, 4-5 mm wide, smaller than lateral lobe, incurved, oblong-lanceolate, acute, margins entire to erose; disc with 2 small keels around the nectar and 2 curved appendages in the mouth; *spur* 1–1.2 cm long, prominent, well developed, bent forward, narrowly horn-shaped. *Column* 2-3 mm long; foot 5–6 mm long; anther cap obtuse, beaked, ca 3 mm. fruit 2.0–3 x 1–1.4 cm, ovoid, shortly stalked.

Colour Plate 1

Flowering: May - June

Habitat and Ecology: Epiphytic and growing on the main tree trunks exposed to full or diffused sunlight. 500-1300 m

Distribution: India (Arunachal, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Orissa, Tamil Nadu, Uttar Pradesh, West Bengal, Bihar), Bangladesh, Bhutan, Borneo, Myanmar, Cambodia, Sri Lanka, Laos, Nepal, Vietnam.

Specimens examined: Nunumi village (Zunheboto district) HYJ178 (NUH), Chare village (Tuensang district) HYJ213 (NUH)

AGROSTOPHYLLUM Blume

Bijdr. 6: t. 3, 8: 368. 1825.

The genus was described by Carl Ludwig Blume in 1825. The generic name is derived from Greek word ‘agros’ (field) and ‘phyllon’ (leaf) referring to the grass like leaves in some species.

4 species in India, 3 in Nagaland, 1 sp. recorded by the author

1. Agrostophyllum callosum Rchb.f. in Seem. Fl. Vit. 296. 1868; Hook. f., Fl. Brit. India 5: 824. 1890; King & Pantl. in Ann. Roy. Bot. Gard. Calc. 8 : 155. T. 212. 1898; Hynniewta, Kataki & Wadhwa. Orch. Nagaland (BSI), 34. 2000.

Stems 25 – 40 cm, distant, sub-clavate, many leaved, stems wider at apex than base; rhizome sheathed, stout, branched, bearing shoots 1 – 3.5 cm apart; sheaths cylindric, 1 – 2.5 cm long. *Leaves* 7 - 17 x 0.8 – 1.0 cm, linear-lanceolate, many up stem, alternate, linear-oblong, tapering gradually to emarginated apex, apex notched, sessile and sheathing at base. *Inflorescence* 2 – 3 cm across, capitates-globose, densely many flowered; floral bracts 3 – 6 x 2 – 3 mm, spathe-like, subacute, membraneous. *Flowers* 4 – 6 mm long; sepals, petals and lip pinkish yellow, column purplish, pollinia yellow; pedicel and ovary 7-9 mm long. S*epals* ca 4 x 3 mm, oblong or elliptic, obtuse, concave; *petals* ca 3.5 x 2 mm, linear-oblong or orbicular – oblong ; *lip* ca 5.5 mm long, adnate to the foot of the column, yellowish with scattered, minute, pink dots; side lobes rounded; mid lobe sub-orbicular; apex emarginated; callus 1, large, bi-lobed; *column* ca 2 mm long; foot very short; apex narrowly winged; *pollinia* attached to elastic threads arising from a viscid appendage. **Colour Plate 2**

Flowering: June - August

Habitat and Ecology: Epiphytic and found growing on the shade of trees exposed to diffused sunlight or very less sunlight.

Distribution: India (Arunachal, Assam, Meghalaya, Nagaland, Sikkim, West Bengal), Nepal, China, Thailand, Bhutan, Myanmar.

Specimens examined: Pangsha village (Tuensang district) HYJ194 (NUH), Sukhalu village, Asukhomi village (Zunheboto district) HYJ056 (NUH)

ANTHOGONIUM Wall. ex Lindl.

Gen. Sp.Orchid. 425.1840

The genus was described by John Lindley in 1840. The generic word is derived from the Greek word ‘anthos’ (flower) and ‘gonua’ (angle), referring to the nature of the flowers.

1 species in India and Nagaland and recorded by the author.

1. Anthogonium gracile Lindl., Nat. Syst. 341. Ed. 2. 1836; Hook.f., Fl. Brit. India. 8:822. 1890; King & Pantl. in Ann. Roy. Bot. Gard. Calcutta. 8: 96. t. 134. 1898; Pradhan, Indian Orch. 2: 247. 1979; Hegde, Orchids of Arunachal Pradesh, 43. 1984;

Kataki, Orch. Meghalaya, 108. Pl. 31(3a & 3b) & A (ii). 1986; H.J. Chowdhery, Orchid Fl. Arunachal Pradesh 65. fig. 28. 1997; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI). 45. fig. 8. 2000. *Anthogonium griffithii* Rchb. f. in Bonplandia 2:90. 1851. *Anthogonium corydaloides* Schltr. in Feddes Repert. Spec. Nov. Regni Veg. Beih. 4:66, 230. 1919.

Plant upto 30 cm long. *Pseudo-bulbs* 0.5–1.6 x 0.6–1.7 cm, ovoid, erect, bearing tubular sheaths. *Stem* 2 – 5 leaved at apex, 3 – 6 cm long, sheathed at base; sheaths ca 2.5 cm long, clasping. *Leaves* 9–15 x 0.7–2.8 cm, oblong–lanceolate to narrowly elliptic, acuminate. Many veined. *Inflorescence* 20-40 cm long arising from side of pseudobulb, laxly 4–6 flowered; peduncle 8–32 cm long, slender, glabrous, intermittently sheathed; sheaths 0.5–2 cm long, tubular; rachis 1 – 9 cm long, glabrous; floral bracts 0.5–0.7 x 0.1–0.15 cm, lanceolate, long- acuminate. *Flowers* 1–1.7 cm long, dark pink to light pink, lip spotted with dark purple, anther bright yellow; pedicel and ovary 1–1.7 cm long. *Sepals* weakly falcate, oblanceolate, subacute, connate in lower half to form a narrow cylindric tube, upper half free, spreadin; *Dorsal* sepal 15×2 mm, oblong-lanceolate, apex obtuse; lateral sepals falcate-spatulate, 15×4 mm, apex acute. *Petals* 1–1.7 cm long, elongate-spathulate, linear at base. *Lip* ca 1–0.7 x 0.9 cm, adnate to column base, simple; base narrow, expanding towards apex; apex obscurely 3-lobed, emarginated. *Column* ca 8 mm long, slender, apex dilated, abruptly bent, narrowly 2 –winged. *Fruit* 1–2.3 x 0.3– 0.5 cm, narrowly ellipsoid. **Colour Plate 2**

Flowering: August - September

Ecology: Terrestrial and growing along with grasses on roadside

Distribution: India (Arunachal, Assam, Meghalaya, Nagaland, Sikkim) Bhutan, Myanmar, Cambodia, China, Laos, Nepal, Thailand, Vietnam.

Specimen examined: Asukhomi village (Zunheboto district) HYJ199 (NUH)

ARACHNIS Bl.

Bijdr. 6: t. 3; 8: 365. 1825.

The Genus was described by Carl Ludwig Blume in 1825. The generic name has been derived from the Greek word' arachne' (spider' due to resemblance of the flower to a spider.

About 4 species is found India, 3 in Nagaland, (1 sp. reported by the author as a new record for Nagaland and 1 sp. as a new record for India). Total 5 spp. in India and 3 spp. in Nagaland.

Key to species

1. Flowers white with different shades of pink ..... *A. senapatiana*
- Flowers dirty yellow, with or without markings..... 2
2. Sepals and petals with deep brownish-maroon cross markings……..……. *A. labrosa* var. *labrosa*
- Sepals and petals uniformly dirty yellow without any marking ....…….. …… *A. labrosa* var. *zhaoi*

1. Arachnis labrosa (Lindl. & Paxton) Rchb. f., Bot. Centralbl. 28:343. 1886. ; Hook.f., Fl. Brit. India 6: 28.1890; King & Pantl. In Ann. Roy. Bot. Gard. Calc. 8: 210 t. 280.1898; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI). 47. 2000. *Arrhynchium labrosa* Lindl. & Paxton in Paxtons Fl. Gard.1.: 142. 1850. *Armadorum labrosa* (Lindl. & Paxt.) Schltr., in Fedde Repert.10: 177.1911. *Arachananthe bilinguis* Benth. In Benth. & Hook.f., Gen. Pl. 3: 573. 1883.

Plant 40-100cm long. *Roots* thick, axillary. *Stem* erect, covered by leaf sheaths. *Leaves* many, 15-27 x 2-2.8 cm, oblong, apex unequally 2- lobed, sessile, joined, distichous, bases overlapping. *Inflorescence* axillary, arising from within leaf sheaths, slender, very long, branched, 3 to 6 flowered; peduncle sheathed, 25-80 cm long; ovate-lanceolate, subacute, 1-1.3 cm long; floral bracts ovate, subacute, 6-9 x 3-4 mm. *Flowers* 2-3.4 cm across; *sepals* and *petals* pale yellow with deep brown-maroon markings, lip cream-yellow, column white; *pedicel* and *ovary* slender, 1-2 cm long. *Dorsal sepal* 1.2- 1.5 x 0.2-0.25cm, oblong, subacute; *lateral sepals* 1.2-1.8 x 0.2 cm, oblong- lanceolate, acute. *Petals* 0.8-1.1 x 0.2 cm, oblong- spathulate, acute, *Lip* obscurely 0.6-1 x 0.2-0.3 cm long 3-lobed, shortly clawed, fleshy, spurred; lateral lobes short, horn-like to truncate, 0.8 -1mm long; mid -lobe oblong-lanceolate, with a fleshy, oblong, 2-layered , obtuse protuberance, subglobose at apex. *Spur* 2-2.5 x 1.1.2mm, horn-like, *Column* 3-4mm long slender, straight. **Colour Plate 2**

Flowering: August - September

Habitat and Ecology: Epiphytic and found Growing on the main tree trunk exposed to full sunlight, 400 – 600 m.

Distribution: India (Arunachal, Assam, Nagaland, Meghalaya, Sikkim), Bhutan, China, Vietnam.

Specimen examined: Lumami Village, Mishilimi village (Zunheboto district) HYJ227 (NUH); HYJ243 (NUH)

2. Arachnis labrosa var. zhaoi (Z. J. Liu, S. C. Chen & S. P. Lei) S.C. Chen & J.J. Wood, Fl. China 25: 466. 2009. *Arachnis zhaoi* Z. J. Liu, S. C. Chen & S. P. Lei, Acta Bot. Yunnan. 30: 529. 2008.

Stems 30 - 80 cm long, 0.7-1.5 cm thick, rigid with many nodes with distichous leaves. *Leaf* blade lorate, leathery, 22–33cm long, 2.1–3.2 cm broad, Apex unequally rounded – bilobed, with ample xicaul sheaths at base, persistent. *Inflorescence* arising from within leaf sheath, ascending, racemose, 40–90 cm long, 10–23 flowers; floral bracts reddish brown, broadly ovate, persistent, 5–9 mm long, apex obtuse; *pedicel* with 1.5–2.4 cm long, yellowish green,; *Flowers* dirty yellowish green; lip with yellow side lobes and yellow-whitish midlobe; *sepals* oblong, 1.3 – 2.0 cm long, 3-4 mm broad, having dorsally thick midrib, apex acute and curved backward; *petals* narrowly falcate, 1.3-1.7 cm long, 4-5 mm broad with slightly thicker midrib dorsally, apex acute and slightly curved backward; lip fleshy 1.2-1.5 cm long, 3 lobed; side lobes small, ca. 2mm broad, apex obtuse; midlobe fleshy, ligulate, 6-9 mm long, 3-5 mm broad, apex acute, base concave; *spur* 2-3 mm long; *column* 3-6 mm long.

Colour Plate 2

Flowering: July - August.

Habitat and Ecology: Epiphytic and found growing on *Lithocarpus* sp. near river side. 500m

Distribution: India (Nagaland), China

Specimen examined: Tsuyi riverside, Mukalimi Village (Zunheboto district) HYJ 54 (NUH).

3. Arachnis senapatiana (Phukan & A. A. Mao) Kocyan & Schuit., Phytotaxa 161(1):62. 2013. *Armodorum senapatianum* Phukan & A. A. Mao, Orchid Review 110:298.2002; Nelumbo 51: 229. 2009.

Stems 70-90 cm long, 1.8-2.3 cm thick. *Leaves* distichous, coriaceous, linear, oblong bilobed at apex, 17-32 x 2.3-3.1 cm. *Inflorescence* axillary, 24-30 cm long, simple, rigid, cylindrical, laxly twelve-flowered: bracts scarious, triangular, brown, 7-10mm long. *Flower* 30-50 mm across, creamy white with shades of pink, fragrant, spreading. Ovary and pedicle 17-20 mm long. *Sepals* linear-oblong, trinerved; dorsal 23-34 x 5-8 mm, subacute to obtuse; laterals 26-35 x 4-7mm, acute, keeled dorsally. *Petals* 23-33 x 6-8 mm, oblanceolate, acute, five nerved. *Lip* 10-13 mm long, shorter than sepals and petals, three-lobed, with two basal callus; side lobes 6-8 x 3-4 mm, erect, oblong, obtuse, deep pink or purple – streaked; mid-lobe marked with deep pink or purple, 6-10 x 4-6 mm, deflexed, oblong, serrulate at apex with a small beak facing downwards; spur prominent , 5-7 mm long, 3 mm wide , touching the beak of the mid-lobe. *Column* 6-8 x 4-5 mm thick, fleshy spotted with purple, *pollinia* two.

Colour Plate 2

Flowering: June- July

Habitat and Ecology: Epiphytic sand found growing in subtropical broad-leaved hill forest dominated by *Quercus griffithii* and *Lithocarpus* e*legans* 1700 m.

Distribution: India (Manipur, Nagaland, West Bengal)

Specimen examined: Asukhomi village (Zunheboto district) HYJ032 (NUH)

ARUNDINA Bl.

Bijdr.6: t.2; 8; 401. 1825

The genus was described by Carl Ludwig Blume in 1825. The generic name is derived from the Greek word ‘arundo’ (a reed), referring to the presence of reed-like stem.

1 species in India and Nagaland and recorded by the author.

1. Arundina graminifolia (D.Don) Hochr. In Bull. New Tork Bot. Gard. 6: 270. 1910; Seidenf. & Smitnd. Orch. Thailand, 2(1): 184. 1959; Hook. f., Fl. Brit. India 5: 857. 1890; King & Pantl. in Ann. Roy. Bot. Gard. Calc. 8: 112. T. 156. 1898; Kataki, Orch. Meghalaya, 142. Pl/ 52 (i) & (ii). 1986; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 74. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 47. 2000. *Bletia graminifolia* D. Don, Prodr. Fl. Nepal. 29. 1825. *Arundina Chinensis* Bl., *op. cit*. 402. 1825. *Arundina bambusifolia* Lindl. Gen. & Sp. Orch. 125. 1830.

Plant 70 - 190 cm tall. *Stems* 0.8 – 1.4 cm wide, long, erect or semi erect, cane –like, leafy throughout. *Leaves* 15 – 25 x 2.0 – 2.5 cm, lanceolate or oblong-lanceolate, acuminate, distichous, sessile, bases clasping, sheathed at base. *Inflorescence* 15 – 20 cm long, racemose; *panicle* branched , erect or sub-erect, few to many flowered with showy flowers; peduncle glabrous, intermittentely sheathe; rachis glabrous, 12 – 23 cm long; floral bracts 0.8 – 1 x 0.4 – 0.5 cm, lanceolate, acute. *Flowers* 3 – 5 cm across, magenta to pinkish/purplish white, with a yellow throat; pedicel and ovary 2 – 3 cm long; Floral bracts ca 1.5 cm long, lanceolate, acute, brown and keel like. *Sepals* 3.0 – 3.5 x0.8 – 1.2 cm, lanceolate or ovate - lanceolate, acute. *Petals* 3.2 – 3.5 x 1.3 – 1.6 cm, orbicular-ovate, acute. *Lip* 3.8 – 4.2 cm long, dark pinkish purple, 3-lobed; side lobes convulate covering the column; midlobe longer than the side lobes; 3 lamellae, undulate. *Column* 3 – 3.5 cm long. *Pollinia* oblong 8, unequal, 4 large and 4 smaller. *Fruit* 3.4 – 7 x 0.8 – 1.4 cm, long-ellipsoid.

Colour Plate 2

Flowering: July - September

Habitat and Ecology: Terrestrial and found growing along with grasses on roadside. 1800-2300m

Distribution: India (Arunachal, Assam, Meghalaya, Nagaland, Sikkim, West Bengal), Bhutan, Myanmar, Cambodia, Laos, Nepal, Thailand, Sri Lanka, Malaysia, Vietnam.

Specimens examined: Asukhomi village, Naltoqa village (Zunheboto district) HYJ230 (NUH); HYJ248 (NUH), Longmatra (Kiphiri district) HYJ179 (NUH)

BULBOPHYLLUM Thou.

Hist. Pl. Orch., tabl. Esp. 3. Sub. u.1822

The genus was described by in 1822 by Aubert du Petit-Thouars. The generic name is derived from the greek words '*bulbos*' (bulb) and '*phyllon'* (leaf). It is one of the largest genera with about 1000 species in S.E. Asia, Africa, Australiasia, Madagascar and tropical America.

About 1900 species and 100 species are recorded from India, 36 Spp. in Nagaland and 17 Spp. reported by the author.

Key to species

1. Pseudobulbs with 2 leaves ……...…. 1
- Pseudobulbs with 1 leaf ……3

2. Inflorescence laxly flowered; lateral sepals more than 1.4 cm long……
……..… *B. viridiflorum*

- Inflorescence densely flowered; lateral sepals less than 0.7 cm long …….
……..... *B. cariniflorum*

3. Pseudobulbs strictly 1-flowered ……...… 4

- Pseudobulbs 1, 2- or many flowered ……..…….. 5

4. Lip simple, yellow …… *B. affine*

- Lip 3-lobed, red ……...… *B. monanthum*

5. Inflorescence laxly 1 or 2-flowered ……...…..…… 6

- Inflorescence cylindric, capitate, densely many flowered ……...…… 7

6. Leaves more than 4.5 cm width, oblong-elliptic, apex mucronate .....
……*B. leopardinum*

- Leaves less than 2.5 cm width, narrowly oblong, emarginated… *B. umbellatum*

7. Inflorescence capitate ……..…… *B. odorotissimum*

- Inflorescence cylindric, racemose …… 8

8. Pseudobulbs clustered on rhizome …….. *B. cylindraceum*

- Pseudobulbs distant along rhizome ……..……. 9

9. Scapes shorter than pseudobulbs; flowers reddish brown, lip yellow ……
…….. *B. crassipes*

- Scapes longer than the pseudobulbs; flowers purplish-brown, lip dark brown ...
…….. *B. careyanum*

10. Pollinia naked, lacking stipes ……..……..….. 12

- Pollinia with stipes ……...….. 11

11. Stipes linear; viscidia 2 ……..……. *B. candidum*

- Stipes Y-shaped or horseshoe-shaped; viscidium single ……...… *B. sunipia*

12. Lateral sepals joined only at base……..... 13

- Lateral sepals connivent throughout, or forming a closed tube…….. 14

13. Inflorescence laxly racemose ……. *B. reptans*

- Inflorescence umbellate to sub-umbellate …….. *B. elatum*

14. Lateral sepals forming a closed tube ……. *B. helenae*

- Lateral sepals connivent but not forming a closed tube ……. 15

15. Flowers glabrous; dorsal sepal and petals brick red, lateral sepals yellow to orange ……..…..…… *B. retusiusculum*

- Flowers pubescent; dorsal sepal and petals purple veined, covered with purple hairs, lateral sepals purple …… *B. rothschildianum*

1. Bulbophyllum affine Lindl., Gen. Sp. Orchid. Pl. 48. 1830; Reichenbach f., in Walp. Ann. 6: 246, 1861; Hooker f. 756:1890; King & Pantling 67. PI. 91. 1898; Gagnepain 270:1934; Merrill & Metcalf 7:1945; T. A. Rao 117:1959; Seidenfaden & Smitinand fig. 285. 378:1961; Panigrahi & Joseph 156:1966; Rao & Balakrishnan 205:1973; Garay & Sweet 134:1974. *Sarcopodium affine* (Lindl.) Lindl., Paxt. FI. Gard. 1:155, 1850. *Phyllorchis affinis* (Lindl.) Kuntze., Rev. Gen. 2:677, 1891. *Bulbophyllum kusukuensis* Hayata, Ic. PI. Form. 4: 48, Fig. 19, 1914.

Rhizome ca 4 mm in diam., stout, covered with scalelike sheaths, rooting from nodes. *Pseudobulbs* 5-8 cm apart on rhizome, erect, subcylindric, 2-4 x 0.4-0.7 cm in diam., with a terminal leaf. *Leaf* 1, 6-19 x 1-3 cm, oblong, leathery or fleshy, base contracted into petiole ca 1.5cm, apex obtuse and slightly emarginate. Scape from node of rhizome and base of pseudobulb, 4-6 cm. *Inflorescence* 1-flowered, base with 3-5 sheaths; pedicel and ovary 3.5-7 cm. *Flower* thickly textured; sepals and petals pale yellow with purplish stripes, lip purplish orange. *Dorsal sepal* 1.5-1.8 x 0.4-0.5 cm, lanceolate, apex acute; lateral sepals sub-similar, falcate-lanceolate, base adnate to column foot forming a broad mentum, apex acute. *Petals* 1.1-1,4 x 0.3-0.4 cm, lanceolate, margin entire, apex acute. *Lip* ca 1 cm long, lanceolate, fleshy, adaxially glabrous, grooved at base, hinged to end of column foot by a mobile joint, apex acuminate, slightly recurved. *Column* ca 0.4 cm, stout; stelidia inconspicuous; foot ca 0.4 cm, without free part; anther cap ca 0.3 cm, adaxially finely papillate.

Colour Plate 3

Flowering: May - June

Habitat and Ecology: Epiphytic and found growing on tree branch with full head sunlight. 600-800m.

Distribution: India (Arunachal, Assam, Manipur, Meghalaya, Nagaland, Sikkim, West Bengal) Bhutan, China, Japan Laos, Nepal, Thailand, Vietnam

Specimens examined: Chare village (Tuensang district) HYJ190 (NUH), Lumami village (Zunheboto district) HYJ216 (NUH)

2. Bulbophyllum candidum (Lindl.) Hooker f., Fl. Brit. India 5(2): 770. 1890. *Sunipia candida* (Lindl.) P.F. Hunt in Kew Bulletin 26(1): 183. 1971. *Ione candida* Lindley, Fol. Orchid. Ione 2: 3 no. 7. 1853; Pearce & Cribb, Orch. Bhut., 483. 2002.

Rhizome creeping, ca 1.5 mm in diam. *Pseudobulbs* 1.5-2 cm apart on rhizome, 1-1.5 x 0.5-6 cm in diam., ovoid. *Leaf* 1, 3-6 x 0.4-0.6 cm, erect, narrowly oblong, leathery, apex obtuse and retuse; petiole short. *Inflorescence* 6- 8 –flowered from base of pseudobulb, scapes solitary or in pairs, erect, 4-6 cm; peduncle 2-4 cm, yellowish green, slender, with 2 or 3 tubular sheaths ca 5 mm; raceme ca 3 cm, floral bracts narrowly lanceolate, 5-7 mm, membranous, apex acuminate; pedicel and ovary 4-7 mm. *Flowers* thinly textured, translucent green, lip white to greenish. *Dorsal sepal* 0.5-0.6 x ca 0.2 cm, ovate-lanceolate, apex acuminate; lateral sepals similar to dorsal sepal, lower edges connate to each other except apices. *Petals* ca 0.3 x 0.2 cm, ovate, membranous, 1-veined, margins erose, apex acute. *Lip* ca 0.6 x ca 0.2 cm, ovate-lanceolate, abruptly contracted near middle, adaxially with 1 thickened keel from base to apex, margins erose-lacerate in basal half, apex obtuse. *Column* and foot ca 0.2 cm. *Pollinia* in pairs each with a stipe and a viscidium.

Colour Plate 3

Flowering: August

Habitat and Ecology: Epiphytic and found growing on tree branch in an undisturbed forest. 1800-2200m

Distribution: India (Arunachal, Assam, Manipur, Meghalaya, Nagaland,) Bhutan, China

Specimens examined: Pangsha and Melangkiur village (Tuensang district) HYJ023 (NUH), Tsuruhu village (Zunheboto district) HYJ094 (NUH)

3. Bulbophyllum careyanum Spreng, Syst. Veg. 3: 732. 1828; Hook. f., Fl. Brit. India 5: 760. 1890; King & Pantl. in Ann. Roy. Bot. Gard. Calcutta 8: 71. t. 97. 1898; Pradhan, Indian. Orch. 2: 398, 1979; Deva & Naithani, Fl. N. W. Himalaya. 211. 1986; Kataki. Orch. Meghalaya, 73. Pl. 16(1). 1986; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 95. 1998. *Anisopetalum careyanum* Hook. Fl. Exot. T. 149. 1825. *Pleurothlis purpurea* D. Don, Prodr. Fl. Nepal, 33. 1825. *Bulbophyllum neigherrense* Sensu Arora in Indian J. for. I: 298. 1978 (non. Wight). *Tribrachia purpurea* (D. Don) Lindl., Call. Bot. Sub. t. 419. 1826. *Bulbophyllum cupreum* auct. Non Lindl.: W. J.

Hook., Mag: t. 5316. 1862. Non *Bulbophyllum careyanum* Hook. Bot. Mag. t. 4166. 1845.

Rhizome ca 0.4 cm diam., woody, stout. *Pseudobulbs* 2-4 cm long, ovoid, acuminate at apex, erect, wrinkled, spread about ca 5 cm on rhizome. *Leaves* 10 22 x 2.0-5.4 cm, oblong, acute, sub-sessile, tapering both ends, thick. *Scape* more or less as long as pseudobulb, stout, bearing many lanceolate bracts, with densely-flowered decurved raceme of 4.5-7.0 cm long; floral bract 0.5-0.6 x 0.25-0.30 cm long, oblong-lanceolate, acute, 1-veined, longer than the stalked ovary. *Inflorescence* 5-7 cm long, arising from the base of the pseudobulb, densely many flowered. *Flowers* 0.5 cm across, dark maroon, shining. *Dorsal sepal* 0.45-0.60 x 0.25 cm, oblong, acute, 3-nerved. Lateral sepals 0.7 – 0.85 x 0.3 cm, elliptic, acute, 5-nerved. *Petals* 0.3-0.45 x 0.2 cm, ovate, acute, 1-veined. *Lip* 0.5 cm long, lanceolate, maroon, 3-lobed, lateral lobes 0.2-0.3 cm long, linear, acute, much stronger than the midlobe; mid-lobe 0.5-0.7 cm long, lanceolate, obtuse, with a broad base. *Column* 0.2-0.3 cm long, stout, with two apical teeth and a curved column foot. *Pollinia* 4, obovoid.

Colour Plate 3

Flowering: September - October

Habitat and ecology: Epiphytic and found growing on bottom tree trunk in a disturbed forest. 1600m

Distribution: India (Arunachal, Assam, Meghalaya, Nagaland, Sikkim, West Bengal, Western Himalaya), Bhutan, Nepal, Thailand, Burma.

Specimens examined: Wangshoi village (Tuensang district) HYJ180 (NUH)

4. Bulbophyllum cariniflorum Rchb. f. in Walpers, Ann. Bot. Syst. 6:253. 1861; *Bulbophyllum densiflorum* Rolfe in Bull. Misc. Inform. Kew 1892: 139. 1892; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 162. fig. 95. 1998.

Rhizome creeping. *Roots* clustered from pseudobulb base, filiform. *Pseudobulbs* 1.8–3 x 1.8–2.6 cm, ovoid to cylindric, ridged, flattened. *Leaves* 2, 8–16 x 2.5–3.3 cm, present at flowering, fleahy, elliptic to broadly elliptic, acute; petiole 0.7–0.9 cm long, channeled. *Inflorescence* basal from pseudobulb, racemose, 15–28 flowered; peduncle 6–9 cm long, erect, sheathed, glabrous; sheaths 0.8–1.0 cm, lanceolate, acute; rachis 3–4.5 cm, decurved, glabrous; floral bracts 2–3 x ca 1 mm, lanceolate, acute. *Flowers* ca 6–8 mm across, foetid; sepals and petals light greenish yellow, lip bright yellow; pedicel and ovary 3–4 mm long, glabrous. Dorsal sepal 3-

4.5 x 2–3 mm, ovate, concave; lateral sepals 4–5 x 3–4 mm, broadly ovate, apex acute, keeled, adnate to the column foot. Petals 2.5–3 x ca 1 mm, oblong, acute. *Lip* 3–3.5 x 1.5–2 mm, simple, oblong, margins entire, base orbicular to wedge shaped, fleshy. *Column* with 2 steledia; foot curved.

Colour Plate 3

Flowering: July - September

Habitat and Ecology: Epiphytic and found growing on tree trunk in an undisturbed forest.

Distribution: India (Arunachal, Assam, Meghalaya, Nagaland, West Bengal) Nepal.

Specimens examined: Pangsha village (Tuensang district) HYJ181 (NUH)

5. Bulbophyllum crassipes Hook. f., Fl. Brit. India 5: 760. 1890. *Phyllorchis crassipes* (Hook. f.) Kze., Rev. Gen. 2: 677, 1891. *Bulbophyllum careyanum* var. *crassipes* (Hook.f.) Pradhan, Indian Orch.: Guide Identif. Cult. 2: 713, 1979.

Rhizome ca 4 mm in diam., stout. *Roots* ca 1.5 mm, arising from base of pseudobulbs. *Pseudobulbs* 2-4 cm apart on rhizome, 2.5-3.5 x 1.5-2.5 cm in diam., ovoid or conic. *Leaf* 1, terminal on pseudobulb, 12-16 x 2-3 cm, oblong, fleshy or thickly leathery, apex obtuse and slightly emarginated; petiole ca 1.5 cm. *Inflorescence* scape from base of pseudobulb, 3-4 cm; arching raceme 2-7 cm, densely many flowered; peduncle stout, base with 3 or 4 sheaths; floral bracts pale brown, ovate-lanceolate, 0.4-0.6 cm, apex acute; pedicel and ovary ca 0.4 cm. *Flowers* yellowish brown and dotted, many, opening widely. *Dorsal sepal* 0.4-0.6 x ca 0.3 cm, oblong, concave, apex obtuse-rounded; lateral sepals 0.6-0.7 x ca 0.35 cm, ovate-lanceolate, lower edges connate and upper edges incurved near apex to form an ovoid sac, apex acute. *Petals* 0.2-0.3 x ca 0.2 cm, obliquely triangular, decurrent to column foot, margins irregularly denticulate, apex shortly caudate. *Lip* ca 0.35 cm, ligulate, fleshy, margin finely papillate, grooved at adaxial base, with 2 auricles on both basal sides; auricles subsquare, ca 1 mm, apex truncate and slightly retuse. *Column* and foot ca 3 mm; stelidia deltoid ca 1 mm, apex acute, anther cap glabrous.

Colour Plate 3

Flowering: September - November

Habitat and Ecology: Epiphytic and found growing on main tree trunk in a semi-disturbed forest. 1000-1400 m.

Distribution: India (Arunachal, Assam, Meghalaya, Nagaland, Sikkim, Andaman & Nicobar) Bhutan, China, Malaysia, Myanmar, Thailand.

Specimens examined: Chare village (Tuensang district) HYJ233 (NUH), Ghokimi village (Zunheboto district) HYJ209 (NUH)

6. Bulbophyllum cylindraceum Wall. ex. Lindl., Gen. Sp. Orchid. Pl. 53. 1830; King & Pantling 70, PI. 96:1898: Seidenfaden & Smitinand 394:1961. *Phyllorchis cylindraceum* (Wall. ex lindl.) Kuntze, Revis. Gen. Pl. 2:677, 1891.

Rhizome ca 5mm in diam creeping. *Pseudobulbs* ca 4-5 mm apart on rhizome or sometimes clustered, ca 0.5 x 0.5 cm, rigid. *Leaf* 1, 5-12 x 2-4 cm, terminal on pseudobulb, erect, elliptic-oblong or obovate-lanceolate, fleshy or leathery, apex obtuse and apiculate; petiole 4-6 cm. *Inflorescence* scape 15-23 cm from base of pseudobulb, erect; raceme pendulous 5-6.5 cm long, densely many flowered, with an involucre at base; involucre spathelike; peduncle with 2 or 3 tubular sheaths ca 1.5cm; floral bracts ca 4 mm, ovate; pedicel and ovary ca 3 mm. *Flowers* pale dark-purple, thickly textured, not widely opening. *Dorsal sepal* 0.4-0.5 x ca 0.2cm, ovate-triangular, abaxially ± scaly, apex acute; lateral sepals ca 0.5 x 0.3 cm, obliquely ovate, their lower edges connate to each other except apices, apex obtuse. *Petals* ca 0.4 x 0.2 cm, oblong-lanceolate, thinly textured, entire, acute or obtuse. *Lip* ca 0.3 x 0.32 cm, recurved, ligulate, fleshy, grooved at base, adaxially with 3 keels, densely papillate, apex obtuse. *Column* and foot ca 1.5 mm, stout, without conspicuous free part; stelidia narrowly fusiform, ca 1 mm; anther cap truncate and slightly apiculate at apex. **Colour Plate 3**

Flowering: September

Habitat and Ecology: Epiphytic and found growing on tree branch by the side of a stream. 900-1200 m.

Distribution: India (Arunachal, Assam, Manipur, Meghalaya, Nagaland, Sikkim, West Bengal), Bhutan, China, Nepal.

Specimens examined: Akuluto village, Khashito village (Zunheboto district) HYJ183 (NUH) ; HYJ254 (NUH).

7. Bulbophyllum elatum (Hook. f.) J. J. Smith, Bull. Jard. Bot. Buitenzorg, ser. 2. 8: 23. 1912; King & Pantl. in Ann. Roy. Bot. Gard. Calcutta 8: 93. t. 130. 1898.

Cirrhopetalum elatum J.D. Hooker, Fl. Brit. India 5: 775. 1890. *Phyllorchis elata* (Hook.f.) Kuntze, Revis. Gen.Pl. 2:677. 1891

Pseudobulbs contiguous, cylindric, 3.5-4 x ca 0.6 cm in diam. *Leaf* 1, terminal, 7-14 x 1.6-2 cm, leathery, oblong, apex obtuse and slightly emarginated, petiole ca 2 cm. *Inflorescence* scape 13-17 cm from base of pseudobulb, erect; umbel many flowered; peduncle ca 2 mm in diam., with 3 or 4 sheaths; floral bracts lanceolate, shorter than pedicel and ovary. *Flowers* dark yellow with small dotted brown-reddish spots. *Dorsal sepal* 0.5-0.9 x ca 0.6 cm, ovate, apex acute; lateral sepals 1-1.4 x ca 0.6 cm, narrowly lanceolate, abaxially finely papillate, base twisted, their upper edges connate to each other, apex acuminate. *Petals* ca 0.3 x 0.3 cm, obliquely ovate-triangular, entire, acute. *Lip* ca 0.5 x 0.4 cm, recurved, ovate-lanceolate, fleshy, grooved at base, apex acute. *Column* and foot ca 0.5 cm, stout, deltoid, rounded wings along lower margins; foot with free part; stelidia slender, slightly hooked.

Colour Plate 4

Flowering: May - June

Habitat and Ecology: Epiphytic and found growing on tree branch by the side of a stream. 1800m.

Distribution: India (Arunachal, Assam, Meghalaya, Manipur, Nagaland) Bhutan, China, Nepal, Vietnam.

Specimens examined: Helipong village (Tuensang district) HYJ182 (NUH)

8. Bulbophyllum helenae (Kuntze) J.J. Smith in Bull. Jard. Bot. Buitenzorg 2(8): 24. 1912. *Cirrhopetalum cornutum* Lindl. in Bot. Reg. 24: misc. 75, no. 38. 1838; King & Pantl. in Ann. Roy. Bot. Gard. Calcutta 8: 87. t. 120. 1898; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 115. Fig.57. 1998. *Cirrhopetalum elatum* J.D. Hooker, Fl. Brit. India 5: 774. 1890. *Phyllorchis elata* (Hook.f.) Kuntze, Revis. Gen.Pl. 2:677. 1891. *Bulbophyllum cornutum* sensu (Lindl.) Rchb. f. in Walpers, Ann. Bot. Syst. 6: 261. 1861. *Phyllorchis helenae* Kuntze, Revis. Gen. Pl. 2: 676. 1891. *Rhytionanthos cornutum* (Lindl.) Garay, Hamer & Siegerist in Nordic J. Bot. 14(6): 637. 1994.

Rhizome short, fibrous-sheathed, 3-5 mm thick. *Roots* densely caespitose. *Pseudobulbs* 2-4 x 08–1.4 cm, clustered, ovoid-cylindric, compressed. *Leaf* 1, 13-22 x 1.6–2.8 cm, linear oblong to oblong-elliptic, obtuse, obliquely retuse; petiole 2–3 cm long, channeled. *Inflorescence* basal from pseudobulb, sub-erect, umbellate, 6–8

flowered; peduncle 10–15 cm long, slender, sheathed, glabrous; sheaths 0.8–1.0 cm, overlapping, tubular; floral bracts 3–4 x 0.5–1.0 mm, narrowly lanceolate, acute. *Flowers* 1.5–2.3 cm long, scented; dorsal sepal yellow-red, spotted with red, petals yellowish white spotted with red, lip deep red with yellow; pedicel and ovary 5 – 8 mm long, slender, glabrous. *Dorsal sepal* 3.5–5 x 1.8–2mm ovate, subacute to acute, hooded over column, scabrid, margins entire to minutely serrate, 3-veined; lateral sepals 2–3 x0.2–0.3 cm narrowly lanceolate, falcate, acuminate, connivent centrally, free at base and apex, shortly ciliate. *Petals* 1.4–1.6 x 1–1.2 mm ovate, acute, 3 – veined, ciliate-dentate. *Lip* 3-4 x 0.8–1.0 mm simple, thick, oblong, subacute, deflexed from base; disc 2–lamellate. *Column* 1- 1.5 mm tall, broad; steledia 2, erect, acute; foot curved, 1–1.5 mm long; anther cap pappilose, 0.70 mm across. Fruit ovoid-cylindric, stalked, 1.5 – 1.8 x 0.4 – 0.6 cm.

Colour Plate 4

Flowering: June - September

Habitat and Ecology: Epiphytic and found growing on tree trunk in an undisturbed forest, 1200 – 1800 m.

Distribution: India (Arunachal, Assam, Meghalaya, Nagaland, Sikkim), Bhutan, Nepal, Myanmar and Thailand.

Specimens examined: Chendang saddle village (Tuensang district), Aquaba village (Zunheboto district) HYJ070 (NUH)

9. Bulbophyllum leopardinum (Wall.) Lindl., Gen. Sp. Orchid. Pl.: 48.1830; Hook. f., Fl. Brit. India 5: 756. 1890; King & Pantl., in Ann. Roy. Bot. Gard. Calc. 8:67. t. 92. 1898; Seidenf. in Dansk Bot. Ark. 33(3): 28. t. 10. 1979; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 119. fig. 61.1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 63. fig. 26. 2000. *Dendrobium leopardinum* Wall., Tent. FI. Nep. 1: 39, t. 28, 1824. *Sarcopodium leopardinum* (Wall.) Lindl., Paxt. FI. Gard. 1: 155, 1850; Lindl. Fol. Ore. Sarc. 5, 1853. *Phyllorchis leopardina* (Wall.) Kuntze., Rev. Gen. 2: 677, 1891.

Rhizome 3-4 mm in diam., stout, creeping, covered by fibrous sheaths. *Pseudobulbs* 2-5 x 1.5- 2.2 cm in diam., bract fibers usually forming a loose net around pseudobulb, usually clustered pseudobulbs somewhat wrinkled, cylindric ovoid to cylindric-obpyriform. *Leaf* 1, apical, 8-20 x 2.5-5 cm, oblong-elliptic, mucronate, coriaceous, rigid, petiole channeled, 2-6 cm long. *Inflorescence* 5-8 cm

long, erect to spreading, 1-2-flowered on a raceme; peduncle 1-1.6 cm long, sheathed at base 0.5-0.7 cm long; rachis ca 0.5 cm; floral bracts tubular, 0.6-1.2 cm, acute. *Flowers* 2-3 cm across, fasciculate, globose-campulate, yellowish to scarlet, sepals and petals mottled with dark scarlet, lip deep crimson, pedicel and ovary ca 2.5 cm long. *Dorsal sepal* 1.4-2.0 x 0.6-0.8 cm, recurved with top incurved, elliptic to ovate-triangular, rather thick, glabrous, base rather broadly attached, apex truncate and apiculate to acute; lateral sepals 1.5-2.2 x 0.7-1.1 cm, free, recurved, obliquely ovate, acuminate, forming a mentum at base. *Petals* 0.8-1.2 x 0.4-0.7 cm, broadly ovate, acute to acuminate. *Lip* 1-1.4 x 0.5-0.8 cm, fleshy, ovate-lanceolate, obtuse, entire, decurved, attached to apex of column foot; disc with 2 dentate basal auricles and two pronounced longitudinal ridges. *Column* ca 4-6 mm long; foot curved, ca 1.3 cm; stelidia stout, triangular, ca 1 mm; pollinia 2.5-3mm. Fruit cylindric, stalked.

Colour Plate 4

Flowering: June - July

Habitat and Ecology: Epiphytic, sometimes lithophytic and found growing on main tree trunk in a closed forest.

Distribution: India (Arunachal, Manipur, Meghalaya, Nagaland, Sikkim), Bhutan, Nepal, Myanmar, Thailand.

Specimens examined: Chare old village (Tuensang district) HYJ090 (NUH)

10. Bulbophyllum odoratissimum (J.E. Smith) Lindl., Gen. Sp. Orchid. Pl.: 55. 1830; Hook. f., Fl. Brit. India 5: 758. 1890; King & Pantl. im Ann. Roy. Bot. Gard. Calc. 8: 79. t. 109. 1898; Seidenf. In Dansk Bot. Ark. 33(3): 76. t. 43. 1979; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 123. fig. 65. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 63. fig 17. 2000. *Stelis odoratissima* J. E. Sm. in Rees, Cyclop. 34: Stelis, no. 12. 1814. *Phyllorchis odoratissima* (J.E. Smith) Kuntze, Revis. Gen. Pl. 2: 677. 1891.

Rhizome 1 – 2 mm thick, slender, crreping, woody; *roots* clustered at nodes, filiform. *Pseudobulbs* 2 – 3 x 0.3 – 0.6 cm, erect cylindric, smooth to ridged, inserted at intervals of 4 – 7 cm along rhizome. *Leaf* 1, 6 - 9 x 1.2 – 1.8 cm, oblong-elliptic to oblong-lanceolate, apex emarginated, sub-sessile to shortly petiolate; petiole 1-3 mm long. *Inflorescence* capitate, 1 or 2 from pseudobulb, densely many flowered; peduncle 3–8 cm long, sheathed; sheaths imbricate, lanceolate, tubular, 0.5–1.8 cm, mouth wide; floral bracts 4–7 x 1–2 mm, 3-veined, lanceolate, acute to acuminate,

concave. *Flowers* 5–7 mm across, fragrant; sepals and petals white tipped with yellow, lip white to pale orange; pedicel and ovary slender, 3 – 5 mm long. *Dorsal sepal* 0.25 – 1 x 0.1 – 0.15 cm lanceolate, acuminate to subcaudate, 5-veined; *lateral sepals* 0.4–1.0 x 0.1 – 0.14 cm, spreading, lanceolate, acuminate to subcaudate, falcate. *Petals* 1–1.5 x 0.5–0.7 mm spreading, ovate, obtuse, 1–veined. *Lip* simple, 1.3–1.7 x 0.3–0.6 mm, fleshy, oblong-lanceolate, centrally grooved, glandular-pubescent, margins glandular-pubescent. *Column* 0.4 – 0.6 mm tall, stout; steledia short; foot short; anther pappilose, 0.4 – 0.6 cm.

Colour Plate 4

Flowering: May - June

Habitat and Ecology: Epiphytic or lithophytic and found growing on main tree trunk with full head sunlight.

Distribution: India (Arunachal, Assam, Manipur, Meghalaya, Nagaland, Sikkim, West Bengal), Bhutan, Nepal, Myanmar and Thailand, Laos, Vietnam.

Specimens examined: Chiang Mai village (Tuensang district), HYJ184 (NUH)

11. Bulbophyllum pteroglossum Schltr. in Feddes Repert. Spec. Nov. Regni Veg. Beih. 4:71. 1919. *Sarcopodium uniflorum* (Griff.) Lindl., Fol. Orchid. Sarcopodium 2:6, no.16. 1853; Pearce & Cribb 2002. The Orch. Of Bhutan Vol. 3(3). 443 (1-643). *Phyllorkis monantha* Kuntze, Revis. Gen. Pl. 2:676. 1891. *Bulbophyllum monanthum* (Kuntze) J. J. Smith in Bull. Jard. Bot. Buitenzorg ser.2, 8:16. 1912. *Bulbophyllum devangiriense* Balakrishnan in J. Bombay Nat. Hist. Soc. 67:66. 1970.

Rhizome ca 5 mm in diam., stout. *Root* arising from nodes. *Pseudobulbs* 5-9 cm apart from each other, 3-4 x ca 0.5 cm in diam., cylindric. *Leaf* 1, 12-20 x 2.5-3 cm, terminal from pseudobulb, subsessile, oblong, fleshy and thickly leathery, apex obtuse. *Inflorescence* scape 5-8 cm, flattened, arising from nodes of rhizome, pendulous, terminating in a solitary flower; floral bracts ovate, shorter than pedicel and ovary, apex acute. *Flowers* pale yellow spotted with red, thickened, erect, purple-red mid-lobe of lip. *Dorsal sepal* 0.9-1.1 x 0.6-0.7 cm, elliptic, concave, apex obtuse; lateral sepals 0.6-0.8 x 0.3-0.4 cm, obliquely ovate-triangular, contracted and twisted above middle, base adnate to column foot forming a broad mentum, apex obtuse. *Petals* 0.5-0.7 x ca 0.3 cm, oblong-lanceolate, margin entire, apex subacute. *Lip* ca 0.3 cm, erect, basal half subsquare, cordate at base, connected to end of column foot by a mobile joint, near middle 3-lobed; lateral lobes erect, apices ca 5 mm apart; mid-lobe

deltoid, apex obtuse-rounded. *Column* stout; foot upcurved, ca 1 cm, with free part ca 2 mm; stelidia inconspicuous; anther cap nearly subspherical.

Colour Plate 4

Flowering: October - November

Habitat and Ecology: Epiphytic and found growing on main tree trunk with full head sunlight. 1500m.

Distribution: India (Arunachal, Assam, Nagaland, Sikkim), Bhutan, China, Myanmar

Specimens examined: Chiang Mai village (Tuensang district) HYJ055 (NUH).

12. Bulbophyllum reptans (Lindl.) Lindl., Gen. Sp. Orchid. Pl. 51. 1830; Hook. f., Fl. Brit. India 5: 768. 1890; King & Pantl. in Ann. Roy. Bot. Gard. Calc. 8: 78. t. 106. 1898; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 136. fig. 74. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 72. fig 21. 2000. *Tribachia reptans* Lindl. in Coll. Bot. t.41a 1826. *Bulbophyllum grandiflorum* Griff., Itin. Not. 146:1848. *Phyllorchis reptans* (Lindl.) Kze., Rev. Gen. 2: 677, 1891.

Rhizome ca 2 mm in diam., creeping, branched, covered with tubular sheaths ca 8 mm. *Pseudobulbs* 5-7 cm apart on rhizome, 1-1.5 x 0.6-0.8 cm in diam., ovoid or ovoid-conic. *Leaf* 1, 7-10 x 0.8-1.2 cm, terminal on pseudobulb, narrowly oblong, leathery, base contracted into petiole, petiole 1-2 cm, apex obtuse and slightly emarginated. *Inflorescence* scape from base of pseudobulb, 8-10 cm, erect, slender, raceme 4-6 cm, 3-5-flowered; peduncle with tubular sheaths; floral bracts ca 3mm, ovate-lanceolate; pedicel and ovary ca 4 mm. *Flowers* yellow with purplish red stripes. *Dorsal sepal* 0.7-1.0 x ca 0.25 cm, lanceolate, thickly textured, abaxially carinate, apex subacute; lateral sepals sub-similar, slightly longer, lower edges of basal half connate to each other, base adnate to column foot. *Petals* 0.3-0.4 x ca 0.2 cm, ovate-elliptic or obovate, thinly textured, entire, obtuse-rounded. *Lip* recurved, longer than petals, fleshy, entire, obtuse. *Column* ca 0.8 mm; foot ca 2 mm, with free part ca 1 mm; stelidia ca 0.8 mm, filiform or subulate.

Colour Plate 4

Flowering: October - November

Habitat and Ecology: Epiphytic or lithophytic and found growing on moss covered rocks. 1500m.

Distribution: India (Arunachal, Assam, Manipur, Meghalaya, Nagaland, Sikkim), Bhutan, China, Myanmar, Nepal, Thailand.

Specimens examined: Chiang Mai village (Tuensang district) HYJ185 (NUH)

13. Bulbophyllum retusiusculum Reichb.f. in Gard. Chron. 1182. 1869; Seidenf. in Dansk Bot. Ark. 29(1):195.tt.106-108. 1973; Hook.f., Fl. Brit. India 5: 776. 1890; King & Pantl, Ann. Roy. Bot. Gard. Calcutta 8: 88. t. 121. 1898 (non Lindl., 1839); H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 136. fig. 75. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 72. fig. 22. 2000. *Cirrhopetalum wallichii* Lindl., Gen. Sp. Orch. 59. 1830. *Bulbophyllum wallichii* auct. *non* Rchb.f. Tuyama in Hara, Fl. E. Himalaya. 1: 428. 1966.

Rhizome ca 2.5 mm in diam., creeping. *Roots* from base of pseudobulbs. *Pseudobulbs* 1.5-3 cm apart on rhizome, 0.7-2 x 0.4-1.4 cm in diam., rarely close, ovoid-conic or narrowly ovoid. *Leaf* 1, 1.8-8 x 0.5-1.7 cm, oblong or ovate-lanceolate, leathery, base contracted into a short petiole, apex obtuse and slightly emarginated. *Inflorescence* scape from base of pseudobulb, 12-14 cm, suberect, slender; umbel 4-8 flowered, peduncle ca 1 mm in diam., sparsely with 3 tubular sheaths; floral bracts ca 0.4 cm, narrowly lanceolate, cymbiform, apex acuminate; pedicel and ovary ca 0.7 cm, slender. *Flowers* yellow to reddish with reddish veins. *Dorsal sepal* ca 0.3 x 0.2 cm, oblong-ovate or suboblong, abaxially sometimes sparsely papillate in basal half, margin entire or scabrid, apex subtruncate and emarginate; lateral sepals 1.5-2.2 x ca 0.35 cm, narrowly lanceolate or linear, abaxially sometimes sparsely papillate, twisted near base, upper and lower edges connate to each other forming an ellipsoid or horn-shaped synsepal. *Petals* 0.2-0.3 x ca 0.2 cm, nearly oblong or ovate, adnate to column foot, margins entire or scabrid, apex obtuse-rounded. *Lip* ca 3 mm long, recurved, ligulate, fleshy, base grooved, attached to end of column foot by a mobile joint, apex obtuse. *Column* ca 1.5 mm, with wings slightly dilated at base; foot ca 2 mm, with free part ca 1 mm, upcurved; stelidia subtriangular, ca 0.8 mm; anther cap slightly finely papillate.

Colour Plate 5

Flowering: August - September

Habitat and Ecology: Epiphytic or lithophytic and found growing on main tree trunk in a semi-disturbed forest. 1600-2300 m

Distribution: India (Assam, Manipur, Meghalaya, Nagaland, Sikkim), Bhutan, China, Myanmar, Nepal, Thailand.

Specimens examined: Chiang mai village (Tuensang district) HYJ040 (NUH), Tsutoho village (Zunheboto district) HYJ097 (NUH)**,** Pungro (Kiphire district) HYJ113 (NUH).

14. Bulbophyllum rotschildianum (O' Brien) J. J. Smith in Bull. Jard. Bot. Buitenzorg., 8: 27.1912. *Cirrhopetalum rothschildianum* O'Brien, Gard. Chron., ser. 3, 18: 608. 1895.

Rhizome 5-7 mm in diam, sheathed, stout, densely with short tubular sheaths. *Pseudobulbs* 2.5-4.5 x 1.5-1.9 cm, ovoid-pyriform, distant on rhizome well spaced, with 1 leaf at apex. *Leaf* 1, 8.5-12.5 x 1.8-3.6 cm, emarginated, leaf blade sub-elliptic, thick leathery, apex obtuse and retuse; Petiole 0.8 – 1 cm long; Scape from base of pseudobulb, erect, 2.0 - 2.2 cm, stout. *Inflorescence* umbellate, erect, 2 - 3 flowered; peduncle 7 – 14 x ca 0.3 cm diam, sheathed, glabrous; sheaths distant ca 5 – 7 cm, tubular, 0.8 – 1.2 cm long; floral bracts 1 – 1.2 x 0.2 – 0.3 cm, narrowly lanceolate, acuminate. *Flowers* 8 – 11 cm long; dorsal sepal and petal green with purple veins and fringing, lateral sepals crimson-purple blotched with yellow green, lip purple, column green; pedicel and ovary 1.5 – 1.8 cm long, glabrous. *Dorsal sepal* 1 – 1.2 x 0.5 – 0.7 cm, ovate, cymbiform, abaxially sparsely papillate, hooded, warty externally, margins fimbriate, apex caudate; *lateral sepals* 8–11 x 0.9-1.2 cm, lanceolate, oblong below, tapering to long filiform –caudate apex, warty at base, 5-veined, outer margins connivent centrally forming a synsepal. *Petals* 0.7- 0.9 x 0.2–0.3 xm, triangular lanceolate, acuminate, falcate, margins long-fimbriate, 3-veined. *Lip* 5-7 x 3–4 mm , simple, adnate to apex of column foot, ovate-oblong, narrowed to obtuse base, margins and adaxial surface densely fimbriate-hairy, apex obtuse. *Column* ca. 4.5 mm, stout, winged; stelidia 2, linear; foot ca 8 mm.

Colour Plate 5

Flowering: September - October

Habitat and Ecology: Epiphytic and found growing on tree trunk in a disturbed forest, 430 m.

Distribution: India (Nagaland, West Bengal), Bhutan, Nepal.

Specimen examined: Sumi Shettsu (Zunheboto district) HYJ066 (NUH).

15. Bulbophyllum sunipia J.J.Verm., Schuit. & de Vogel, *nom. nov*. Phytotaxa 166:2.2014. *Sunipia scariosa* Lindl., Gen. Sp. Orchid. Pl. 179. 1833. *Ione scariosa*

(Lindl.) King & Pantl., in Ann. Roy. Bot. Gard. Calc. 8: 161, t. 219. 1898. *Ione racemosa sensu* Seidenfaden in Bot. Tidsskr. 64:227. 1969.

Rhizome creeping, stout, ca 4.5mm in diam. *Pseudobulbs* ca 2-2.5cm apart on rhizome, ovoid or obliquely ovoid, 2-3 x 1.3-1.5cm. *Leaf* 1 at apex of pseudobulb, 8-11 x 1.5-2cm, petiole ca 1.5cm, oblong, leathery, base contracted into petiole, apex obtuse and retuse. *Scape* 16-22cm; raceme ± nodding, more than 10-14flowered or more; peduncle 8-15cm, 2-3 mm in diam., sparsely with 3-5 tubular sheaths; floral bracts regularly distichous, broadly ovate, cymbiform, ca. 7-6mm, membranous, apex acute; pedicel and ovary ca 2 mm. *Flowers* enclosed in floral bracts, pale yellow. *Dorsal sepal* ca 4.5-3mm, ovate, concave, apex acute; lateral sepals obliquely ovate, ± V-shaped-conduplicate, ca 6 x 2mm, with 1 vein, their lower edges connate to each other, apex acute. *Petals* ca 3 x 2.2mm,obliquely ovate, 1-veined, abaxial base with 1 fleshy ligulate appendage, margins denticulate, apex obtuse. *Lip* ca 4 x 2mm, ligulate, fleshy, adaxial base with a channel and a keel in it, apex obtuse. *Column* ca 2 mm; foot inconspicuous.

Colour Plate 5

Flowering: May - June

Habitat and Ecology: Epiphytic and found growing on tree trunk in a disturbed forest 1900m

Distribution: India (Arunachal, Manipur, Nagaland, Sikkim) Myanmar, Nepal, Thailand, Vietnam.

Specimens examined: Noklak (Tuensang district) HYJ186 (NUH)

16. Bulbophyllum umbellatum Wall. Lindl., Gen. Sp. Orchid. Pl.:56. 1830; King & Pantl., Ann. Roy. Bot. Gard. Calcutta 8: 95. t. 132. 1898. *Cirrhopetalum maculosum* Lindl. in Bot. reg. 27: misc.81, no.173. 1841. *Bulbophyllopsis maculosum* var. *fuscescens* Hok. f., Fl. Brit. India 5 (2):776.1890.

Rhizome 2–3mm in diam, fibrous-shetahed. *Roots* slender, branching form pseudobulb base. *Pseudobulbs* 2.5–3 x 0.9–1.4 cm, ovoid to conical broadly, fibrous sheathed at base. *Leaves* 1, 4–12 x 1.5–2.4 cm, coriaceous, narrowly oblong, obtuse, emarginated; Petiole 0.6 – 1.5 cm long. *Inflorescence* 2 - 3 flowered, shorter than leaves, umbellate to racemose; peduncle 6 – 8 cm x ca 0.25 cm diam, slender, sheathed; sheaths 0.8 – 1.2 cm, tubular, lanceolate; floral bracts 5 – 7 x ca 1.5 mm, lanceolate, acute. *Flowers* ca 1.5 cm long; sepals and petals yellowish-green, pale

pink to yellow brown, lip green-yellow to reddish brown, column foot greenish-white. *Dorsal sepal* 0.7–1.0 x 0.5–0.7 cm, broadly ovate, acute, 5–veined; *lateral sepals* 1.0–1.2 x 0.4–0.7 cm, free, ovate-lanceolate, falcate, subacute, base broad, adnate to column foot, 7-veined. *Petals* 0.6–0.9 x 0.4–0.7 cm, broadly ovate, obtuse, 5 – veined. *Lip* 3– 3.5 x 1- 3 mm, simple, oblong, tapering to subacute apex, surface grooved. *Column* ca. 2.5 mm, winged; stelidia short, curved; foot curved, ca 3.5 mm long.

Colour Plate 5

Flowering: April - June

Ecology: Epiphytic and found growing on tree trunk in a disturbed forest with diffused sunlight, 1400 -1800m.

Distribution: India (Assam, Manipur, Nagaland, Sikkim), Bhutan, Nepal, China, Myanmar, Thailand.

Specimens examined: Tsaru village - Chare (Tuensang district) HYJ102 (NUH).

17. Bulbophyllum viridiflorum (Hook. f.) Schltr. in Orchis 4:108. 1910; King & Pantl. in Ann. Roy. Bot. Gard. Calc. 8:86.1. 118.1898; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 153. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 79. fig 25. 2000. *Cirrhopetalum viridiflorum* Hook.f., Fl.Brit, India 5(2) : 779.1890. *Phyllorchis viridiflora* (Hook.f.) Kuntze, Revis. Gen. Pl. 2:678.1891.

Rhizome absent. *Roots* filiform, clustered. *Pseudobulbs* 1.3–3 x 0.8–1.1 cm, caespitose, ovoid. *Leaves* 2, 6–10 x 1.5–2.3cm, oblong-lanceolate, acute, narrow and sub-sessile. *Inflorescence* basal from pseudobulb, racemose, densely 10–12 flowered; peduncle 6–11 cm long, erect, sheathed; sheaths 3, 1.0-1.2 x ca 0.4 cm, distant, lanceolate, acute; floral bracts 3–4 x ca 3 mm,ovate-lanceolate, acute to acuminate. *Flowers* 1.4–1.6 long; sepals yellowish-green, turning brown with age, petals transluscent green with purple blotch, lip purple, column pinkish purple; pedicel and ovary ca 5 mm long, slender. *Dorsal sepal* 0.8–1.1 x 0.3-0.4 cm, ovate oblong, acute, concave, 5–veined; lateral sepals 1.4–1.6 x 0.4–0.6 cm, ovate-lanceolate, apex emarginated, lobules subacute. Petals ca 1.5 x 1.5 mm, rounded, membraneous, 1-veined. *Lip* ca 2 mm long, fleshy, basal margins reflexed, deflexed centrally, margins finely crenulate. *Column* ca 2 mm long; stelidia linear, falcate, hooked; foot curved, ca 2 mm long; anther cap obovate, pappilose.

Colour Plate 5

Flowering: October - November

Ecology: Epiphytic and found growing on tree trunk in an undisturbed forest with diffused sunlight, 1200 – 1500 m.

Distribution: India (Arunachal, Meghalaya, Nagaland, Sikkim, West Bengal), Bhutan, Nepal

Specimens examined: Wangshoi village (Tuensang district) HYJ069(NUH)

BULLEYIA Schltr.

Notes Roy. Bot. Gard. Edinburgh. 5: 108. 1912

The genus was described by Richard Rudolf Schlechter in 1912. The Genus is monotypic represented only by *Bulleyia yunnanensis* and is found in Assam, Bhutan and Yunnan and recorded by the author.

1. Bulleyia yunnanensis Schltr. in Notes Roy. Bot. Gard. Edinburgh. 5: 108. 1912; Pearce & Cribb 2002. The Orch. Of Bhutan Vol. 3(3). 323-324, fig 78. (1-643).

Plants 27–34 cm tall; *rhizome* with crowded pseudobulbs, golden yellow colour, narrowly ovoid-ellipsoid, 3.4–6.0 x 1.0–2.0 cm , grooved with filiform, elongate roots. *Leaves* 2, erect, papery, oblong-lanceolate, acuminate, 18.0–24.0 x 1.3-2.1 cm; petiole grooved, 5–10 cm long. *Inflorescence* laxly10–14-flowered; peduncle slender, glabrous, 22–35 cm long; rachis glabrous, zigzag, 7–15 cm long; floral bracts pale reddish green, papery, subacute, ovate 1.5–-2.0 x 1.2–1.5 cm. *Flower* brown with pale brown lip; pedicellate ovary 6–8 mm long, glabrous. *Sepals* sub similar, ovate-oblong, glabrous, apiculate, oblique , 15–18 x 5-7 mm. *Petals* elliptic –oblong, oblique, 14–18 x 2–3 mm, 3-veined, acute to apiculate; *Lip* simple, 12–15 x 5–6 mm, deeply constricted in the middle, spurred, entire; hypochile ovate-elliptic; epichile reniform, margin undulated with 3 thickened, keeled veins on mesochile; spur cylindric, curved. *Column* glabrous, 8–11 mm. Fruits not seen.

Colour Plate 5

Flowering: June – August.

Habitat and Ecology: Epiphytic or lithophytic and found on main tree trunk, 1600 m

Distribution: India (Assam, Arunachal Pradesh, Nagaland), Bhutan and China.

Specimens examined: Helipong village area (Tuensang district)

CALANTHE R. Br.

Bot. Reg. 7: sub. t. 573. 1821 (*nom.cons.*)

The genus was described by Robert brown in 1821. The generic name is derived from the Greek words *'kalos'* (beautiful) and *'anthe'* (flower) referring to the beautiful flowers of many species of the genus. About 209 species throughout the tropics and tropical Asia.

33 species in India, 13 species in Nagaland and 6 species reported by author.

Key to species

1. Flowers without spur; mid-lobe of lip lacking lamellae …….. *C. puberula*
- Flowers with a spur……...…… 2
2. Lip simple; lip base clawed, apex deeply 2-lobed ……... *C. biloba*
- Lip 3-lobed ……. 3
3. Spur less than 3 mm …… 4
   Spur more than 4 mm; flowers white …… 5
4. Flowers more than 3 cm across, brick red to purple, spreading; lip with 3 lamellae on mid-lobe only ……...…. *C. brevicornu*
- Flowers less than 1 cm across, pale green to dull brown, pendent; lip yellow with 3 lamellae from base to apex …….. *C. mannii*
5. Spur 0.8 cm ……..……..……..……. *C. alismifolia*
   Spur more than 1.5 cm ……...…. *C. triplicata*

1. Calanthe alismifolia Lindl., Fol. Orchid. Calanthe 6, 7: 8, no. 27. 1855; Hook.f., Fl. Brit. India 5: 849. 1890; King & Pantl in Ann. Roy. Bot. Gard. Calcutta 8: 170. t. 230. 1898; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 158. fig. 87. 1998; *Alismorchis alismifolia* (Lindl.) kuntze, Revis. Gen. Pl. 2: 650. 1891. *Alismorchis japonica* (Bl. Ex miquel) Kuntze, *loc. cit.* 1891. *Calanthe fauriei* Schltr. in Feddes Repert. Spec. Nov. Regni Veg. Beih. 4: 66. 1919.

Plant 20-40 cm tall. *Rhizome* inconspicuous. *Pseudobulbs* 1-3 x 0.3-0.5 cm, cylindric. *Leaves* 3-5, 10-20 x 5-9 cm, basal, well developed and spreading at anthesis, not deciduous, elliptic to ovate-elliptic, glabrous abaxially sometimes with short hairs, apex acute; petiole-like base 6-13 cm, slender. *Inflorescence* arising from leaf axils, scapes 1 or 2, erect, 10-15 cm, slender, densely puberulent; rachis 3.5-4 cm, 3- 10-flowered; floral bracts ca 0.9 cm, persistent, slightly recurved, broadly ovate-lanceolate, abaxially sparsely puberulent. *Flowers* usually white tinged purplish

violet; pedicel and ovary 1-1.2 cm, puberulent. *Sepals* ca 0.8 x 0.6 cm, similar, subobovate, abaxially pilose, 5-veined. *Petals* ca 0.9 x 0.5 cm, subrhombic, glabrous, 3-veined, apex obtuse. *Lip* adnate to entire length of column wings, spreading, deeply 3-lobed; lateral lobes linear or narrowly oblong, ca 0.8 x 0.2 cm, apex rounded; mid-lobe ca 1.5 x 1.2 cm, flabellate, base clawed, apex subtruncate, divided by a deep sinus into 2 lobules; lobules subrhombic, much larger than lateral lobes, ca 0.5 cm wide, margin entire or erose, apex truncate-obtuse; disk with several yellow, wartlike calli at base; spur straight, cylindric, ca 0.8 cm, slender, glabrous. *Column* ca 0.3 cm, slightly dilated at apex, glabrous; rostellum 2-lobed; lobes ca 1.2 mm. *Pollinia* ca 2 mm, ovoid, subequal in size. *Capsule* ca 2 x 0.6 cm.

Colour Plate 6

Flowering: June - July

Habitat and Ecology: Terrestrial or lithophytic and found growing on the side of stream in a shaded area, 1200-1800m.

Distribution: India (Arunachal, Assam, Meghalaya, Nagaland, Sikkim) Bhutan, China, Japan, Vietnam.

Specimens examined: Khashito village (Zunheboto disrict) HYJ259 (NUH).

2. Calanthe biloba Lindl., Fol. Orch. 3. 1854; King & Pantl. im Ann. Roy. Bot. Gard. Calc. 8: 169. t. 228. 1898; Seidenf. In Dansk Bot. Ark. 29 (2): 12. t. 1. 1975; Pradhan, Indian. Orch. 2: 255, 1979; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 162. fig. 90. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 83. 2000. *Calanthe biloba* var. *diptera* Hook. f., Fl. Brit. India 5: 848. 1890. *Alismorchis biloba* (lindl.) Kuntze, Revis. Gen. Pl. 2:650. 1891.

Plant upto 60 cm. *Pseudobulbs* 5-13 x 0.6-0.7cm, cylindric, stout. *Roots* fasciculate, thickly fibrous. *Leaves* 3 or 4, unequal, 20–28 x 6-10cm, oblanceolate and broadly elliptic, acute or acuminate. *Inflorescence* 25–37 cm long, terminal, glabrous, subdensely to densely many-flowered; peduncle pubescent, sheathed 20 -30 cm long; sheaths 3-3.5 x 0.4-0.7 cm, lanceolate, acuminate; rachis pubescent, 18-20 cm long; floral bracts 2-4 x 0.1-0.3 cm, blackish brown, linear-lanceolate, acuminate. *Flowers* ca 3.6 cm across, golden yellow, mottled with dark brown almost dark reddish; sepals and petals yellow ochre –spotted with purple brown, lip pale violet, whitish at base, spur purplish violet; pedicel and ovary 1.4–1.9 cm long, linear. *Sepals* 1.4–1.6 x 0.8-1.1 cm, sub-similar, spreading, broadly ovate-lanceolate, caudate-acuminate; lateral

sepals falcate. *Petals* 1.2–1.3 x 0.4–0.5 cm, linear-oblong, acuminate. *Lip* 1.2–1.5 cm simple, long, pale violet, base with a whitish claw, deeply 2-lobed, apex emarginated; lobes broadly hatched–shaped, deflexed; *Spur* ca 3mm long, conical, obtuse; *column* ca 4 mm long, brownish; *pollinia* 8, linear-oblong, unequal, attached to transparent elliptical gland.

Colour Plate 6

Flowering: October - November

Habitat and Ecology: Terrestrial or lithophytic and found growing on the side of stream in semi shaded area, 1400–1800m.

Distribution: India (Arunachal, Assam, Meghalaya, Nagaland, Sikkim) Bhutan, China, Myanmar, Nepal.

Specimens examined: Anangba village (Tuensang District) HYJ201(NUH), Asukhomi village (Zunheboto District) HYJ195 (NUH).

3. Calanthe brevicornu Lindl., Gen. & Sp. Orch. 251. 1833; Hook., f., Fl. Brit. India 5: 848. 1890; King & Pantl. in Ann. Roy. Bot. Gard. Calc. 8 : 168. t. 227. 1898 (incl. var. wattii hook. f.); H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 162. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 84. 2000. *Alismorchis brevicornu* (Lindl.) Kuntze, Revis. Gen. Pl. 2:650. 1891.

Plant 40-60cm. *Pseudobulbs* 4–6 cm long, ovoid-oblong, pointed. *Roots* fasciculate, thickly fibrous. *Leaves* 3 or 4, 25-30 x 5–7cm, ovate–elliptic, shortly acuminate, petiolate when mature, petiole 12 – 18 cm; basal sheathing leaves 3–5cm long. *Inflorescence* laxly 8-16 flowered, 40–50 cm long, glabrous; peduncle softly puberous, sheathed, 18-28cm long; sheaths ca 1.4 x 0.4cm, distant, appressed, lanceolate, acute; rachis puberulous, 18-24 cm long; floral bracts pubescent at base, lanceolate, acute to acuminate, 1.6-2 x 0.2-0.4cm. *Flowers* ca 5cm across, spreading, brick red to purple striped with white or yellow; lip paler purple, striped maroon and yellow; pedicel and ovary 1.6-2cm long, purplish green, linear, pubescent. *Sepals* 1.4-1.8 x 0.4-0.5cm, similar, spreading, lanceolate to ovate-lanceolate, acute. *Petals* 1.2–1.6 x 0.3–0.4 cm, and shorter than the sepals, lanceolate, acute. *Lip* ca 1.1 x 0.7cm, 3-lobed, adnate to column base, shortly spurred; lateral lobes oblong, obtuse, diverging; mid-lobe broadly ovate, apex emarginated-apiculate, margins undulate, clawed at base, with 3 fleshy lamellae from midlobe base, enlarging towards apex. *Spur* broad

1.4 – 2.8 mm, obtuse, straight mouth with retroflexed hairs, 1.5-3mm long. *Column* ca 3 mm long, Fruit ca 2.2 x 1.4 cm, ellipsoid.

Colour Plate 6

Flowering: May - June

Habitat and Ecology: Terrestrial or lithophytic and found growing as undergrowth in a closed forest, 1900m

Distribution: India (Arunachal, Nagaland, Sikkim, West bengal), Bhutan, Nepal.

Specimens examined: Chiang mai village (Tuensang District) HYJ187 (NUH).

4. Calanthe mannii Hook. f., Fl. Brit. India. 5(2): 850. 1890; King & Pantl. in Ann. Roy. Bot. Gard. Calc. 8 : 167. t. 225. 1898; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 167. fig. 95. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 89. fig 28. 2000. *Alismorkis mannii* (Hook. f.) Kuntze, Revis. Gen. Pl. 2:650.1891. *Calanthe brachychila* Gagnepain, *op. cit*. 79:162.1932. *Calanthe pusilla* Finet. In Bull. Soc. Bot. France 46:436. 1899.

Plants 30-45 cm tall. *Rhizome* inconspicuous. *Pseudobulbs* conic, sheathed. *Leaves* 3-5, 16-30 x 3-5 cm, oblanceolate or oblong, plicate, abaxially puberulent, base subsessile or attenuate into a petiole-like stalk, apex acute; petiole-like base 4-8 cm, usually forming a pseudostem 4-7 cm. *Inflorescence* 10 - or more flowered, scape arising from leaf axil, erect, densely puberulent, rachis 4-9 cm; floral bracts 2-4 mm, persistent, lanceolate, glabrous. *Flowers* ca 0.9 cm across, dark brown, lip yellow; pedicel and ovary 5-7 mm, densely puberulent. *Sepals* similar, 0.6-0.8 x 0.3 – 0.5 cm, ovate-lanceolate or oblong, concave, abaxially densely puberulent, 3-5-veined, apex acute; lateral sepals ± oblique. *Petals* 0.5-0.6 x ca 0.2 cm, glabrous, 1-3-veined, obovate-lanceolate or oblong, apex acute. *Lip* 0.4-0.5 x 0.2-0.3 cm, adnate to entire length of column wings, 3-lobed; lateral lobes ovate, oblique, apex obtuse-rounded; mid-lobe transversely oblong or nearly reniform, margin slightly undulate, apex emarginate and mucronate in sinus; disk with 3 lamellae or ridges; lamellae extending from base of lip to apex of mid-lobe, expanding to semilunate swellings on mid-lobe; spur ca 0.3 x ca. 1 cm, straight, outside puberulent. *Column* white, ca 3 mm, dilated at apex, ventrally puberulent; rostellum small, 2-lobed. *Pollinia* narrowly ovoid, subequal in size, ca 0.1 cm; viscidium suborbicular, small.

Colour Plate 6

Flowering: April - May

Habitat and Ecology: Terrestrial or lithophytic and found growing on humus rich soil in a plateau, 1500m

Distribution: India (Arunachal, Assam, Manipur, Meghalaya, Nagaland, Sikkim), Bhutan, Myanmar, Nepal, Vietnam.

Specimens examined: Asukhomi village (Zunheboto district) HYJ251 (NUH).

5. Calanthe puberula Lindl., Gen. Sp. Orchid. Pl. 252. 1833; Hook. f., Fl. Brit. India. 5(2): 848. 1890; King & Pantl. in Ann. Roy. Bot. Gard. Calc. 8 : 166. t. 224. 1898; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 171. fig. 98. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 90. 2000. *Alismorkis puberula* (Lindl.) Kuntze, Revis. Gen. Pl. 2:650.1891. *Calanthe amoena* W. W. Smith in notes roy. Bot. Gard. Edinburgh 13:191.1921. *Calanthe lepida* W. W. Smith, *op. cit*. 192. 1921. *Paracalanthe reflexa* var. *puberula* (Lindl.) Kudo in J. Soc. Trop. Agric. 2:236. 1930.

Plant 25-50 cm tall. *Rhizome* usually inconspicuous. *Pseudobulbs* ca 2 x 1.5 cm, narrowly cylindric, enclosed in leaf sheaths. *Leaves* 4 or 5, 12-20 x 5-7 cm, basal, well developed at anthesis, not deciduous, elliptic or elliptic-oblong, glabrous or sparsely puberulent along veins abaxially, with 5 main veins, apex acute or acuminate; petiole-like base upto 10 cm. *Inflorescence* laxly 5-10-flowered; Scapes 1 or 2, arising from near apex of pseudobulb, erect, 20-34 cm, slender, with several lanceolate sterile bracts; rachis 7-13 cm; floral bracts 0.1-0.2 cm, persistent, lanceolate, abaxially puberulent, apex long acuminate. *Flowers* greenish pink; pedicel and ovary ca 0.3cm, densely puberulent. *Sepals* 1.8-2.0 x 0.5 – 0.7 cm, similar, ovate-lanceolate, abaxially puberulent, 5-veined, apex cuspidate; lateral sepals oblique. *Petals* linear, 1.2-1.7 x 0.2 –0.4 cm, 3-veined usually, apex acuminate. *Lip* 1.2-1.5 x 0.7-0.9 cm, adnate to base of column wings, spurless, 3-lobed; lateral lobes ca 0.6 mm across their apices, oblong-falcate, margin entire, apex obtuse; mid-lobe rhombic-elliptic to obovate-cuneate, apical margin irregularly dentate or fringed, apex acute; disk without lamellae or calli. *Column* ca 0.5 cm, glabrous; rostellum 3-lobed. Anther cap narrowly ovate-cordate, ca 0.4 cm. *Pollinia* clavate, ca 1.5 mm, with conspicuous caudicles; viscidium linear, ca 1 mm.

Colour Plate 6

Flowering: May - June

Habitat and Ecology: Terrestrial or lithophytic and found along the sides of stream in an undisturbed forest, 2300 m.

Distribution: India (Arunachal, Meghalaya, Nagaland, Sikkim, West Bengal), Japan, Nepal, Vietnam.

Specimens examined: Satoi village (Zunheboto district) HYJ253 (NUH)

6. Calanthe triplicata (Willemet) Ames in Philipp. J. Sci. 2:326. 1907; Hook. f., Fl. Brit. India 5: 853. 1890; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 176. 1998; Pearce. N.R. & Cribb. P.J., Orch. Bhutan, 293. 2002. *Orchis triplicata* Willemet in Ann. Bot. (Usteri) 6:52. 1796. *Calanthe odora* Griff., Notul. 3: 365. 1851.

Plant 40-90cm. *Pseudobulbs* 3–5 cm long, ovoid, conical. Rhizome stout, short, *Roots* caespitose. *Leaves* 3-6, 25-40 x 5–9cm, ovate–lanceolate to nearly elliptic-lanceolate, petiolate, ribbed, puberulent below; petiole 8-18cm long, grooved. *Inflorescence* erect, densely many flowered towards towards apex; peduncle 20-35cm long, puberulent, sheathed; sheaths 2-4x0.5-0.8cm, lanceolate, acute; rachis10-22cm long, puberulent; floral bracts 1-4x 0.5-0.8cm, lanceolate, acute. *Flowers* ca 5cm across, white with pale green tips on sepals, callus yellow to red-orange; pedicel and ovary pubescent, 2.4-4cm. *Sepals* 1.2-1.6 x 0.5-0.6cm, similar, elliptic-obovate, apiculate. *Petals* 1.2–1.3 x 0.4–0.6 cm, broadly oblong to oblanceolate, apiculate. *Lip* 1.2–1.7 x ca 1.2cm, adnate to column base, spurred, 3-lobed; lateral lobes oblong, obtuse, spreading; mid deeply divided into 2 linear-oblong, falcately recurved segments, sinus acute; disc tuberculate. *Spur* 1.5–2.2cm long, slender, curved. *Column* 4–6. mm long, puberulent. Fruit ca 3 x 1.4cm, ellipsoid.

Colour Plate 6

Flowering: May - July

Habitat and Ecology: Terrestrial or lithophytic and found growing in between rocks on a slope in an open disturbed forest. 500 – 1900m

Distribution: India (Arunachal, Assam, Manipur, Meghalaya, Nagaland), Bhutan, Nepal, S.E. Asia, Sri Lanka, Australia and Fiji.

Specimens examined: Ghokimi village (Zunheboto district) HYJ217 (NUH), Chiang mai village (Tuensang district) HYJ188 (NUH).

CHILOSCHISTA Lindl.

Edwards's Bot. Reg. 18: ad t. 1522. 1832

The genus was described by John Lindley in 1832. The generic name, derived from the Greek words 'cheilos' (lip) and 'schistos' (cleft), describes the cleft lip found on the flowers.

1 species in India and Nagaland and recorded by the author.

1. Chiloschista parishii Seidenfaden in Opera Bot. 95:176, t.109. 1988. *Thrixspermum luniferum sensu* Rchb.f. in trans. Linn. Soc. London 30:136. 1874, *non* Rchb.f. 1868; Pearce & Cribb 2002. The Orch. Of Bhutan Vol. 3(3). 503 (1-643).

Roots 2-3 mm in Diam., numerous, elongate. *Inflorescence* pubescent, pendent, laxly many-flowered; peduncle 1.4-2.2 cm long, sheathed, hirsute; sheaths ca 2.5 mm long distant, lanceolate, membraneous, acute; rachis 4-8 cm long, softly hirsute; floral bracts 2-3 x 1-1.5 mm, ovate-lanceolate, membraneous. *Flowers* 0.9-1.2 cm across, subsessile, sepals and petals yellow with brown blotches and spots, lip whitish yellow with bands of brown, pedicel and ovary ca 3 mm long, subsessile, pubescent. *Dorsal sepal* 0.5-0.6 x 0.3-0.4 cm, ovate, obtuse, concave, arching over the column, outer surface hirsute; lateral sepals 0.4-0.5 x 0.3-0.4 cm, ovate-orbicular, obtuse, spreading, outer surface hirsute. *Petals* 0.4–0.5 x 0.3-0.4 cm, subquadrate, truncate, outer surface hirsute. *Lip* deeply saccate, parrellel to the column, adnate to the column foot, 3-lobed; lateral lobes 0.2-0.3 x ca 0.1 cm, large, erect, obliquely oblong, glabrous; mid-lobe knob-like, reduced; sac ca 2mm long; disc with a pubescent ridge. Column thick, ca 1.2 mm long; foot ca 3mm long; anther cap with 2 long, filiform decurved lateral setae, ca 2 mm long. *Fruit* 2.8-4 x ca 0.3 cm, fusiform-cylindric.

Colour Plate 7

Flowering: April - May

Habitat and ecology: Epiphytic and found growing on branch of tree. 1300-1900m

Distribution: India (Arunachal, Assam, Nagaland, Sikkim, West Bengal), Bhutan, Myanmar, Nepal.

Specimens examined: Satoi village (Zunheboto district) HYJ104 (NUH)

CLEISOCENTRON Bruhl.

Guide Orchids Sikkim 136. 1926

The genus was established by Paul Bruhl in 1926 in his 'Guide to the orchids of Sikkim'. the generic name is derived from the Greek words 'kleitos – closed' and 'kentron – spur' referring to the morphology of the spur which is completely closed by thickening of its wall.

The genus comprises about five species distributed from Sikkim, Bhutan, Myanmar, Vietnam to Borneo. 1 species in India and Nagaland and reported by the author.

1. Cleisocentron pallens (Cathcart ex Lindl.) N. Pearce & P.J. Cribb in Edinb. J. Bot. 58 (1): 118. 2001; Hook. f., Fl. Brit. India 6 : 65. 1890; King & Pantl. in Ann. Roy. Bot. Gard. Calc. 8 : 229. T. 306. 1898; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 198. Fig. 114. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 95. 2000. *Saccolabium pallens* Cathcart ex Lindl. in J. Proc. Linn. Soc., Bot. 3 (9): 35. 1858. *Saccolabium trichromum* Rchb. f. in Ham. Garten-Blume. 15: 51. 1859. *Cleisocentron trichromum* (Rchb. f.) Bruhl., Guide Orchids Sikkim. 137. 1926.

Plant 30 – 110 cm long. *Stem* branched, pendulous, covered with fibrous sheaths. *Leaves* 9–16 x 1.4–1.8cm, narrowly oblong, tapering slightly, apex obliquely bifid, sessile and jointed. *Inflorescence* 3–5 cm long, divergent, secund, few to many flowered; peduncle 1.2 – 1.9 cm long, sheathed at base; shetahs tubular, 4–5 mm long; rachis glabrous 3 – 7 cm long; floral bracts 3 -5 mm long, broad, obtuse. *Flowers* 2.2–2.6 cm across; sepals and petals pale white, lined with pink, spur pinkish white, column pale white; pedicel and ovary 1.5– 3 cm, slender. . *Sepals* 0.7–0.9 x 0.2– 0.3 cm, narrowly oblong, spreading, subacute, sub-similar; lateral sepals 0.8–1.0 x 0.2–0.3 cm, oblong-lanceolate, acute. *Petals* 0.4–0.6 x ca 0.2 cm, obovate-oblong, apiculate. *Lip* 1.4 1.7 x 0.2 – 0.5 cm (with spur), adnate to the column foot, long spurred, 3-lobed; lateral lobes broadly triangular; mid-lobe short, triangular, concave, acute, entire; spur funnel shaped, slightly curved, obtuse, two large projecting calluses down the tube, front wall callus projecting upwards as a plate dividing the upper spur into 2 chambers. *Column* 0.4 x 0.2 cm, column foot curved ca 2mm long; anther cap depressed, front beaked.

Colour Plate 7

Flowering: August - October

Habitat and Ecology: Epiphytic and found growing on tree trunk with diffused or full head sunlight. 1400-1500m

Distribution: India (Arunachal, Assam, Manipur, Meghalaya, Nagaland, Sikkim) Bhutan.

Specimens examined: Asukika Area, Pughoboto (Zunheboto district) HYJ049 (NUH), Sikimi/ Sikiur village (Tuensang district).

CLEISOSTOMA Blume

Bijdr. 6:t.3, f.27; 8:362. 1825

The genus was described by Carl Ludwig Blume in 1825. The generic name is derived from the Greek words '*kleistos*' (closed) and '*stoma*' (mouth); referring to the inflated calli which are almost closing the muth of the spur. About 100 species distributed in India, S.E. Asia, Indonesia, New Guinea, Phillipines and Pacific Islands to Australia.

19 species in India, 8 in Nagaland and 3 species reported by the author.

Key to species

1. Leaves terete ……..… *C. williamsonii*
- Leaves flat, unequally bi-lobed apex, leathery ……..... 2
2. Leaves rather close, linear-lorate; Flowers whitish, tinged with purple …… ……..... *C. parishii*
- Leaves narrowly oblong to linear; Flowers yellowish to purplish brown, lip yellow ……..… *C. paniculatum*

1. Cleisostoma paniculatum (Ker-Gawl.) Garay in Bot. Mus. Left. Harv. 23 (4): 173. 1972; Seidenf. In Dansk Bot. Ark. 29 (3) : 37.Pl. 16. 1975; Pradhan, Indian Orch. 2: 512. 1979; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 204. Fig. 119. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 101. 2000. *Aerides paniculata* Ker-Gawl. In Bot. Reg. 3: Pl. 220. 1817. *Vanda paniculata* (Ker-Gawl.) R. Br. In Bot. Reg. 6. Sub, Pl. 516. 1820. *Sacranthus paniculatus* (Ker-Gawl.) Lindl. in Bauer, III. Orch. Pl. 9. 1832.

Plant erect, sometimes pendant. *Stems* erect, 35–55 cm long, compressed, terete, elongate 5–8 mm in diam., sometimes branching, many leaved. *Leaves* 10-12, 10–25 x 0.8–2cm, distichous, flat, narrowly oblong or linear, leathery, ± conduplicate at base, unequally bilobed, sometimes mucronate in sinus. *Inflorescence* 18-32cm long, axillary, many branched, many flowered; floral bracts ca. 2 mm ovate. *Flowers*

opening widely; sepals and petals yellowish green abaxially, purplish brown adaxially, margins and midvein yellow, lip yellow; pedicel and ovary ca. 1 cm. *Dorsal sepal* ca. 4.5 x 2.5mm, suboblong, concave, obtuse; lateral sepals ca. 4.5 x 2.5 mm, obliquely oblong, base adnate to column foot. *Petals* 4 x 1.5mm, smaller than sepals; lip with lateral lobes erect, deltoid, relatively small, apex obtuse, proximal margin sometimes ± thickened-callose; mid-lobe fleshy, apex upcurved and incurved-beaked, with 2 basal backward subulate lobules, adaxially with a ridge highly raised at apex. *Spur* ca. 4.5 mm, straight, apex obtuse, interior usually septate, with a back wall callus; callus rectangular, longitudinally concave at center, base slightly bilobed and densely papillate-hairy. *Column* ca 2 mm long, stout; anther cap truncate, incised; stipe short, broad, geniculate-folded at base; viscidium crescent-shaped or saddlelike, large. *Pollinia* oblong.

Colour Plate 7

Flowering: June - July

Habitat and Ecology: Epiphytic and found growing on main tree trunk in open primary forest, 650m

Distribution: India (Arunachal, Assam, Manipur, Meghalaya, Nagaland, Sikkim) China, Taiwan, Thailand.

Specimens examined: Sumi Shettsu village (Zunheboto district) HYJ064(NUH)

2. Cleisostoma parishii (Hook.f.) Garay, Bot. Mus. Leafl. 23: 173. 1972. *Sarcanthus parishii* Hook.f. Bot. Mag. 86: t. 5217.1860.

Epiphytic. *Stems* 1-6 cm, stout. *Leaves* 6-18 x 1.2-2.5 cm, twisted, distichous, rather close, flat, linear-lorate, fleshy or thickly leathery, unequally bilobed. *Inflorescence* racemose or paniculate, borne from middle or usually lower part of stem, much longer than leaves, laxly many flowered; peduncle purplish brown; floral bracts ovate-triangular, small, 1-2 mm, acute. *Flowers* opening widely, whitish, tinged with purple, column pale purple; pedicel and ovary purplish brown, ca 1 cm. *Dorsal sepal* 0.3 – 0.4 x ca 0.2 cm, suboblong, obtuse; lateral sepals 0.3 – 0.4 x ca 0.2 cm, slightly oblique ovate, base adnate to column foot. *Petals* similar to dorsal sepal, 0.3 – 0.4 x ca 0.15 cm, smaller, obtuse. *Lip* ca 0.3 x 0.2 cm; lateral lobes erect, suborbicular, bilobed; mid-lobe deltoid, fleshy, acute, with 2 basal backward lobules; spur horn-shaped, ca 2 mm, apex obtuse, inside longitudinally septate; back wall callus 3-lobed, T-shaped; lateral lobules short, stout; mid-lobule narrowed toward

base, with a central longitudinal groove, base slightly bilobed and densely papillate-hairy. *Column* ca 2 mm; anther cap not narrowed toward apex; stipe threadlike; viscidium suborbicular, very small.

Colour Plate 7

Flowering: September

Habitat and Ecology: Epiphytic and found growing on main tree trunk with full sunlight. 900m

Distribution: India (Nagaland), China, Myanmar

Specimens examined: Asukika area – Ghokimi, Tsaphimi village (Zunheboto district) HYJ218 (NUH)

3. Cleisostoma williamsonii (Reichb. f.) Garay, Bot. Mus. Leafl. Harv. 23(4): 176. 1972. Seidenf. In Dansk Bot. Ark. 29 (3): 50. T. 21. 1975; Hook. f., Fl. Brit. India 6: 67.1890; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 208. Fig. 123. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 103. Fig. 33. 2000. *Sacranthus williamsonii* Reichb. f. in Gard, Chron. 674. 1865.

Plant 30-60cm long, clustered, pendent. *Roots* basal, caespitose. *Stems* 35–45 cm long, slender, branched, many-leaved, covered by leaf sheaths, 2–3 mm wide; sheaths tubular, ridged, overlapping, 1.5–2 cm long. *Leaves* 8–13 x 0.2–0.3 cm, distichous, linear - terete, apex acute or obtuse, sessile. *Inflorescence* 6–9 cm long, pendent, laxly many-flowered, racemose or paniculate, lateral from half-way down leaf-sheath; peduncle sheathed at base; floral bracts1 x 0.5 mm long, triangular. *Flowers* 3–5 mm across; sepals and petals pink, lip pale purple; pedicel and ovary slender, 2 – 3 mm long. *Dorsal sepal* ovate, sub-acute, 2 x 0.8 mm. *Lip* 3–lobed, spurred, 2-3 mm long; hypochile globose saccate, lateral lobes oblong, rounded, 0.8 x 0.2 mm; epichile decurved, lanceolate, apex curved inwards; *spur* globose, 1.5 x 1 mm; back wall callus 2-lobed with side horns. *Column* 1 mm long; stipe mitre-shaped, base broad. *Pollinia* elliptic.

Colour Plate 7

Flowering: June - July

Habitat and Ecology: Epiphytic, Sometimes lithophytic and found growing on main tree trunk with full sunlight. 2300m

Distribution: India (Arunachal, Assam, Nagaland, Andaman Islands), Bhutan, Myanmar, Cambodia, China, Taiwan, Thailand, Vietnam.

Specimens examined: Melangkiur village (Tuensang district) HYJ202 (NUH)

COELOGYNE Lindl.

Coll. Bot. sub. t. 33. 1821.

The genus was described by John Lindley in 1821. The generic name is derived from the Greek words '*koilos*' (hollow) and '*gyne*' (female), in illusion to the shape of the stigma. About 100 species distributed in India, S.E. Asia, Indonesia, China and Pacific Islands.

43 species in India, 24 spp. in Nagaland and 15 spp. reported by the author.

Key to species

1. Flowers opening successively ……..... 2
- Flowers opening simultaneously …… 5
2. Peduncles at base naked, but with a series of distichous sheaths just below the racemes ……..…..... 3
- Peduncles at base with enveloping sheaths,but without sheaths below the racemes ……..…..... 4
3. Inflorescence Zig-zag; flowers brown, ca 2.5 cm across; mid-lobe narrowly truncate at base, entire …… ……..……...… *C. griffithi*
- Infloresecence erect; flowers white marked with yellow, 4-5 cm across; mid-lobe quadrangular, margin fimbriate except around tip ….….. *C. calcicola*
4. Epichile of lip with additional keels; lateral lobes of lip obong-elliptic, obtuse ……..…… *C. fimbriata*
- Epichile of lip without additional keels; lateral lobes erect, rounded …….. *C. ovalis*
5. Inflorescence with distichous sheaths between apex of peduncle and base of Rachis..……..……..…... 6
- Inflorescence withhout sheaths between apex of peduncle and base of rachis ……..…..…… 9
6. Growth extension annual with distichous sheaths between new and old growth ……..……...…. 7
- Growth extension not annual ……. 8
7. Flowers yellow, less than 1.5 cm across ……..….... *C. prolifera*
- Flowers brownish yellow to brown, upto 3 cm across ……. *C. schultesii*

8. Disc with 3 keels; lip margins fimbriate ……..…….....… *C. barbata*

- Disc with 2 keels, lip margins erose …….…….….. *C. stricta*

9. Inflorescence terminal …… 10

- Inflorescence from base of pseudobulb …….……...….. 12

10. Lip obscurely –lobed; lamellae 5, undulate and confined to epichile only …… ……...… *C. suaveolens*

- Lip distinctly 3-lobed; lamellae 3, crenulate, extending to blotches on epichile ……..…… 11

11. Lateral lobes of lip oblong–ovate, apex rounded; streaked with reddish-brown ……...…..… *C. punctulata*

- Lateral lobes of lip rounded, serrulate at apex; yellow to reddish brown blotch at base ……..……..… *C. corymbosa*

12. Inflorescence 1 - 2 flowered ……..... *C. occultata*

- Inflorescence more than 4 flowered ……...… 13

13. Lip with 4 or 5 keels, keels yellow, fimbriate ……...… *C. cristata*

- Lip 3 simple keels, keels white, not fimbriate …….……... 14

14. Leaves oblong elliptic; Inflorescence, 5-12 flowered; petals linear-lanceolate; mid lobe ovate. ……...……....*C. flaccida*

- Leaves narrowly elliptic-lanceolate; Inflorescence 3-7 flowered; Petals narrowly oblong-lanceolate; mid-lobe orbicular-cordate ……..*C. nitida*

1. Coelogyne barbata Lindl. Griff., Itin. Not. Pl. 72. 1848; Hook.f., Fl. Brit. India 5: 839. 1890; Pradhan, Indian Orch. 2:276. 1997; Hegde, Orch. Arunachal Pradesh, 47. Fig. 51. 1984; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh 216. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 107. 2000. *Pleione barbata* (Lindl. ex Griff.) Kuntze. Revis. Gen. Pl. 2: 680 1891.

Rhizome 1–1.2 cm in diameter, stout, rigid, covered with scaly sheaths, with short internodes. *Pseudobulbs* 8 - 10 × 2.5–3.0 cm, sparse, sub-pyriform, sub-acute, with 2 leaves at apex and several sheaths at base, membraneous. *Leaves* 1 or 2, 20–40 x 4.0–5.8 cm, ovate - lanceolate, acuminate, margins undulate, coriaceous; petiole 8-11 cm. *Inflorescence* 22–27 cm, hysteranthous, erect to arching, 4–8 flowered (opening in succession); peduncle sheathed; sheaths 0.7–1.3 cm, distichious, overlapping, glume like, ovate –lanceolate; rachis slender and zig-zag, ca 13 cm long; floral bracts caduceus. *Flowers* 5–7 cm across, scented; sepals and petals, white, lip

fringed with dark brown to sepia projections, column white; pedicel and ovary 1.3–1.8 cm long, slender. *Dorsal sepal* 3.5–4 x 0.7–1.6 cm, ovate-oblong, acute, margins reflexed, veined; lateral sepals similar, apex acute to acuminate. *Petals* 3.5–3.7 x 0.3–0.4 cm, linear lanceolate, acute, apex reflexed, veined. *Lip* 2.5-3.0 × 2.0–2.4 cm, 3-lobed; lateral lobes ovate, erect, nearly suborbicular, margin fimbriate; mid - lobe ovate to suboblong, triangular, margins with dense fimbriate projections ca 7 mm; callus with 3 lacerate - fimbriate lamellae. *Column* 1.7-2.3 cm, arcuate, slightly curved. Capsule obovoid, ca. 4 × 1.5 cm, slightly 3-ridged.

Colour Plate 7

Flowering: September - October

Habitat and Ecology: - Lithophytic or epiphytic and found growing on lower tree trunk as well as rocky surfaces exposed to diffused as well as full head sunlight, 1800–2200m

Distribution: India (Arunachal, Assam, Manipur, Meghalaya, Nagaland, Sikkim, West Bengal) Bhutan, Nepal.

Specimens examined: New Sangsomong village (Tuensang district) HYJ203(NUH), Naltoqa village, Sukhalu village (Zunheboto district) HYJ219 (NUH), Pungro (Kiphire district) HYJ231(NUH)

2. Coelogyne calcicola Kerr, J. Siam Soc., Nat. Hist. Suppl. 9: 233. f.3. 1933; N. Odyuo, C. Deori and R. Daimary, R. Richardiana. 16: 343–346. 2016.

Rhizome short-creeping with imbricate scales on young shoots. *Pseudobulbs* 3-4 cm apart, 4-10 cm long, ovoid to ellipsoid, oblique, with 2 leaves, enclosed with persistent bracts at base. *Leaves* 25-30 x 5-7 cm, oblong-lanceolate or oblong-obovate, subacute to acute, subcoriaceous, many veined. *Inflorescence* 12-14 cm, 6 flowered, hysteranthous, erect, rigid; peduncle bare, with 6-7 densely imbricate, convolute, sheathing sterile bracts at interface between peduncle and rachis; floral bracts 3-3.2 x ca 2cm, many veined; rachis 6-8 cm. *Flowers* 5-6 cm across, spreading, sepals and petals creamy white. *Dorsal sepal* 2.6-2.8 x 1.4-1.6 cm, 7-9 veined, oblong-lanceolate, somewhat acute; lateral sepals 2.6-2.8 x 1.2-1.4 cm, oblong-lanceolate, 7-9-veined somewhat acute. *Petals* linear, 2.6-2.8 x 0.3-0.4 cm, 3-veined, obtuse. *Lip* 2.6-2.7 x ca 2.5 cm, 3-lobed; side lobes small compared with remainder of lip, rounded, front margin fimbriate; mid-lobe 1.2-1.4 cm long, quadrangular, margin long fimbriate except around tip; callus with 2 keels extending

from base of lip and reaching middle of mid-lobe, fimbriate at apex, keels broadening into a warty protrusion. *Column* with foot ca 3 x 0.8 cm, slightly arched, ca. 17 mm, hood winged. Anther broadly flattened, ca 0.4 cm. *Pollinia* 4, unequal in 2 pairs, oblong or subelliptic.

Colour Plate 8

Flowering: April - May

Habitat and Ecology: - Epiphytic and found growing on lower tree trunk in an open forest exposed to diffused sunlight, 1600–1800m

Distribution: India (Nagaland), Myanmar, China, Thailand, Laos, Vietnam.

Specimens examined: Dan-ITC- Pangsha village (Tuensang district), HYJ189 (NUH)

3. Coelogyne corymbosa Lindl., Fol. Orchid. Coelogyne 5:7, no.16 1854; Hook.f., Fl. Brit. India 5: 831. 1890; King & Pantl. in Ann. Roy. Bot. Gard. Calc. 8: 134. T.185. 1898; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 216. fig. 125. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 108. 2000. *Pleione corymbosa* (Lindl.) Kuntze, revis. Gen. Pl. 2:680. 1891.

Rhizome somewhat rigid, 3-4 mm in diam., with brown scaly sheaths. *Pseudobulbs* 2-4 x 0.6-1.2 cm, densely jointed, less than 1 cm apart from each other, bright yellow to greenish yellow, wrinkled when older, oblong-ovoid or nearly rhombic-oblong, several sheaths at base; sheaths 1.4-2.5 cm, papery lucid, ovate. *Leaves* 2 from apex of pseudobulb, 4.5-10 x 2-3 cm, oblong-oblanceolate to obovate-oblong, subleathery, adaxially with raised transverse veinlets, apex often acuminate; petiole 1-2 cm. *Inflorescence* 7-12 cm (elongated when fruiting), proteranthous to synanthous, embraced by sheaths below middle, 2-4-flowered; floral bracts caducous. *Flowers* white, with 4 yellow eyelike blotches surrounded by reddish orange on lip. *Dorsal Sepals* 1.8-2 x 0.7-0.8 cm, oblong-lanceolate, apex acute or obtuse; lateral sepals narrower than dorsal sepal. *Petals* 1.8-2.1 x 0.3-0.4 cm, linear-lanceolate. *Lip* 1.6-2.4 x 1.4-1.6 cm, subovate, 3-lobed; lateral lobes erect, suborbicular or nearly subovate, serrulate at apex; mid-lobe ovate or ovate-lanceolate, 6-8 mm; 2 or 3 low lamellae extending from base to mid-lobe. *Column* 1.2-1.4 cm, slightly arcuate, both sides winged; wings widened from base to apex, upper side ca 1.6 mm wide on one side, apex obtuse. *Capsule* 2-2.8 x 1-1.4 cm, subobovoid, slightly trigonous.

Colour Plate 8

Flowering: February - April

Habitat and Ecology: Epiphytic or lithophytic sometimes and found growing both on tree trunk and rocks on a cliff. 2700 m.

Distribution: India (Arunachal, Meghalaya, Nagaland, Sikkim, West Bengal) Bhutan, Myanmar, Nepal.

Specimens examined: Thanamir village (Kiphire district) HYJ091 (NUH).

4. Coelogyne cristata Lindl., Coll. Bot.: Sub t. 33. 1821; Hook.f., Fl. Brit. India 5: 829. 1890; King & Pantl in Ann. Roy. Bot. Gard. Calc 8 : 133, t. 184. 1898; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh 216.fig 126. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 108. 2000. *Cymbidium speciosissimum* D. Don, prodr. Fl. Nepal.: 35. 1825.

Rhizome sheathed, stout. *Pseudobulbs* 4.5–7 x 2–3.5cm, cylindric ovoid, smooth to wrinkled. *Leaves* 2, 14–22 x 2–3.8cm, linear–lanceolate, acute, margins slightly undulate, sessile. *Inflorescence* 16–8 cm, hysteranthous, pendent, 3–8 flowered (opening together); peduncle sheathed, 6–8 cm long; sheaths 2.5–3 x 0.9–1.8cm, overlapping, lanceolate, acute; rachis 8-10 cm long; floral bracts 3–4 x 1.3–1.6cm, oblong- lanceolate, acute, persistent. *Flowers* 6–8cm across; sepals and petals white, lip white whith yellow keels between lateral lobes, crenulate plates on the mid-lobe, column white; pedicel and ovary 4–5.5cm long, widening at base of flower. *Dorsal sepal* 3.8–4.7 x 1.3–1.6 cm, narrowly elliptic-oblong, sub-acute, undulate; lateral sepals similar. *Petals* 3.6–4.4 x 0.7–1.5 cm, narrowly elliptic-oblong, acute, undulate. *Lip* 3.4–4 x 3–3.3cm, 3-lobed; lateral lobes large, rounded; mid - lobe sub – orbicular; Disc with 4 to 5 fimbriate keels from lip base to apex. *Column* 2.4–3.0cm, curved, broadly winged. **Colour Plate 8**

Flowering: February - April

Habitat and Ecology: Epiphytic or lithophytic (sometimes) and found growing on lower tree trunk in an undisturbed forest as well as on rocky soil by a stream. 1500-2200m.

Distribution: India (Arunachal, Assam, Manipur, Meghalaya, Nagaland, Sikkim, West Bengal) Bhutan, Myanmar, Nepal.

Specimens examined: New Sangsomong village (Tuensang district) HYJ038 (NUH), Naltoqa village (Zunheboto district) HYJ204 (NUH)

5. Coelogyne fimbriata Lindl. in Bot. Reg. 11: t. 868. 1825; Hook.f., Fl. Brit. India 5: 836. 1890; Seidenf. in Dansk Bot. Ark. 29 (4) : 15, fig. 4. 1975; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh 219. fig 127. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 110. fig 34. 2000. *Pleione chinensis* Kuntze, Revis. Gen. Pl. 2: 680. 1891. *Pleione fimbriata* (Lindl.) Kuntze, *loc. cit*. 1891. *Coelogyne ovalis sensu* Pfitzer & Kranzlin, Pflanzenr. (IV.50) *Coelogyne*: 53, t. 17d, e (1907), *non* Lindl. 1838.

Rhizome creeping, slender, sheathed. *Pseudobulbs* 3–4cm apart on rhizome, 2.8–4 x ca 1.1cm. *Leaves* 2, 7-8.5 x 1.0-1.3cm, oblong, elliptic, acute, 5–veined; petiole 0.5-1.3 cm long, grooved. *Inflorescence* hysteranthous, few flowered (opening in succession; peduncle ca 2.5 cm long, slender, erect, sheathed at base; sheaths overlapping; rachis often with 1 or 2 flowers opening successively, 2.5-5cm, zig-zag; floral bracts caducous. *Flowers* 3-3.5cm across; sepals and petals pale yellow or nearly, lip whitish or pale yellow with brown stripped; pedicel and ovary 1-1.2cm long, slender. *Dorsal Sepals* 1.6-2.0 × 0.4-0.7cm, oblong-lanceolate, acute; lateral sepals 1.6-2.0 x 0.4-0.7cm, oblique, lanceolate, acute. *Petals* 1.6-2.0 × ca 0.1cm, filiform, narrowly linear. *Lip* 2-2.4 x 1.2-1.5cm, 3-lobed; lateral lobes obong-elliptic, obtuse, margins fimbriate; mid-lobe orbicular, margins fimbriate, long-pubescent; disc 3-keeled from lip base, median keel a bbrown line, lateral keels undulate, almost meeting near apex. *Column* 1.0-1.3cm, slender, curved, expanded into a hood, apex crenate. **Colour Plate 8**

Flowering: September - October

Habitat and Ecology: Epiphytic sometimes lithophytic and found growing on tree trunk in a disturbed forest with diffused sunlight, 600-1500m

Distribution: India (Arunachal, Assam, Meghalaya, Nagaland, Sikkim, West Bengal), Bhutan, Myanmar, China, Nepal, Thailand, Laos, Indonesia.

Specimens examined: New Sangsomong village (Tuensang district) HYJ226 (NUH), Sumi – Shettsu village (Zunheboto district) HYJ192 (NUH).

6. Coelogyne flaccida Lindl., Gen. Sp. Orchid. Pl.: 39. 1830; King & Pantl in Ann. Roy. Bot. Gard. Calc 8 : 133, t. 183. 1898; Seidenf. in Dansk Bot. Ark. 29 (4) : 38. 1975; Pradhan, Indian. Orch. 2 : 278, 1979; Hegde, Orch. Arunachal Pradesh 46. Fig 52. 1984; Kataki, Orch. Meghalaya 121. 44 (5). 1986; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh 219. fig 128. 1998; Hynniewta, Kataki & Wadhwa, Orch.

Nagaland (BSI), 110. 2000. *Coelogyne lactea* Rchb. f. in Gard. Chron. N.s. 23: 692. 1885. *Coelogyne huettneriana* sensu Hook. f., Fl. Brit. India 5(2). 830.1890.

Rhizome 9–10 mm in diam., stout, leathery sheaths. *Pseudobulbs* 4-11 x 1.5-3.8cm, conical to ovoid-cylindric, grooved, clustered, sheathed at base. *Leaves* 2, 8-18 x 1-4.5cm, oblong elliptic, acute to acuminate, prominently 3-veined, leathery; petiole grooved, 2-4 cm. *Inflorescence* 16-28cm, heteranthous, 5-12 flowered, (opening together); peduncle ca 6.5 cm long, sheathed at base; rachis ca 20 cm long, weakly zig-zag; floral bracts ca 2.5 cm, caducous, obovate-elliptic. *Flowers* 3-5 cm across, creamy white, centre of lip yellow, lateral lobe veins marked reddish-brown, mid-lobe spotted red at base, keels white, red-brown near apex; pedicel and ovary 2.0 – 2.3 cm long, slender, straight. *Sepals* 1.5-2.3 x 0.4-0.5 cm, similar, lanceolate. *Petals* 1.5-2.2 x 0.1-0.2 cm, linear-lanceolate, acute. *Lip* 3-lobed, 1-1.3 x 0.5-0.7 cm; lateral lobes oblong, erect, rounded; mid lobe ovate, lanceolate, acute, reflexed; disc 3-keeled from lip-base to base of mid-lobe, undulate-flexuous. *Column* straight, expanded into a winged hood, apex obscurely 2-lobed, ca 1.5 cm long. *Fruit* ovoid to obovoid.

Colour Plate 8

Flowering: March - April

Habitat and Ecology: Epiphytic or lithophytic and found growing on tree trunk in forest with diffused to full head sunlight, 1500-2100m

Distribution: India (Arunachal, Assam, Meghalaya, Nagaland, Sikkim, West Bengal) Myanmar, China, Nepal, Thailand, Laos.

Specimens examined: New Sangsomong village (Tuensang district) HYJ067 (NUH), Asukhomi & Aquaba village (Zunheboto district) HYJ205 (NUH)

7. Coelogyne griffithii Hook. f., Fl. Brit. India 5(2):838. 1890; Das & Jain in Fasc. Fl. India 5: 14. 1980; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 226. Fig. 132. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 112. fig 35. 2000. *Pleione griffithii* (Hook.f.) Kuntze. Revis. Gen. Pl. 2: 680 1891.

Plant 30cm or more. *Roots* ca 2mm *in diam*., *Rhizome* 6-12cm, stout. *Pseudobulbs* 5-9.5cm, compressed, linear-oblong, sulcate, with 2 leaves at apex and several sheaths at base. *Leaves* 2, 11.5-14 x 4.5-6cm, elliptic-lanceolate, leathery, acuminate; petiole ca 5 cm. *Inflorescence* 15-17cm, hysteranthous; peduncle 5-7cm, green, slender, glabrous; rachis zigzag, 8-11cm, 8-14 flowered, opening in succession; imbricate sterile bracts 2 x 0.8-1cm, at interface between peduncle and rachis.

Flowers light brownish, ca. 2.5 cm across. *Dorsal Sepal* 1.4-1.5 x0.7-0.8cm, ovate, glabrous, 3-veined, acuminate; lateral sepals 1.4-1.5 x ca 0.5cm, oblanceolate . *Petals* 1-1.3 x ca 0.1cm, very slender, glabrous, 1-veined, obtuse; lip 3-lobed; lateral lobes rounded with broad crenulations; mid-lobe narrowly truncate at base, entire, undulate, recurved; callus with 5 prominent, short lamellae, outer ones broader. *Column* ca. 3 mm, hood narrowly winged with wings serrate; anther cap ca 2mm across *Pollinia* 4 (2x2), ca 1 x 1mm.

Colour Plate 8

Flowering: April - May

Habitat and Ecology: Epiphytic and found growing on tree trunk in village forest with diffused sunlight, 1800m

Distribution: India (Arunachal, Assam, Manipur, Nagaland).

Specimens examined: Anangba village (Tuensang district) HYJ074 (NUH), Khashito (Zunheboto district) HYJ110 (NUH)

8. Coelogyne nitida (Wall. Ex D. Don) Lindl., Gen. Sp. Orchid. Pl.: 40. 1830; Hook. f., Fl. Brit. India 5: 831.1890; King & Pantl in Ann. Roy. Bot. Gard. Calc 8 : 132, t. 182. 1898; Seidenf. in Dansk Bot. Ark. 29 (4) : 53. Pl. 20. 1975; Pradhan, Indian. Orch. 2 : 272, 1979; Kataki, Orch. Meghalaya 124. Fig. 44 (1). 1986; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh 230. fig 136. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 114. fig. 36. 2000. *Cymbidium nitidum* Wall. Ex D. Don Prodr. Fl. Nepal 35. 1825 (*non C. nitidum* Roxb. 1832). *Coelogyne ochracea* Lindl., Bot. Reg. 20. Pl. 69. 1846.

Rhizome stout. *Pseudobulbs* 1.5-2.5cm apart on rhizome, 4-6.5 x 1-2cm, ovoid to conical, furrowed, erect. *Leaves* 2 from pseudobulb apex, 18-24 x 2-2.8cm, narrowly elliptic-lanceolate, acute, 8-veined; petiole 3.5-4cm long, grooved. *Inflorescence* proteranthous, erect or pendent, 3-7 flowered (opening together); peduncle 13-15cm long, bare or sheathed at base; sheaths 2-3cm long, broadly lanceolate, acute, overlapping; rachis 6-8 cm long, weakly zig-zag; floral bracts caduceus, 2.0-2.2 x 0.5-0.7cm. *Flowers* ca. 4 cm across; sepals and petals white, lip white with 4 yellow eye marks on the lateral lobes, disc yellow bordered with red; pedicel and ovary 1-2cm long. *Sepals* 2.2-2.8 x 0.3-0.5cm, similar, narrowly oblong, subacute to obtuse. *Petals* 2-2.2 x 0.3-0.4 cm, narrowly oblong-lanceolate, subacute. *Lip* 1.4-1.8 x 1-1.4cm, 3-lobed, ovate; lateral lobes oblong to rounded; mid-lobe

orbicular-cordate, apex rounded to sub-acute; disc 3-keeled from lip base. *Column* slender, weakly curved, hooded at apex, margins entire to weakly erose ca 1.3 cm long. *Fruit* ellipsoid.

Colour Plate 9

Flowering: April - June

Habitat and Ecology: Epiphytic or lithophytic and found growing on tree trunk in a disturbed forest with full head sunlight as well as undisturbed forest in between rocks, 1600-1900m

Distribution: India (Arunachal, Assam, Manipur, Meghalaya, Nagaland, Sikkim, West Bengal) Myanmar, Nepal, China, Thailand, Vietnam.

Specimens examined: Helipong village, Pangsha village (Tuensang district) HYJ116 (NUH), Tsutoho village (Zunheboto district), Thanamir Saramati (Kiphire district) HYJ115 (NUH).

9. Coelogyne occultata Hook. f. Fl. Brit. India 5 : 832. 1890; King & Pantl in Ann. Roy. Bot. Gard. Calc 8 : 135, t. 186. 1898; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh 230. fig 137. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 116. 2000. *Coelogyne occultata* var. *uniflora* N.P.Balakr. J. Bombay Nat. Hist. Soc. 75:159, 1978.

Rhizome stout, 4-5mm in diam, creeping. *Pseudobulbs* 2.5-4 x 0.7-1.3cm, ovoid, apex turbinate, acute, ridged, glossy green. *Leaves* 2, 3-8 x 1.0-2.2cm, narrowly elliptic to elliptic, acute, 3-5 veined; petiole grooved, ca 1 cm. *Inflorescence* hysteranthous, erect, 3 or 4 flowered; peduncle slender, enclosed by overlapping sheaths, ca 4 cm long; sheaths lanceolate, acute, 1-1.4cm long; rachis ca 4 mm long, 2 0r 3 flowered; floral bracts 2-3 cm, caducous, linear lanceolate. *Flowers* ca 2.5cm across; sepals and petals white, lip white, lateral lobes streaked with red brown, mid-lobe with yellow eyes, column white with orange yellow band at base; pedicel and ovary ca 15 mm long. *Sepals* similar, 2.0-2.2 x 0.5-0.6cm, spreading, oblanceolate, acute. *Petals* 1.8-2.0 x 0.3-0.4cm, narrow, linear-oblong, acute. *Lip* 2.0-2.4 x 1.3-1.5cm, 3-lobed; lateral lobes large, erect, rounded, margins crenulate; mid-lobe ovate, obtuse, margins crenulate; disc 3-keeled from base to midlobe, median keel short, lateral keels thick, crenate. *Column* slender, hooded, broadly winged.

Colour Plate 9

Flowering: June - July

Habitat and Ecology: Epiphytic or lithophytic and found growing on tree trunk in an undisturbed forest with diffused sunlight, 1750m

Distribution: India (Arunachal, Assam, Meghalaya, Nagaland, Sikkim, West Bengal) Myanmar, Cambodia, China, Nepal, Thailand.

Specimens examined: Wangsoi village (Tuensang district) HYJ078 (NUH), Satoi (Zunheboto district) HYJ260 (NUH)

10. Coelogyne ovalis Lindl. in Bot. Reg. 24: 91. misc. 191, 1838; Hook. f., Fl. Brit. India 5: 836.1890; King & Pantl in Ann. Roy. Bot. Gard. Calc 8 : 135, t. 187. 1898; Deb, Bull. Bot. Surv. India, 3(2): 115 – 138. 1961; Rao & Joseph, Bull. Bot. Surv. India 7 (1-4): 138 – 161. 1965; Seidenf. in Dansk Bot. Ark. 29 (4) : 23. T. 6. 1975; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh 234. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 116. 2000. *Coelogyne fimbriata sensu* Lindl., Gen. Sp. Orchid. Pl: 41. 1830, *non* Lindl. (1825).

Rhizome ca 3mm in diam., creeping, slender, branched, sheathed. *Pseudobulbs* 2-3 cm apart on rhizome, 4-6cm × ca 1cm, narrowly cylindric, angular, bare at base, 2 leaves at apex and 2 sheaths at base; sheaths ca 3 cm, membranous, deciduous when old. *Leaves* 12-14 x 1.2-3.0cm, lanceolate, acute, 9-veined, papery, apex acuminate or obtuse; petiole grooved ca 1.2cm long. *Inflorescence* hysteranthous, 2 0r 3 flowered, opening in succession; peduncle ca 3.2cm long, distinct, sheathed at base; sheaths overlapping; rachis ca 3.2 cm long, slender, zig-zag; floral bracts caducous. *Flowers* 5-6cm across, greenish yellow, with purplish brown stripes on lip; pedicel and ovary 2.0-2.2cm long, slender. *Sepals* ca 2.4 x 0.8-1.0cm, oblong-lanceolate, 5-7 veined. *Petals* ca 2.3 x 0.1-0.2cm, filiform or narrowly linear. *Lip* 2.0-2.2 x 1.4-1.8 cm spread, suboblong-ovate, 3-lobed; lateral lobes erect, rounded, margins fimbriate; mid-lobe orbicular, apex obtuse, margins fimbriate, hirsute; disc 3-keeled, median keel short, indistinct, lateral keels from base to apex, undulate. *Column* ca 1.3cm, slightly arching, both sides with wings, apex crenualte. *Capsule* subobovoid.

Colour Plate 9

Flowering: Sept - Oct

Habitat and Ecology: Epiphytic or lithophytic and found growing on tree trunk in a disturbed forest with diffused sunlight, 500-1900m

Distribution: India (Arunachal, Assam, Meghalaya, Nagaland, Sikkim, West Bengal) Myanmar, Cambodia, China, Nepal, Thailand.

Specimens examined: Pangsha village (Tuensang district) HYJ196 (NUH), Naltoqa & Lumami village (Zunheboto district) HYJ197 (NUH).

11. Coelogyne prolifera Lindl., Gen. Sp. Orchid. Pl.: 40. 1830; Hook. f., Fl. Brit. India 5: 828.1890; King & Pantl in Ann. Roy. Bot. Gard. Calc 8 : 138, t. 191. 1898; Seidenf. in Dansk Bot. Ark. 29 (4) : 82. t. 36. 1975; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh 234. fig 138. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 117. fig 37. 2000. *Coelogyne flavida* Wall. ex Lindl., Fol. Orchid. Coelogyne 5 :10, no.24. 1854.

Rhizome 5-6mm in diam., stout, creeping, densely covered with leathery scaly sheaths, short internodes; sheaths 1-2 x 0.5-0.9cm, overlapping, ovate-lanceolate, acute. *Pseudobulbs* 3-6 x 1.2-1.5cm, ovoid-cylindric, compressed, sheathed at base, 3-4cm apart on rhizome, several sheaths at base. *Leaves* 2, 8-14 x 1.5-2.4cm, leaf blade oblong-lanceolate or suboblong, apex acuminate; petiole 2-3cm, grooved. *Inflorescence* 10-15cm, hysteranthous, 3-10 flowered opening together; peduncle 9-13cm, slender; sheaths at junction of peduncle and rachis overlapping; rachis 3.5-5cm long, slender, zigzag; floral bracts ca 1.0cm, caduceus. *Flowers* 1-1.4cm across, green or yellowish green, lip lateral lobes brown veined, mid-lobe yellow, column yellow; pedicel and ovary 8-10 mm, slender. *Sepals* oblong, 0.7-0.8 x 0.2-0.3 cm, sub-similar, triangular to oblong, obtuse. *Petals* 0.6-0.8 x ca 0.1cm, linear, acute, reflexed, slightly narrowed toward base. *Lip* 3-lobed, ca 6mm long, subovate, base concave and shallowly saccate, 3-lobed; lateral lobes erect, enclosing the column, small, ovate; mid-lobe ca 4 x 3 mm, nearly elliptic, wedge-shaped to obcordate at base, rounded-retuse apex, margins undulate-dentate; callus with 2 inconspicuous longitudinal lamellae extending from base of mid-lobe and then diminishing. *Column* ca 5 mm, almost erect, subclavate, apex narrowly winged and irregularly notched.

Colour Plate 9

Flowering: May - June

Habitat and Ecology: Epiphytic and found growing on tree trunk in a disturbed forest with diffused sunlight, 600-2100m

Distribution: India (Arunachal, Assam, Meghalaya, Nagaland, Sikkim, West Bengal) Myanmar, Cambodia, China, Nepal, Thailand, Vietnam.

Specimens examined: Pangsha village (Tuensang district) HYJ082 (NUH), Lumami and Sumi - Shettsu village (Zunheboto district) HYJ061 (NUH).

12. Coelogyne punctulata Lindl., Coll. Bot. ad t. 33. 1821; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 234. fig. 139. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 119. Fig 38. 2000. *Coelogyne ocellata* Lindl., Gen & Sp. Orch. 40. 1830; Seidenf. in Dansk Bot. Ark. 29(4): 57.t. 21.1975. *Coelogyne goweri* Reichb. f. in gard. Chron, 443. 1869. *Coelogyne nitida* (Roxb.) Hook.f, Fl. Brit. India 5: 837. 1890. *non*. (Wall. ex D. Don) Lindl. 1830. *Cymbidium nitidum* Roxb. Fl. Ind.3:349.1832, (*non* Wall. ex Don, 1825).

Rhizome stout, rigid, 0.4-0.6 cm in diam., with brown scaly sheaths. *Pseudobulbs* 2.5-4 cm x 0.8-11.4 cm, around 1 cm apart on rhizome, rather contiguous, greenish, bright yellow when dried, oblong or narrowly ovoid-oblong, sheathed at base; sheaths ca 2-5 cm long, ovate-oblong, papery. *Leaves* 2, 8-16 x 1.4-2.7 cm, lanceolate or narrowly oblong-lanceolate, dense raised transverse veinlets adaxially, apex acuminate; petiole 2-4 cm. *Inflorescence* 8-16 cm long, hysteranthous, slightly recurved, rachis 2-4-flowered; floral bracts ca 2-3 cm long, caducous, suboblong-lanceolate; pedicel and ovary 1.3-1.6 cm. *Flowers* white, with deep-colored eyelike blotches on lip. *Dorsal sepal* 1.7-2 x 0.8- 1 cm, oblong-lanceolate, apex acute; lateral sepals sub-similar, slightly narrower. *Petals* 1.8-2 x ca 0.4 cm, linear. *Lip* 1.6-1.8 x ca 1.2 cm when open, oblong-ovate, 3-lobed; lateral lobes erect, oblong-ovate, apex rounded; mid-lobe ca 0.6 cm long, ovate-lanceolate, with 2 longitudinal, dentate lamellae extending from base of lip to mid-lobe and a short median lamella between them. *Column* ca 1 cm long, slightly arcuate, both sides winged; wings widened from base to apex, apex subtruncate or obtuse. Anther cap 2mm. *Pollinia* 4, unequal in pairs, ca 1mm. *Capsule* ca 2.3 x 1cm, obovoid-oblong.

Colour Plate 9

Flowering: April

Habitat and Ecology: Epiphytic and found growing on branch of tree in a disturbed forest with diffused sunlight, 1800-2300m

Distribution: India (Arunachal, Assam, Manipur, Meghalaya, Nagaland, Sikkim), Bhutan Myanmar, Nepal.

Specimens examined: Chiang mai village (Tuensang district) HYJ087 (NUH), Khughuto village (Zunheboto district) HYJ083 (NUH).

13. Coelogyne schultsii S. K. Jain & S. Das in Proc. Indian Acad. Sci., B. 87(5): 121. 1978; King & Pantl in Ann. Roy. Bot. Gard. Calc 8 : 137, t. 190. 1898; H.J.

Chowdhery, Orch. Fl. Arunachal Pradesh 241. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 121. 2000. *Coelogyne prolifera sensu* Lindl., Fol. Orchid. Coelogyne 5: 10, no.23. 1854, *non* Lindl., 1830.

Rhizome 0.3-0.4 cm in diam., stout, creeping, sheathted. *Pseudobulbs* 3.0-5.0 x 1.4-1.8cm, ovoid to ellipsoid, irregularly ridged, furrowed, sheathed at base. *Leaves* 2, 8-16 x 1.2-1.4cm, oblong to elliptic-lanceolate, acute to acuminate, margins entire, 7-veined; petiole grooved, 1-1.2cm long. *Inflorescence* hysteranthous, 5-10 flowered); peduncle 5-20cm, slender, green to greenish brown; sheaths at junction of peduncle and rachis overlapping, glume like, 2-6mm(growth extension annual); rachis 6-8cm long, slender, weakly zigzag; floral bracts not seen, caducous. *Flowers* 1.5-3cm across; sepals and petals brownish yellow to dark brown, lip brownish yellow to dark brown, base creamy, column light yellow; pedicel and ovary 5-8mm long, slender. *Dorsal Sepal* 1.2-1.4 x 0.5-0.7cm, oblong-lanceolate, acute, entire, membraneous, 5-7 veined; lateral sepals1.2-1.4 x 0.4-0.5cm, subsimiliar, spreading. *Petals* 1.1-1.3 x ca 0.2cm, spreading or reflexed, filiform,linear, acuminate, entire, membraneous. *Lip* 1.2-1.5 x 0.4-0.8 cm when spread, 3-lobed; lateral lobes 0.7-1.0 x ca 0.4cm, oblong, obtuse, entire, tips enclosing column; mid-lobe 0.6-0.9 x 0.7-1.0cm, orbicular to sub-quadrate, reflexed, margins finely dentate-undulate; disc 2-keeled, keels faint at base. *Column* ca 4 mm,weakly curved, .entire, broadly winged at apex.

Colour Plate 9

Flowering: April - May

Habitat and Ecology: Epiphytic and found growing on tree trunk in a disturbed forest with diffused sunlight, 1500-1800m.

Distribution: India (Arunachal, Meghalaya, Nagaland, Sikkim), Bhutan Myanmar, Nepal, Thailand, Vietnam.

Specimens examined: Chiang mai village (Tuensang district) HYJ193 (NUH), Aotsakilimi village (Zunheboto district) HYJ244 (NUH).

14. Coelogyne stricta (D. Don) Schltr. in Feddes Repert. Spec. Nov. Regni Veg. Beih. 4 : 184. 1919; Hook.f., Fl. Brit. India 5: 838. 1890; King & Pantl in Ann. Roy. Bot. Gard. Calc 8 : 136, t. 188. 1898; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh 241. fig 143. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 122. 2000. *Cymbidium strictum* D. Don, Prodr. Fl. Nepal. 35. 1825. *Coelogyne elata* Lindl., Gen. Sp. Orchid. Pl.: 40. 1830.

Rhizome sheathed, stout. *Pseudobulbs* 7–14 x 2.5–6cm, 4–5cm apart on rhizomes, cylindric, covered by sheaths at base, glossy. *Leaves* 2, 20–25 x 4–7cm, elliptic-oblong, acute, coriaceous, narrowed to base; petiole 3–6 cm long. *Inflorescence* 10–15 cm, hysteranthous, 8–14 flowered (opening together); peduncle ca 18 cm long, erect, large, overlapping, glume like sheaths between peduncle and rachis; rachis 10-14 cm long, stiff; floral bracts 3.2-3.8 x 2-3cm long, caduceus. *Flowers* ca 3 cm across, white with yellow-orange patch near base of mid-lobe, keels orange; pedicel and ovary 1.4-1.8cm. *Dorsal sepal* 2.8-3.0 x 0.4-1.3 cm, oblong, sub-acute, similar.; lateral sepals sub-similar, slightly longer but less broader. *Petals* 2.5-3.2 x 0.3-0.5 cm, narrowly oblong, acute. *Lip* 2.8-3.1 x 1-1.3 cm, 3-lobed; lateral lobes erect, narrow, entire; midlobe sub –orbicular to cordate, margins erose; Disc 2-keeled from lip base to centre of mid-lobe, crenulate or fimbriate. *Column* ca 8 mm, straight, dilated towards apex.

Flowering: April - May

Habitat and Ecology: Epiphytic and found growing on tree trunk in a disturbed forest with full head sunlight, 1500- 2100m

Distribution: India (Arunachal, Assam, Meghalaya, Nagaland, Sikkim, Uttar Pradesh, West Bengal) Bhutan, Myanmar, Nepal.

Specimens examined: New Sangsomong village (Tuensang district) HYJ200 (NUH), Aquaba village (Zunheboto district) HYJ252 (NUH).

15. Coelogyne suaveolens (Lindl.) Hook. f., Fl. Brit India 5: 832. 1890; Hook. f. in Ann. Roy. Bot. Gard. Calc. 5: 27.t . 40. 1895; Das & Jain in Fasc. Fl. India 5: 29. 1980; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh 241. fig 144. 1998. *Pholidota suaveolens* Lindl. in Gard. Chron. 372. 1856.

Rhizome stout, with dense brown scaly sheaths. *Pseudobulbs* 5-7 × 1.4-1.7cm, ca. 5.5cm apart on rhizome, lucid when dried, narrowly ovoid or linear-ovoid, largly sheathed. *Leaves* 2, 28-35 × 5-6cm, oblanceolate or oblong-oblanceolate, thickly papery, base contracted into a petiole 8-10cm, apex acuminate. *Inflorescence* synanthous, 15-24 cm, enclosed in sheaths initially except flowering part; rachis flexuous, ca 8cm, 10-16 flowered; floral bracts deciduous, oblong-ovate, ± cymbiform, ca 2cm, papery; pedicel and ovary 1.5-1.8 mm. *Flowers* white, with yellow spots on lip. *Sepals* 1.1-1.3 × 0.4-0.5cm, similar, suboblong, 5-veined, apex acuminate. *Petals* 1.1-1.3 × 0.3-0.4cm oblong-lanceolate or narrowly ovate-oblong.

Lip ca 1cm, suboblong, near or above middle contracted into hypochile and epichile or slightly 3-lobed; lateral lobes very small or inconspicuous; mid-lobe oblong-ovate; callus with 4 or 5 longitudinal lamellae, 3 lamellae extending from base of lip to base of mid-lobe, further 2 crenate lamellae on outside of existing lamellae extending from base of mid-lobe to tip of mid-lobe. *Column* 5-6mm, both sides narrowly winged.

Colour Plate 10

Flowering: April - May

Habitat and Ecology: Epiphytic and found growing on lower tree trunk in an undisturbed forest with diffused sunlight, 600-1000m

Distribution: India (Arunachal, Assam, Meghalaya, Nagaland, Sikkim) Myanmar

Specimens examined: Mukalimi & Lumami village (Zunheboto district) HYJ081 (NUH).

CREMASTRA Lindl.

Gen. Sp. Orchid. Pl. 172. 1833

The genus was described by John Lindley in 1833. The generic name is derived from the Greek words '*kremaster*' (suspender) referring to the conspicuous pedicel/stalk of flower.

The genus comprises four species of which 1 species is found in India and recorded by the author.

1. Cremastra appendiculata (D. Don) Makino, Bot. Mag. (Tokyo). 18: 24. 1904; N.R. Pearce & P.J. Cribb, The Orch. Of Bhutan vol. 3(3). 237. fig. 53 (1-643). 2000; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 246-248. 1998. *Cymbidium appendiculatum* D. Don, prodr. Fl. Nepal: 36. 1826. *Cremastra wallichiana* lindl., gen. Sp. orchid. Pl.: 173. 1833. *Cremastra triloba* Hayata, Icon. Pl. Formas. 2: 135. 1912.

Plants 20-60 cm tall. *Pseudobulb* 1.8-3 x 1-2.5cm, ovoid or subglobose, few noded. *Leaf* 1 sometimes 2, 18-30 x 4-7cm, narrowly oblanceolate-elliptic, mainly 3-veined, base subcuneate, apex acute or acuminate; petiole-like base 6-11 cm. *Inflorescence* 25-45 cm; rachis 12-16 cm, subdensely to densely 5-12-flowered; floral bracts 1-1.2 cm long, lanceolate to ovate-lanceolate. *Flowers* fragrant, pendulous, not opening widely, Pink to pale purple, narrowly campanulate, petals and lip with darker spots; pedicel and ovary ca 1.4cm long. *Dorsal sepal* narrowly 2-3.5 x 0.3-0.5cm, oblanceolate-spatulate, apex acute or acuminate; lateral sepals subsimiliar, slightly

oblique. *Petals* 1.9-3.3 x ca 0.4cm, narrowly oblanceolate, apex acuminate. Lip 2-3.2 x ca 0.3cm, linear, saccate at base, 3-lobed at apex; lateral lobes linear to narrowly oblong, apex obtuse; mid-lobe ovate to narrowly oblong, apex acute or obtuse; disk with a fleshy callus at base of mid-lobe; callus variable in shape and size, 1-5 mm, sparingly wrinkled or verruculose. *Column* 1.4-2 cm, slender, slightly dilated at apex, with or without narrow ventral wings below anther; anther 1-3 mm. *Capsule* 2 ca 3 x 1.4 cm, pendulous, ellipsoid.

Colour Plate 10

Flowering: May

Habitat and Ecology: Terrestrial and found growing on the side of stream in shaded area. 2300m.

Distribution: India (Arunachal, Assam, Manipur, Meghalaya, Nagaland, Sikkim) Bhutan, Japan, Korea, Nepal, Thailand, Vietnam.

Specimens examined: Satoi Village (Zunheboto district) HYJ261 (NUH).

CREPIDIUM Bl.

Bijde. 387. 1825

Szlachetko in 1995 restablished the genus Crepidium Bl. which otherwise remained under the genus Malaxis Sol. ex Sw. He has therein included about 167 species under Crepidium containing most of the Asiatic species of Malaxis.

The Genus is represented with about 280 species worldwide and 14 species are recorded so far in India. North-east India has the maximum distribution with about 11 species. 3 species are recorded by the author from the state

Key to species

1. Leaves bronze with green spotting……. *C. calophyllum*
- Leaves green ……... 2
2. Lip with a prominent central constriction ……...……. *C. khasianum*
- Lip lacking a prominent central constriction ……..... *C. acuminatum*

1. Crepidium acuminatum (D. Don) Szlachetko in Fragm. Florist. Geobot. Suppl. 3: 123, 1995. *Malaxis acuminata* D. Don, Prodr. Fl. Nepal. 29. 1825; Seidenf. in Dansk Bot. Ark. 33 (1): 55. t. 44. 1975; Hook. f., Fl. Brit. India 5 : 686. 1890; King & Pantl. in. Ann. Roy. Bot. Gard. Calc. 8 : 16. T. 18. 1898; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh. 502. Fig. 304. 1998; Hynniewta, Kataki & Wadhwa, Orch.

Nagaland (BSI), 215. fig 68. 2000. *Microstylis wallichii* Lindl., Gen. & Sp. Orch. 20. 1830.

Roots ca 1mm wide. *Stem* sheathed at base, glabrous. Leaves 3 – 4, 6 – 14 x 3 – 6 cm, ovate - lanceolate, acute to acuminate, membraneous, sheathing base, petiolate, margins undulate; petiole 3 – 4 cm long. *Inflorescence* racemose, laxly many – flowered; peduncle 15 – 30 cm long, ribbed; rachis 5 – 8 cm long, glabrous; floral bracts 3 – 4 mm long, bracts lanceolate, sub – acute, reflexed. *Flowers* 6 – 8 mm long, yellowish green, yellow tinged with reddish purple or pinkish purple; pedicel and ovary 5 – 8 mm long, linear. Sepals 5 – 6 mm long, oblong, sub – similar, margins recurved; dorsal sepal sub-acute, linear- oblong; lateral sepals obtuse, broadly oblong. Petals 4 – 5 mm long, linear, obtuse, margins recurved. *Lip* 6 – 8 x 4 – 5 mm long, slightly convex, narrowly ovate-sagittate, obtuse; base divided into two broad to lanceolate lobes, inner margins separated, straight and parallel; apex flat, incurved at the notch. *Column* fleshy, ca 1 mm long. *Pollinia* ellipsoid.

Colour Plate 10

Flowering: June - July

Habitat and Ecology: Terrestrial or lithophytic and found growing as undergrowth in forests under shade. 900m-1600m

Distribution: India (Arunachal, Assam, Manipur, Meghalaya, Nagaland, sikkim), China, Nepal, Thailand, Myanmar, Vietnam, Malaysia, Philippines.

Specimens examined: Zaphumi village & Aotsakilimi village (Zunheboto district) HYJ206 (NUH).

2. Crepidium calophyllum (Rchb.f.) Szlach., Fragm. Florist. Geobot., suppl. 3: 125. 1995. *Malaxis calophylla* (Rchb.f.) Kuntze in Revis. Gen. Pl.: 673. 1891. *Microstylis calophylla* Rchb.f., Gard. Chron., n.s., 12: 718. 1879. *Microstylis scottii*(Hook.f.) Kuntze, Revis. Gen. Pl. 2: 673. 1891. *Malaxis calophylla* var. *brachycheila* (Hook.f.) Tang & F.T.Wang in Acta Phytotaxa. Sin. 1: 71. 1951.

Plants 22–28cm tall. *Pseudobulbs* erect, leafy. Leaves 3-4, 5–12 x 2-4cm, oblong-lanceolate, oblique, acute, bronze, with green spotting, shortly petiolate, margins crenate, cream-coloured; petiole 1.5–3.3cm long, sheathing at base. *Inflorescence* racemose, laxly many-flowered; peduncle 10–13cm long, ridged; rachis 4–8 cm long; bracts narrow, 3–6mm long acuminate. *Flowers* 3.0–4.5mm long; sepals and petals pale purple to greenish-yellow, lip greenish-yellow; pedicel and ovary 3.0–

3.5 mm long, linear. *Dorsal sepal* 3-4-1mm, oblong, obtuse; lateral sepals 3-4 x 1mm, oblong, curved, obtuse. *Petals* 3.5-4.3 x ca.0.3mm, narrowly linear, obtuse. *Lip* 4-5 x 2.5-3.0 mm, biauriculate; base 3-lobed with projecting, notched mid-lobe. *Column* ca.1mm, stout.

Colour Plate 10

Flowering: June–July.

Habitat and Ecology: Terrestrial and found growing as an undergrowth on humus rich soil in a sub-tropical forest. 700-900m

Distribution: India (Assam, Meghalaya, Sikkim, Nagaland), Bhutan, Myanmar, China, Thailand and Malaysia.

Specimens examined: Lumami village and Izheto village (Zunheboto district) HYJ098 (NUH).

3. Crepidium khasianum Szlachetko in Fragm. Florist. Geobot. Suppl. 3: 123, 1995. *Microstylis khasiana* Hook.f., Icon. Pl., ser. 3 (19) t. 1831. 1889. *Malaxis khasiana* (Hook. f.) Kuntze, Revis. Gen. Pl. 2: 673. 1891; King & Pantl. in. Ann. Roy. Bot. Gard. Calc. 8 : 15. t. 17. 1898; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh. 504. Fig. 307. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 217. fig 69. 2000.

Roots fasciculate. *Stem* 5 – 8 cm long, leafy, short. *Leaves* 4 – 5, 4 – 10 x 2 – 4 cm, petiolate, ovate-lanceolate, oblique, acute to acuminate, strongly veined, greenish grey flushed with purple; petiole 1.5 – 4 cm long extended into sheathing base. *Inflorescence* racemose, lax below, dense above; peduncle 8 – 15 cm long, glabrous, ridged; rachis 4 – 5 cm long; floral bracts 4 – 8 x 1 – 1.5 mm, lanceolate, , acute, 1-veined. *Flowers* ca 2 mm across; sepals and petals purple, lip yellowish green; pedicel and ovary 4 – 5 mm long. Sepals ca 2 mm long, subsimiliar, broadly ovate, concave; dorsal sepal sub-acute; lateral sepals obtuse. Petals ca 2 x 0.5 mm long, linear, truncate. *Lip* 2.5 – 3 x ca 2 mm, concave, broad, with a central constriction, 3 lobed; basal lobes falcate; midlobe truncate. *Column* ca 1 mm long.

Colour Plate 10

Flowering: June–July.

Habitat and Ecology: Terrestrial and found growing on humus rich soil. 700-1200m

Distribution: India (Arunachal, Meghalaya, Sikkim, Nagaland), Bhutan, Myanmar, China, Thailand and Malaysia.

Specimens examined: Alaphumi, Sumi shettsu and Atoizu village (Zunheboto district) HYJ207 (NUH).

CRYPTOCHILUS Wall.

Tent. Fl. Nepal. 36. 1824

The genus was described by Nathaniel Wallich in 1826 in his 'Tentamen Florae Nepalensis illustratae'. The generic name is derived from the Greek words '*Kryptos'* (hidden) and '*cheilos'* (lip) referring to the campanulate flowers in which the lip is hidden.

2 species in India and 2 species in Nagaland and both reported by the author

Key to species

1. Sepaline tube yellow; pollinia yellow ……..… *C. luteus*
- Sepaline tube scarlet; pollinia green ……..…. *C. sanguineus*

1. Cryptochilus luteus Lindl., J. Proc. Linn. Soc., Bot. 3: 21 1858; Hook.f., Fl. Brit. India 5: 827. 1890; King & Pantl. in Ann. Roy. Bot. Gard. Calc. 8: 163. T. 221. 1898; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 124. 2000. *Cryptochilus farreri* Schltr. in Feddes repert. Spec. Nov. Regni Veg. 20: 384. 1924

Plant 15-30cm tall. *Pseudobulbs* 1.6-3.8 x0.8-1cm, clustered on a short rhizome, cylindric. Leaves 2, 6-17 x 1.5-2.5cm, narrowly oblong or suboblanceolate-oblong, papery, acuminate; petiole 1-3 cm. *Inflorescence* subdensely 24-38-flowered; peduncle 8-13 cm, slender, glabrous; rachis 4-7.5 cm; floral bracts alternate, narrowly lanceolate, 0.6-1.2cm, grooved, long acuminate. *Flowers* yellowish green or yellow; pedicel and ovary ca 0.4cm, densely pubescent. *Sepals* connate into an urceolate tube ca o.5 cm, outer surface glabrous; free apical lobes ovate-triangular, ca 1 mm; *lateral sepals* convex on one side; mentum saccate, short. *Petals* ca 4 x 0.7mm, hidden in mentum, obovate-lanceolate. *Lip* ca 4 x 0.8 mm subrhombic-cuneate, base slightly curved, apex obtuse. *Column* short, thick, apex dilated, with a short foot. *Capsule* ca 6 x 3 mm, suboblong.

Colour Plate 10

Flowering: May - June

Habitat and Ecology: Epiphytic or lithophytic, found growing on tree trunk under a dense canopy. 1900.

Distribution: India (Arunachal, Assam, Nagaland, Sikkim), Bhutan, China, Myanmar, Vietnam.

Specimens examined: Pangsha village (Tuensang district) HYJ225 (NUH).

2. Cryptochilus sanguineus Wall., Tent. Fl. Nepal. 36. T. 26. 1824; Hook. f., Fl. Brit. India 5 : 827. 1890; King & Pantl. in Ann. Roy. Bot. Gard. Calc. 8: 163. t. 220.1898; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 198. Fig.248. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 124. Fig. 39. 2000.

Plant 14-28cm tall. *Pseudobulb* 2.4-4.2 x 0.5-1.3cm, ovoid to ellipsoid-cylindric, sheathed at base, green. *Leaves* 2, 12-20 x 3-4cm, oblong to elliptic, coriaceous, acute to acuminate; petiole 4-5cm long. *Inflorescence* 4-9 cm long, 8-13 flowered; peduncle glabrous, 8-12cm long; rachis 4-8cm long, glabrous; floral bracts 0.7-1.5 x 0.2-0.3cm, alternate, linear-lanceolate, acuminate, erect. *Flowers* in 2 ranks, pubescent externally, 1-1.6cm long; sepaline tube scarlett with dark purple apices, petals lip and column yellowish; pedicel and ovary 2-4 x ca 2mm, densely white pubescent. *Sepals* 1-1.6cm long, connate, to form a sepaline tube, free apices triangular, divergent, acute, puberlous externally. *Petals* ca 1.0 cm long, oblanceolate-spathulate, obtuse. *Lip* ca 1 cm long simple, oblong, entire, deflexed from a curved base, expanded slightly at apex. *Column* ca 0.5 cm long, puberolous distally, stout; foot short. *Fruit* 0.6-1.2cm long, ellipsoid-ovoid, erect. *Pollinia* green.

Colour Plate 11

Flowering: May - July

Habitat and Ecology: Terrestrial or epiphytic and found growing on tree trunk with diffused or full head sunlight, 2100m

Distribution: India (Arunachal Pradesh, Assam, Manipur, Meghalaya, Nagaland, Sikkim, West Bengal) Bhutan, Nepal, Myanmar.

Specimens examined: Naltoqa area (Zunheboto district) HYJ052 (NUH), Thonger village (Tuensang district) HYJ208 (NUH).

CYMBIDIUM Swartz

Nova Acta Reg. Soc. Sci. Upsal. 2, 6: 70.1799

The genus was described in 1799 by Olof Swartz. The generic name is derived from the Greek '*cymbi*' (a boat) in illusion to the shape of the lip. About 50 species distributed in S.E. Asia, China, Japan, Indonesia, India to Australia.

23 species in India, 11 species in Nagaland, and 9 species reported by the author.

Key to species

1. Flowers pendent, campanulate ……..…….…..… 2
- Flowers erect, not campanulate ……... 3
2. Flowers greenish-brown……..… *C. cochleare*
- Flowers cream yellow, slightly fragrant ……...…. *C. elegans*
3. Inflorescence axillary from between the leaves…….. *C. mastersii*
- Inflorescence arising from base of pseudobulb; leaf apex acute ...…… 4
4. Pseudobulb few leaved; sepals and petals yellowish green, not streaked with red veins ……...……...… *C. tigrinum*

   Pseudobulb many-leaved; sepals and petals brick red or streaked with red brown veins…….….. 5
5. Lip white with sparse, irregular red brown spots; dorsal sepal less than 1 cm wide.……..… *C. erythraeum*
- Lip strongly marked with red or brown spots; dorsal sepal more than 1.2 cm wide…….. *C. iridiodes*
6. Callus ridges reduced to 2 small swellings at base of mid-lobe of the lip .……..…… *C. devonianum*
- Callus ridges S-shaped, often broken in middle …… 7
7. Lateral lobes of lip exceeding the column, veined with maroon....*C. aloifolium*
- Lateral lobes of lip not exceeding the column, mottled with maroon or red …. ……. *C. bicolor*

1. Cymbidium aloifolium (Linn.) Sw. in Nov. Act. Soc. Sci. Upsal. 6: 73. 1799; Wight, Icon. 5 (1): 11. t. 1687 & 1688. 1851; Hook. f., Fl. Brit. India 6 : 10. 1890; King & Pantl. in Ann. Roy. Bot. Gard, Calc. 8: 189. t. 252. 1898; Kataki, Orch. Meghalaya 150. Pl. 57 (2). 1986; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 253. fig. 149. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 126. 2000. *Epidendrum aloifolium* Linn., Sp. pl. 853. 1753. *Epidendrum aloifolium* Linn., Sp. pl. 853. 1753. *Cymbidium bicolor* Hook. f., 1. C. 6: 11. 1890 (*non* Lindl., Gen. Sp. Orch. 164. 1833).

Plant 40-100cm tall. *Pseudobulbs* ovoid, bilaterally flattened, 6-10 × 2.5-4cm, usually enclosed in leaf bases. *Leaves* 4 or 5, lorate, 40-90 × 3-4cm, thickly leathery, articulate 8-16 cm from base, apex obtuse and unequally 2-lobed.

Inflorescence arising from within sheaths at base of pseudobulb, pendulous, 20-60cm; rachis 20-30 flowered; floral bracts 2-5mm. *Flowers* slightly fragrant, medium-sized; pedicel and ovary 12-20mm; sepals and petals pale yellow to cream-yellow, with a broad, central maroon-brown stripe; lip white or cream-colored, with dense, maroon venation on lateral lobes and longitudinal maroon stripes on mid-lobe. *Sepals* spreading, narrowly oblong to narrowly elliptic, 1.5-2 × 0.4-0.6cm, apex obtuse. *Petals* narrowly elliptic, 1.4-1.8 × 0.4-0.6cm, apex obtuse to acute. *Lip* subovate, 1.3-1.8cm, not fused to basal margins of column, base slightly saccate, 3-lobed; lateral lobes acute, loosely clasping column and exceeding column and anther; mid-lobe recurved; disk minutely papillate or puberulent, with 2 sigmoid lamellae; callus ridges S-shaped, lamellae usually broken in middle and inflated toward base and apex. *Column* slightly arcuate, 10-12 mm; *pollinia* 2. *Capsule* oblong-ellipsoid, 35-65 × 20-30 mm.

Colour Plate 11

Flowering: May - June

Habitat and Ecology: Epiphytic and found growing on tree trunk of sparse sub – tropical forest, 400-1600m

Distribution: India (Arunachal, Assam, Meghalaya, Nagaland, Northern & Southern India), Bhutan, Myanmar, Nepal, Sri Lanka, Thailand, Malaysia.

Specimens examined: Mukhami village (Zunheboto district) HYJ234 (NUH), Chare (Tuensang district) HYJ210 (NUH), Ngoromi village (Kiphiri district) HYJ278(NUH).

2. Cymbidium bicolor Lindl., Gen. Sp. Orch. 164. 1833; Hook. f., Fl. Brit. India. 6: 11. 1890: H.J. Chowdhery, Orch. Arunachal Pradesh 253. Fig. 150. 1998. *Cymbidium crassifolium* Lindl., Gen. Sp. Orchid. Pl.: 165. 1833. *Cymbidium mannii* Rchb. f. in flora 55: 274. 1872. *Cymbidium pendulum sensu* King & Pantl. in Ann. Roy. Bot. Gard. (Calcutta) 8: 188, t. 251. 1898, *non* (Roxb.) Sw. *Cymbidium flaccidum* Schltr. in Feddes Repert. Spec. Nov. Regni Veg. 12:109. 1913.

Plant 20-70cm tall. *Pseudobulbs* 6-10 × 2.5- 3.5cm, narrowly ovoid, usually enclosed in persistent, bladless sheaths 4 or 5 ,6-9cm, scarious fibrous with age. *Leaves* 5-7, 40-70 × 2.5-3.5cm, narrowly oblong, obtuse, stiff and arching; leaf base 3-10 cm long. *Inflorescence* arching to pendent, 10-15 flowered; peduncle 8-12cm, sheathed; sheaths 5, 3-4.5cm long, spreading, boat-shaped and overlapping; rachis 8-

20cm long; floral bracts 2-4mmlong. *Flowers* 2.5-4cm across; sepals and petals pale yellow and striped brown-maroon; lip white to cream-yellow, with a broad, central maroon-brown stripe; lip white or cream-colored, with a yellow patch at base, lateral lobes mottled with maroon or red, callus cream yellow, column cream; pedicel and ovary0.8-4cm long. *Sepals* 1.5-1.8 x 0.4-0.5cm,similar, narrowly oblong to obovate-oblong, obtuse to subacute, erect to spreading. *Petals* 1.4-1.8 × 0.4-0.6cm, narrowly oblong-elliptic and spreading. *Lip* 1.2-1.8 x 1-1.6cm, saccate at base, pappilose to shortly pubescent; lateral lobes clasping the colum, not excedding, erect, obtuse and recurved; mid-lobe 5-8 x 5.5-7mm, broadly-elliptic, rounded and mucronate at apex; callus 2ridged, entire, minutely pappilose-pubescent. *Column* curved, winged at apex, 0.8-1cm long; Foot short. *Fruit* 4-5 x 2-2.5cm, cylindric-ellipsoid.

Colour Plate 11

Flowering: March - April

Habitat and Ecology: Epiphytic and found growing on tree trunk with direct head sunlight, 800-1300m

Distribution: India (Arunachal, Assam, Manipur, Meghalaya, Nagaland, Sikkim), Bhutan, Nepal, Myanmar, China.

Specimens examined: Nunumi village (Zunheboto district) HYJ215 (NUH), Honito village (Kiphiri district) HYJ100 (NUH).

3. **Cymbidium cochleare** Lindl. in Jour. Linn. Soc. 3: 28. 1859; King & Pantl. in Ann. Roy. Bot. Gard. Calcutta 8: 194, t. 160. 1898; H. J. Chowdhery, Orch. Arunachal Pradesh 256. fig. 257. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 127. 2000. *Cyperorchis cochleare* (Lindl.) Benth. in Jour. Linn. Soc., Bot. 18: 318. 1881; Hook. f., Fl. Brit. India 6: 15. 1890.

Plant 40-65cm. *Pseudobulbs* 5-8 × 2- 2.5cm, narrowly ovoid. *Leaves* 5-8, 40-55 × 0.8-1.2cm, distichous, linear, tapering to acute apex and jointed; leaf base broad and sheathed, 3-6cm; bladeless sheaths 3-4.5 cm long, scarious. *Inflorescence* 7-10 flowered; peduncle suberect to horizontal or arching, sheathes; sheaths ca 3cm, boat-shaped and inflated; rachis slender,pendent; floral bracts 5mm long, triangular, scarious. *Flowers* ca 2.6cm (in diam.), campanulate, waxy, pendent; sepals and petals greenish-brown, , margins pale yellow, lip yellow or orange-yellow, red-brown spotted, column whitish green; pedicel and ovary 0.8-2.5cm long. *Sepals* 3.5-4 x 0.5-0.9cm, sub-similar, narrowly obovate, acute; dorsal sepalporrect; lateral sepals

mucronate, not spreading. *Petals* 3.5-4 x 0.5-0.6cm, narrowly oblong-obovate, subacute, weakly falcate, porrect. *Lip* 3.5-3.8cm, slender, elongate, deltoid, 3-lobed, adnate to column base; lateral lobes0.7-1.0cm broad, triangular, sub-acute, erect, glabrous; mid-lobe0.6-0.8 x 0.6-0.8 cm, cordate-elliptic, mucronate, porrect, margin minutely undulate; callus2-ridged, puberulent, shell-shaped towards apex. *Column* 2.8-3cm long, slender, puberulent and deflexed at apex. *Fruit* ca 2.5 x 1.4cm, broadly ellipsoid, beaked.

Colour Plate 11

Flowering: September - October

Habitat and Ecology: Epiphytic sometimes terrestrial and found growing on tree trunk in a primary forest, 1900-2300m

Distribution: India (Arunachal, Assam, Meghalaya, Nagaland, Sikkim), China, Taiwan.

Specimens examined: Melangkiur village (Kiphiri district) HYJ211 (NUH), Tsutoho & Asukhomi village (Zunheboto district) HYJ240 (NUH), Anangba village (Tuensang district) HYJ212 (NUH).

4. Cymbidium devonianum Lindl. ex Paxton in Paxton's Mag. Bot. 10: 97. 1843; H. J. Chowdhery, Orch. Arunachal Pradesh 260. Fig. 154. 1998. *Cymbidium sikkimense* Hook.f., Fl. Brit. India 6(1): 9. 1890.

Plant upto 30 cm tall. *Root* ca 0.8cm in diameter. *Pseudobulbs* 2-3.5 x ca. 1 cm, subcylindric, enclosed in leaf bases. *Leaves* usually 4, 25-30 x 3.2-5cm, suberect, oblong-oblanceolate, leathery, with a prominent midvein, tapering into a petiole-like stalk at base, apex acute or obtuse; petiole-like stalk slender, channeled, articulate near middle. *Inflorescence* 25-30cm long, arising from base of pseudobulb, suberect or slightly arching, with several sheaths toward base; rachis 15-22cm, 23-25-flowered; floral bracts ca 0.5cm, ovate-lanceolate. *Flowers* ca 3.5cm in diameter, purplish brown; pedicel and ovary 1.4-1.7cm. *Dorsal sepal* 2-2.2 x ca 0.6cm, narrowly elliptic to ovate-lanceolate, apex acuminate; lateral sepals subsimiliar, slightly subclavate. *Petals* 1.6-1.8 x ca o.5cm, narrowly elliptic-lanceolate, apex acuminate. *Lip* 1.2-1.4 x ca 1cm slightly recurved, subrhombic or obovate-rhombic, not fused to basal margins of column, unlobed or sometimes obscurely 3-lobed, apical margins slightly crisped; disk with 2 fleshy calli at base of mid-lobe. *Column* slightly arcuate ca 1cm. anther cap ca 2mm across. *Pollinia* 2, ca 1mm.

Colour Plate 11

Flowering: April - May

Habitat and Ecology: Terrestrial or lithophytic and found growing on humus rich covered soil by the side of a stream in an undisturbed forest. 2100 m

Distribution: India (Arunachal, Manipur, Meghalaya, Nagaland, Sikkim), Bhutan, Nepal, Thailand, Vietnam

Specimens examined: Pangsha village (Tuensang district) HYJ101 (NUH).

5. Cymbidium elegans Lindl., Gen. Sp. Orchid. Pl. 163. 1833; King & Pantl. in Ann. Roy. Bot. Gard. Calcutta 8: 194, t. 259. 1898; Hook. f., Fl. Brit. India 6: 14. 1890; H. J. Chowdhery, Orch. Arunachal Pradesh 260. Fig. 156. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 129. 2000. *Cymbidium longifolium* D.Don Prodr. Fl. Nepal. 36 1825. *Cyperorchis elegans* (Lindl.) Bl. Rumphia, 4:47. 1849.

Plants 40-80cm, autotrophic. *Pseudobulbs* 4-8.5 x 2-3cm, bilaterally flattened, subovoid, enclosed in persistent leaf bases. *Leaves* 8-14, 30-70 x1-2 cm, distichous, lorate, articulate 4-10 cm from base, apex acuminate or obtuse, slightly 2-lobed. *Inflorescence* 35-50cm, 18-30 flowered, arising from lower part of pseudobulb, arching; rachis pendulous; floral bracts 2-3 mm. *Flowers* ca 3cm (in diam.) slightly fragrant, pendulous, campanulate, not opening widely; pedicel and ovary 13-20 mm; sepals and petals cream-yellow to pale yellowish green, sometimes tinged pale pink; lip cream-yellow to pale yellowish green, occasionally with reddish spots, lamellae bright orange. *Sepals* 3.8-4.5 x 0.8-1.2cm, narrowly obovate-lanceolate, apex acute. *Petals* 3-4.2 x 0.6-0.8cm, broadly linear-oblanceolate, apex obtuse. *Lip* 3-4 × 0.6-0.9cm oblanceolate-triangular, base fused to basal margins of column for 2-3 mm, 3-lobed; lateral lobes loosely clasping column, not ciliate; mid-lobe 0.6-0.1x0.5-0.8cm, small, margin slightly undulate, apex slightly bilobed and incurved; disk minutely papillate on lateral lobes and densely pubescent at center of mid-lobe, with 2 longitudinal lamellae extending from base of lip to near base of mid-lobe; lamellae sparsely pubescent, convergent at their apices and with a longitudinal channel between them, occasionally each lamella with a lanceolate appendage 3-5 mm on outside below middle. *Column* 2.6-3cm, puberulent toward base, narrowly winged; pollinia 2, subclavate-obovoid.

Colour Plate 11

Flowering: November- December

Habitat and Ecology: Epiphytic or lithophytic and found growing on tree trunk and mountain cliff in a primary forest, 1900-2200m

Distribution: India (Arunachal, Assam, Manipur, Meghalaya, Nagaland, Sikkim), Bhutan, India, Myanmar, Nepal, Vietnam.

Specimens examined: Pungro (Kiphiri district) HYJ232 (NUH), Tsutoho & Asukhomi village (Zunheboto district) HYJ241 (NUH), Helipong village (Tuensang district) HYJ221 (NUH).

6. Cymbidium erythraeum Lindl. in J. Proc. Linn. Soc., Bot. 3:30. 1859; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 131. 2000. *Cymbidium longifolium sensu* Lindl., Gen. Sp. Orchid, Pl.: 163.1833, *non* D. Don.

Plant 35- 60cm. *Pseudobulbs* ovoid, 3-5 x 1.5-5cm. *Leaves* about 5- 9, measuring 30-80 x 0.7-1.3 cm, linear –oblong, distichous, tapering to a fine point; leaf base sheathing, 3-6cm long. *Inflorescence* arching, almost erect, 5-12 flowered; rachis slender, 15-25cm long; *bracts* ca 4 x 1.5 mm at base, triangular. *Flowers* ca 4 x 5cm, fragrant; sepals and petals greenish, spotted and stripped with reddish – brown, callus cream-white, column yellow, lip white with sparse, irregular red brown spots lateral, lobes red veined; pedicel and ovary 1.0 – 1.8 cm long. *Sepals* similar; dorsal sepal 2.5-3.5 x ca 1 cm, broad, narrowly obovate, acute. *Petals* 3.5-4.5 x 0.5- 0.8 cm, narrow, oblong, acute, falcate. *Lip* 3-lobed, adnate to base of the column for 2-3.5 mm, ca 2 x 1.5 cm; lateral lobes ca 0.6-1.2 cm broad, acute, erect, pubescent papillose; callus 2-ridged tapering to lip base, densely pubescent, indumendum not extending into mid-lobe. *Column* winged, sparsely pubescent, 1.2-2.9 cm long. *Pollinia* pyramidal.

Colour Plate 12

Flowering: November - December

Habitat and Ecology: Epiphytic or lithophytic and found growing on rhododendron tree trunk in a primary forest, 2100m.

Distribution: India (Arunachal, Assam, Meghalaya, Nagaland, Sikkim, Kumaon,), Bhutan, Myanmar, China.

Specimens examined: Tsutoho village (Zunheboto district) HYJ080 (NUH).

7. Cymbidium iridioides D. Don in Prodr. Fl. Nepal 36. 1825; Pradhan, Indian Orch. 2: 476. 1979; Kataki, Orchi. Meghalaya 152. Pl. 57 (5) & E (iii). 1986; H.J.

Chowdhery, Orch. Fl. Arunachal Pradesh 293. fig. 160. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 129. 2000. *Cymbidium giganteum sensu* Wall. ex Lindl., Gen. Sp. Orchid. Pl.: 163. 1833. *Iridorchis gigantean* (Wall. ex Lindl.) Bl., Coll. Orchid.: 91, t.26. 1858. *Cyperorchis gigantean* (Wall. ex Lindl.) schltr. in Feddes Repert. Spec. Nov. Regni Veg. 20: 107. 1924.

Plant 45-70 cm. *Pseudobulbs* 4-9 × 2-6 cm, ellipsoid-ovoid to narrowly ovoid, bilaterally flattened, partially enclosed in leaf bases. *Leaves* about 6-10, 60-90 × 2-4cm, lorate, articulate, apex acute. *Inflorescence* 50-80cm or longer arising from within sheaths at base of pseudobulb, suberect, spreading horizontally; rachis 6-15 flowered; *bracts* subtriangular, 2-3 mm. *Flowers* ca 10 cm across, fragrant, lip strongly marked with red or brown spots; pedicel and ovary 4.0-4.5cm. Sepals and petals yellowish, with 7-9 brownish or reddish brown longitudinal stripes. *Sepals* 3.5-4.5 × 1.2-1.5cm, narrowly obovate-oblong, apex acute. *Petals* 3.5-4.5 × 6-8 cm, slightly falcate, narrowly ovate-oblong, not twisted, apex acute. *Lip* 1.5-2 x 1.3-1.7cm, yellowish, with reddish brown stripes on lateral lobes and similarly colored mottling on mid-lobe, base fused to basal margins of column; lateral lobes shortly ciliate; mid-lobe strongly recurved, margin erose and undulate; lamellae thickened, long hairs from midway along their length to their apices. *Column* 2.0-2.2 cm long, greenish brown. *Pollinia* 2, subtriangular.

Colour Plate 12

Flowering: September - November

Habitat and Ecology: Epiphytic and found growing on dead tree trunk along with humus, 700m

Distribution: India (Arunachal, Assam, Manipur, Meghalaya, Nagaland, Sikkim), Bhutan, Myanmar, Malaya, Nepal.

Specimens examined: Alaphumi village (Zunheboto district) HYJ223 (NUH).

8. Cymbidium mastersii Griff. ex Lindl. in Bt. Reg. 31: t. 50. 1845; King & Pantl. in Ann. Roy. Bot. Gard. Calcutta 8: 195, t. 261. 1898; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 274. fig. 164. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 133. 2000. *Cymbidium affine* Griff., Not. Pl. Asiat. 3:336. 1851. *Cyperorchis mastersii* (Griff. Ex Lindl.) Benth. In Journ. Linn. Soc. 18: 318. 1881; Hook. f., f. Brit. India 6: 15. 1890.

Plant 35-45cm. *Pseudobulbs* 8-12cm, stemlike, surrounded by numerous , persistent leaf sheaths. *Roots* cauline, rooting from basal part. *Leaves* 9-15, 35-40 x 2.5-3cm, apical from pseudobulb, leathery, distichous, narrowly oblong, tapering, apex acute, unequally 2-lobed, mucronate; leaf base sheathing, persistent, margins membranous. *Inflorescence* 3-5 flowered, 20-28cm long, arising from leaf axils, suberect; peduncle 10-15cm, sub-erect, sheathed; sheaths 3-6, ca 11cm, boat-shaped to cylindric, expanded; rachis 4-8cm long; floral bracts 2–5 mm, triangular, acute. *Flowers* 6-6.5 cm across fragrant, usually not opening widely; sepals and petals white, tinged pink on outer surfaces; lip with a yellow patch at base, callus bright yellow, column white to pale green; pedicel and ovary 1.6-2.4cm. *Sepals* 3.8-4 x 1-1.3cm, sub-similar, narrowly elliptic or broadly lanceolate-oblong, apex acute; lateral sepals weakly falcate. *Petals* 3.5-3.8 x 0.7-0.9cm, narrowly oblong to obovate, weakly falcate, porrect. *Lip* 3.5-3.7 x 1.5-1.6cm (when open), 3-lobed, elongate, adnate to the base; lateral lobes clasping the column, puberulent, broadly rounded to sub-acute, margins fringed; mid lobe ovate, rounded or mucronate, porrect, puberulent, margins undulate. *Column* 2.4-2.8cm, slender, narrowly winged. *Fruit* ca 3x2.5cm, pollinia 2.

Colour Plate 12

Flowering: November - December

Habitat and Ecology: Epiphytic or lithophytic and found growing on stream side in a between rocks, 1800m.

Distribution: India (Arunachal, Assam, Manipur, Meghalaya, Nagaland, Sikkim), Bhutan, Myanmar, China, Thailand, Vietnam.

Specimens examined: Asukhomi village (Zunheboto district) HYJ079 (NUH)

9. Cymbidium tigrinum Par. ex Hook. in Bot. Mag. T. 5457. 1849; Hook. f., Fl. Brit. India : 9. 1890; Hynniewta, T.M. in Orchid rev., 87(1033):219. 1979. London; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 134. 2000. *Cyperorchis tigrina* (C.S.P.Parish ex Hook.) Schltr. Repert. Spec. Nov. Regni Veg. 20: 108 1924.

Plant 25-30cm. *Pseudobulbs* 2.7-5 x 3-3.2cm, subglobose or globose-ovoid, lens-shaped, bilaterally compressed, naked, with several sheaths at base. *Leaves* 2-4, 10-15 x ca. 3cm long, from the apex of pseudobulb, narrowly elliptic, oblong-lanceolate, apex acute; base contracted into a distinct petiole-like stalk and 1.3-1.5 cm length, apex long acuminate. *Inflorescence* 15-25cm arising from base of pseudobulb, arching; rachis 4-6 flowered; *bracts* triangular, 6-8 mm. *Flowers* 4-5cm across,

slightly fragrant; pedicel and ovary 2-4.5cm; sepals and petals yellowish green, brownish green and with purplish brown spots near base. *Sepals* similar, ca 3.5 x 0.5-0.7cm, yellowish green, lanceolate. *Petals* 2.6-3 x 0.5-0.6cm, narrowly elliptic, apex acute, with red-brown dotted at base. *Lip* 3-3.2 x 1.3-1.6cm when open, white tinged purplish brown on lateral lobes and with reddish brown spots and short transverse dashes on mid-lobe, subobovate, base fused to basal margins of column for 2-3 mm, 3-lobed; lateral lobes erect, ca. 13 mm wide; mid-lobe recurved, margin undulate; disk minutely papillate, with 2 glabrous longitudinal lamellae extending from base of lip to near base of mid-lobe. *Column* 2.5-2.8cm. *Pollinia* 2.

Colour Plate 12

Flowering: April - July

Habitat and Ecology: Epiphytic or lithophytic and found growing on tree trunk along with humus, 1900-2200m

Distribution: India (Nagaland), Myanmar

Specimens examined: Asukhomi village (Zunheboto district) HYJ025 (NUH), Chendang saddle (Tuensang district) HYJ222 (NUH)

DENDROBIUM Swartz

Nova Acta Reg. Soc. Upsal. 2, 6:82. 1799

The genus was established by Olof Swartz in 1799. The generic name is derived from the Greek words '*dendros*' (tree) and *'bios'* (life), in illusion to the aerial epiphytic existence of most of the species. A large genus of about 900 species widely distributed in India, China, S.E. Asia, Japan, Malaya, Philippines, New Guinea, Australia, the Pacific Islands and New Zealand.

About 92 species found in India, 37 in Nagaland and 29 species reported by the author.

Key to species

1. Pseudobulbs with 1 terminal leaf ……...……..... *D. jenkinsii*
- Pseudobulbsmore than 1 leaved ……..……. 2
2. Leaf sheaths insignificant; inflorescence pendulous, arising from near stem apex, densely or laxly many flowered; flowers yellow or white tinged with yellow ……....…….. 3
- Leaf sheaths distinct; inflorescence not pendulous and 2 – 4 flowered, flowers usually white ……...… 6

3. Inflorescence laxly flowered, stems thickly fusiform, Lip margin undulate, apex shallowly bilobed ……..... *D. chrysotoxum*

- Inflorescence densely many flowered ……..…..…….. 4

4. Sepals and petals white, leaves usually far apart, lip entire and bluntly rounded ……. *D. thyrsiflorum*

- Sepals and petals yellow, petal margin finely dentate, lip orbicular-rhombic ……..…..….. *D. densiflorum*

6. Stems and leaves hirsute …… 7

- Stems and leaves rather glabrous ……..……...… *D. tamenglongense*

7. Apical lobe of lip not fimbriate, midlobe obscurely 2-lobed, emarginated to minutely mucronate, margins undulate ……..… *D. formosum*

- Apical lobe of lip fimbriated …… 8

8. Petals broadly ovate, much wider than sepals..... *D. wattii*

- Petals oblong, lanceolate, or oblong-elliptic, usually narrower than sepals.. 9

9. Leaf leathery, apex obtuse and unequally bi-lobed, stems stout……..……...…..…… *D. williamsonnii*

- Leaf rather smooth apex acutely bi-fid, stems zig-zag to weakly zigzag ……..……..… *D. longicornu*

10. Sepals and petals yellow, brownish yellow to lemon green, sometimes tinged with pink or purple on margins, lip sometimes blotched with dark purple to brick red ……..……...….. 11

- Sepals and petals white, pink or purplish red, lip blotched with yellow or purple or both……...…….. 20

11. Leaves overlapping and laterally flattened, curved, sessile …..….. *D. spatella*

- Leaves not laterally flattened ……..… 12

12. Stems fleshy, leaves and flowers usually appearing on current years stem . 13

- Stems stout, flowers appearing on previous years stem ……...…..…… 16

13. Flowers yellow, petals elliptic to ovate orbicular or elliptic-lanceolate, apex obtuse or notched, lip with 1 or 2 purple to violet blotch …..…….…… 14

- Flowers lemon green to creamy yellow, petals linear oblong to oblong-lanceolate ……. 15

14. Lip with two separate or confluent deep purple blotch, flowering May-July……...……. *D. chrysanthum*

- Lip with 1 red to violet blotch at centre, flowering April-May... *D. ochreatum*

15. Lip pinkish to violet with a lemon green apex, margins entire, weakly undulate ……..…. *D. porphyrochilum*

- Lip margins serrate-lacerate to serrate crisped with black warty projections …… *D. denudans*

16. Flowers yellow, Lip with 1 or 2 dark reddish blotch, lip margins distinctly fimbriate ……..……..…… 17

- Flowers pale lemon green to pale creamy-yellow, apricot coloured to light brick brown, margins not distinctly fimbriate ……..... 18

17. Lip with a dark maroon blotch unseperated on disc ……..…. *D. fimbriatum*

Lip with two round, purple black spots towards base …...……..… *D. gibsonii*

18. Sepals and oetals pale lemon green turning dirty yellow with age Lip apex acute, recurved, mid-lobe entire and sparsely hairy ……..……..…… *D. sociale*

- Lip apex incurved rounded or dentate ……..……... 19

19. Lip simple, slipper shaped (margins incurved), globose to pyriform, margins entire, pilose ……..…...… *D. moschatum*

- Lip base wedge-shaped, convolute and hooded around the column, margins minutely serrulate-fimbriate ……..…...… *D. heterocarpum*

20. Lip with only yellow or yellow and purplish blotch ……...…. 21

- Lip without a yellow blotch ……..……..... 24

21. Stems distinctly swollen at branched nodes, lip margins not fimbriate ..…. 22

- Stems not distinctly swollen at branched nodes, lip margins slightly to deeply fimbriate ……,……..… 23

22. Lip with yellow blotch on both sides at base, disk with a deep purple blotch ……..……...……..…*D. falconeri*

- Lip with a yellow transverse semilunar central blotch, two separated purplish to maroon blotch on sides ……... *D. wardianum*

23. Lip adaxially densely pubescent, golden yellow blotch unseperated on disc ……..... *D. crepidatum*

- Lip with two yellow round blotch on sides of disc, margins deeply fimbriate ……...…… *D. devonianum*

24. Stems pendent ……...……. 25

- Stems erect …… 27

25. Lip with a distinct deep purple blotch on either side of disc, both surfaces of lip densely pilose ……..…… *D. parishii*

- Lip without a purple blotch ……..…. 26

26. Stem rather fleshy, lip disk with purplish red stripes, margin irregularly denticulate ……..……... *D. polyanthum*

- Stem rather stout, lip with purple lines basally, shortly clawed, broadly sub-orbicular, margins erose basally becoming ciliate towards apex ….... *D. aphyllum*

27. Flowering from current years stem, stems wavy to weakly zigzag, flowers waxy, fragrant, lip dark maroon at base white and purple at margins, margins entire……..**.....**….. *D. nobile*

- Flowering arising from old leafless stem ……..…… 28

28. Lip with a deep purple spot on base, lip adaxially densely barbellate, margin irregularly denticulate. ……....….*D. lituiflorum*

- Lip with a purple patch on either side of disc, lip margins undulate ……..……...*D. transparens*

1. Dendrobium aphyllum (Roxb.) Fischer in Gamble, Fl. Madras 3: 1416. 1928; Rao in Bull. Bot. Surv. Indian. 5 (2): 323. 1964; Balakr., Andaman & Nicobar information 10. 1976; Jain & Hajra, Bull. Bot. Surv. Indian. 17 (1-4). 85. 1978; Hynniewta in Bull. Bot. Soc. Bengal 32:14. 1978; Pradhan, Indian Orch. 2:321. 1979; Hegde, arunachal For. News 3(3): 4. 1980; Misra in Indian J. for. 6(4): 312. 1983; Kataki, Jain & Sastry in Pl. Cons. Bull. 5: 12. 1984; Seidenf. in Opera Bot. 83:70 fig 40. 1985; Deorani & Naithani, Orch. Nagaland. 166. 1995; Hook.f., Fl. Brit. Indian. 5:738. 1890; King & Pantl. in Ann. Roy. Bot. Gard. Calcutta. 8: 51. t. 72. 1898. *Limodorum aphyllum* Roxb. Cor Pl. 1: 34. T. 41. 1975. *Dendrobium cucullatum* R. Br. Bot. reg. 7.t. 548. 1821. *Dendrobium purasdii* roxb. ex Hook. Fl. 1. T. P. 1822. *Cymbidium aphyllum* (Roxb.) Sw. Kgl. Sv. Vet. Akad. Nya. Handl. 6: 73. 1991. *Callista aphyllum* (Roxb.) Kze., Rev. Gen. 2: 653. 1891. *Dendrobium madrasense* A.D. Hawkes in Orquidea (Rio de Janeiro) 25 (3): 102. 1963.

Plant 20-80cm long; *roots* fasciculate, creeping. *Stems* slender, pendent, expanded at nodes; internodes sheathed, 1.5-2.5cm long; sheaths funnel shaped. *Leaves* 5-10 x 0.5-3cm, lanceolate to ovate lanceolate, subacuminate, sessile, distichous. *Inflorescence* lateral, arising from nodes of old stems, 1-flowered;

peduncle attenuate; floral bract ovate, scarious, 4- 5 mm long. *Flower* 2-5 cm across, fragrant; sepals and petals pale pink to pale purple, lip pale yellow with purple lines basally; pedicel and ovary slender, 1.5-2 cm long. *Sepals* sub-similar, 1.8-2.4 x 0.4-0.5cm, oblong-lanceolate, subacute, 5 –veined, lateral sepals adnate at base to form a mentum; mentum short, obtuse, ca 4 x 2mm. *Petals* 2.0-2.3 x 0.8-1.0cm, ovate-lanceolate to elliptic, obtuse, 5-veined. *Lip* 2.4-2.6 x 1.0-2.0cm shortly clawed, broadly sub-orbicular, simple, margins erose basally becoming ciliate towards apex, pubescent, convolute over the column. Column 6 – 7 mm long (with foot). *Fruit* 3-5 x ca 0.7cm, clavate, cylindric.

Colour Plate 12

Flowering: June – July

Habitat and Ecology: Epiphytic and found growing on main trunk of trees in forests with shaded or full head sunlight, 900-1200m

Distribution: India (Arunachal, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura, West Bengal) Bangladesh, Bhutan, Cambodia, China, Laos, Myanmar, Thailand , Vietnam.

Specimens examined: Sikimi/ Sikur village (Tuensang district) HYJ242 (NUH), Sangphure village (Kiphire district) HYJ295 (NUH), Nunumi village (Zunheboto district) HYJ228 (NUH).

2. Dendrobium chrysanthum Wall. ex Lindl. in Bot. Reg.15:t.1299. 1830; Hook.f., Fl. Brit. Indian. 5:747. 1890; King & Pantl. in Ann. Roy. Bot. Gard. Calcutta. 8: 55. t. 77. 1898; Rao in Bull. Bot. Surv. Indian. 1 (1): 117. 1959; Panigrahi & Joseph in Bull. Bot. Surv. Indian. 8 (2): 166. 1966; Deb & Dutta in J. Bombay. Nat. Hist. Soc. 71 (2):287. 1974; Pradhan, Indian Orch. 2:322. 1979; Hegde, arunachal For. News 3(3): 4. 1980; Seidenf. in Opera Bot. 83:53. 1985; Hynniewta, Kataki & Wadhwa, Orch. Nagaland, 140. 2000. *Dendrobium paxtonii sensu* Lindl., Bot. Reg. 25: misc. no.56. 1839, *non* Paxton 1839. *Dendrobium chrysanthum* var. *microphthalma* Rchb., Gard. Chron. 11:366. 1879. *Dendrobium chrysanthum* var *anophthalma* Rchb.f. Gard Chron. 19: 44. 1883. *Callista chrysantha* (Wall. ex Lindl.) Kuntze., Rev. Gen. 2:645. 1891.

Plant 60-120cm long, pendent. *Roots* 2-3.5mm thick, fasciculate. *Stems* slender, pendent, straight to wavy; internodes sheathed, 2-3 cm long. *Leaves* 5-20 x 24 cm, distichous, elliptic-lanceolate, acute to acuminate, sessile, 5-7 veined.

Inflorescence 2-4 flowered, lateral, leaf opposed, fasciculate, on leafy or leafless stems, peduncle attenuate, covered by membraneous sheaths; floral bracts membraneous, ovate, obtuse, 6-7 mm long. *Flowers* 1.5-2.5cm across, fleshy, golden yellow, lip with two separate or confluent deep purple spots; pedicel and ovary slender, 2-4 cm long. *Sepals* 1.2-2.5 x 0.5-0.9cm, sub-equal, oblong-elliptic to ovate, subacute, concave; lateral sepals weakly falcate; *mentum* short, wide, obtuse, 2-3mm long. *Petals* 1.4-3.0 x 0.6-1.1 cm, elliptic to ovate orbicular, obtuse. *Lip* 1.7-2.5 x 1.4-1.7cm simple, clawed at base and enclosing the column, epichile broadly orbicular-oblong to renifrom, concave, pubescent to tomentose, margins shortly fimbriate-dentate. *Column* 8-9mm long (with foot). Fruit 2.5-4.5 x 1.5-2.0cm, ovoid pyriform, long stalked.

Colour Plate 12

Flowering: May - July

Habitat and Ecology: Epiphytic or lithophytic and found growing on main trunk of trees in forests with shaded or full head sunlight, 900-2200m

Distribution: India (Arunachal, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Uttrakhand, West Bengal) Bhutan, Cambodia, China, Laos, Myanmar, Thailand, Vietnam.

Specimens examined: Pangsha ITC, Chiangmai village (Tuensang district) HYJ249 (NUH), Honito, longmatra, seyochung and sitimi village (Kiphire district) HYJ255 (NUH), Mishilimi, Mukalimi, Tokiye and Asukhomi village (Zunheboto district) HYJ229 (NUH).

3. Dendrobium chrysotoxum Lindl. in Bot. Reg. 33: *sub* t.19, t.36. 1847; Hook.f., Fl. Brit. Indian. 5: 750 1890; Deb, Bull. Bot. Surv. India, 3(2): 115-138. 1961; Panigrahi & Naik, Bull. Bot. Surv. India, 3(3 & 4): 361 – 388. 1961; Pradhan, Indian Orch. 2:305. 1979; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh 293. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland, 140. fig. 42. 2000. *Callista chrysotaxa* (Lindl.) Kuntze, Revis. Gen. Pl. 2:654. 1891. *Callista suavissima* (Rchb.f.) Kuntze. Revis. Gen. Pl. 2: 655 1891.

Plant 30-50cm. *Roots* 2-3 mm thick. *Stems* 20-25cm long, erect, clavate, covered with white membraneous sheaths, 2-5 internodes, many bluntly rounded ridges. *Leaves* 10-15 x 2-3cm, sub-terminal, oblong-lanceolate, acute and unequally and obtusely 2-fid, coriaceou, base conracted. *Inflorescence* laxly many flowered,

racemose, 15-26cm long, erect to pendulous, subterminal; peduncle and rachis stout, basal sheaths 4 or 5; floral bracts ovate-lanceolate, 2-3mm, membranous, apex acute; pedicel and ovary to 4-5cm. *Flowers* 3.5-4.2cm across, golden yellow to orange, slightly fragrant, lip deeper yellow with red stripes on each side at base, anther cap pale yellow. *Dorsal sepal* 1.3-1.8 x 0.4-0.7cm, 7-veined, slightly obtuse; lateral sepals slightly equal to dorsal sepal; mentum subglobose, ca 4 mm wide. *Petals* 1.3-1.9 x 0.8.3-1.4 cm, broadly oblong, obtuse, 2-fid, base joint with the foot of the column. *Lip* 1.3-1.8 x 1.5-2.1cm when opened, adaxially densely pubescent, margin undulate, apex shallowly bilobed; disc v shaped. *Column* ca 4.5 mm. *Pollinia* 4, oblong.

Colour Plate 13

Flowering: May - June

Habitat and Ecology: Epiphytic and found growing on main trunk of trees in forests with full head sunlight, 800-1500m

Distribution: India (Arunachal, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura, West Bengal) Cambodia, Indonesia, Laos, Myanmar, Vietnam.

Specimens examined: Chare & Anangba village (Tuensang district) HYJ032 (NUH), Yangzitong village (Kiphire district) HYJ296 (NUH), V.K. area (Zunheboto district) HYJ092 (NUH).

4. **Dendrobium crepidatum** Lindl. & Paxt. In Fl. Gard. 1 : 63. t. 45. 1850; Hook.f., Fl. Brit. Indian. 740. 1890; King & Pantl. In Ann. Roy. Bot. Gard. Calc. 8 : 48. T. 66. 1898; Hynniewta, Kataki & Wadhwa, Orch. Nagaland, 142. 2000; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh 293. fig. 173. 1998. *Callista crepidata* (Lindl. & Paxton) Kuntze, Revis. Gen. Pl. 2: 654. 1891. *Dendrobium roseum* Dalz, in. Hook. Kew Journ. 291. 1852. *Dendrobium. Lawianum* Lindl. in Jour. Linn. Soc. 3: 10. 1859.

Plant 25-50 cm; roots densely clustered. *Stems* 28-36 cm, pendulous, green, cylindric, terete, jointed, weakly zigzag, ca. 1cm in diam., fleshy, base slightly contracted, unbranched, with many nodes, internodes 3-4cm, covered by tubular white-striped sheaths, purplish bronze when dry. *Leaves* 8-12 x 0.9-1.2cm, narrowly lanceolate, subleathery, base with clasping sheath, apex acuminate; leaf sheath membranous. *Inflorescence* arising from old stems after leaves have fallen, very short, 1-6 flowered; peduncle attenuate, 2-3 mm long; basal sheaths 3 or 4, scarious; floral bracts ovate, ca 4 mm, apex acute; pedicel and ovary ca 3.5 cm, pale purple to pink, glabrous. *Flowers* 2.5-3.5, cm across, spreading, thick; sepals and petals white, pale

purple towards margins, waxy when dry, lip pale purplish pink towards margins, golden yellow below middle, column white, front with 2 purplish red stripes. *Dorsal sepal* 1.8-2.0 × 0.7-0.9 cm subelliptic, 5-veined, obtuse; lateral sepals ovate-oblong, slightly as large as dorsal sepal, 5-veined, midvein on abaxial surface ± keeled, base oblique, apex obtuse; mentum subglobose, small, ca 5 mm. *Petals* 1.7-1.9x0.9-1.2cm broadly obovate, 5-veined, rounded. *Lip* 1.6-1.8 x 1.7-1.9 cm when open, orbicular or broadly obovate, both sides embracing column below middle, adaxially densely pubescent. *Column* ca 6 mm long.

Colour Plate 13

Flowering: April - May

Habitat and Ecology: Epiphytic and found growing on main trunk of trees in forests with shaded or full head sunlight, 1800m.

Distribution: India (Arunachal, Assam, Meghalaya, Mizoram, Nagaland, Sikkim, Bhutan, Laos, Myanmar, Nepal, Thailand, Vietnam.

Specimens examined: Pangsha ITC (Tuensang district), Anatonger village (Kiphire district) HYJ112 (NUH), Khuvuxu village (Zunheboto district).

5. Dendrobium densiflorum Lindl., Gen. Sp. Orchid. Pl.: 90.1830; Hook.f., Fl. Brit. Indian. 5:748. 1890; King & Pantl. in Ann. Roy. Bot. Gard. Calcutta. 8: 56. t. 79. 1898; Hynniewta in Bull. Bot. Soc. Bengal 32: 14. 1978; Pradhan, Indian Orch. 2:305. 1979; Kataki, Jain & Sastry in Pl. Cons. Bull. 5: 13. 1984; Seidenf. in Opera Bot. 83:23. Fig. 8. 1985; Kataki, Orch. Meghalaya 48. Pl. 10(4). 1986; Deorani & Naithani, Orch. Nagaland. 172. Pl. 34 (A & B) 1995; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh 295. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland, 142. Fig. 43. 2000. *Dendrobium clavatum* Roxb., Fl. India. 3:481. 1832. *Dendrobium griffithium* var. Guiberttii (Carr.) Veitch., Man. Dendr. 48. 1887. *Callista densiflora* (Wall. ex Lindl.) Kuntze, Rev. Gen. 2: 654. 1891.

Plant 30-45cm. *Roots* ca 3mm across, fasciculate, thick. *Stems* 25-30 x ca 2cm in diam., strongly clavate, swollen, ± pseudobulbous at base, internodes clavate, tapering towards base, obscurely 4-angled, sometimes ridges inconspicuous, yellow, pale brown and glossy when dry, sheathless. *Leaves* 3 or 4, 8-16 x 2.8-5.8cm, subterminal, oblong-lanceolate, leathery, apex acute. *Inflorescence* subterminal, pendulous, densely many flowered; peduncle with 2-4 sheaths at base; rachis 5-15cm; floral bracts broadly oblong or obovate, membranous, revolute, obtuse; pedicel and

ovary, 2-2.5 cm whitish green. *Flowers* spreading, 4-5 cm in diam.; sepals and petals white to pale yellow, lip golden yellow, column and anther cap orange-yellow. *Dorsal sepal* 1.7-1.9 x 1.0-1.2cm, ovate, 5-veined, obtuse; lateral sepals nearly as large as dorsal sepal, ovate-lanceolate, 5- or 6-veined, apex subacute; mentum subglobose, ca. 5 mm wide. *Petals* 1.5-1.8 x 1.2-1.5cm, suborbicular, with 3 main veins and many secondary veins, base contracted into a short claw, margin erose above middle. *Lip* 1.7-2.2 x ca 2.0cm, orbicular-rhombic, both surfaces densely lanate above middle, shortly clawed, both sides embracing column below middle, apex rounded. *Column* ca 4 mm; anther cap compressed subglobose or conic, front margin truncate, finely notched.

Colour Plate 13

Flowering: March – April

Habitat and Ecology: Epiphytic or lithophytic and found growing on main trunk of trees in forests with full head sunlight, lithophytic on moss covered rock, 400-1900m

Distribution: India (Arunachal, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim,) Bhutan, China, Myanmar, Nepal, Thailand, Vietnam.

Specimens examined: Chare village & Meliangkiur village (Tuensang district) HYJ250 (NUH), Anatonger village (Kiphire district) HYJ093 (NUH), Sumi shettsu & Izheto village (Zunheboto district) HYJ236 (NUH).

6. Dendrobium denudans D. Don, Prodr. Fl. Nepal.: 34: 1825; Hook.f., Fl. Brit. Indian. 5:715. 1890; King & Pantl. in Ann. Roy. Bot. Gard. Calcutta. 8: 45. t. 62. 1898; Hynniewta, Kataki & Wadhwa, Orch. Nagaland, 144. fig. 44. 2000. *Callista denudans* (D. Don) Kuntze, Revis. Gen. Pl. 2:654. 1891.

Plant 14-20cm, pendent. *Roots* slender. *Stems* 4-6cm long, suberect, terete covered by leaf sheaths; sheaths tubular, ovate. *Leaves* 3, 6-8 x 0.4-1.0cm, oblong to linear-oblong, acute to sub-acute, obliquely emarginated, sessile, jointed. *Inflorescence* leaf-opposed, axillary, 10 to many flowered; peduncle slender, 2-4 cm long, sheathed, glabrous; sheaths 5-6 x ca 0.5 mm, linear-lanceolate, acute, membraneous; rachis 3-10cm long, glabrous; floral bracts 3-4 x ca 0.5mm lanceolate, acute, membraneous. *Flowers* lunate in bud, 1-2cm across; sepals and petals pale whitish green to pinkish , lip with radiating red-purple lines, mentum purple, column foot red; pedicel and ovary 6-8mm long, slender, glabrous. *Sepals* sub-similar; dorsal sepal linear-lanceolate, acuminate, 3-5 veined, 1.2-1.4 x 0.2-0.4 cm; lateral sepals 1.4-

1.8 x 0.5-0.7cm, lanceolate-triangular, acuminate, falcate,5-veined; mentum broadly conical, 2-3mm long. *Petals* 0.8-1.1 x 0.1-0.2cm, linear-oblong, acute to acuminate, 3-veined.. *Lip* 0.4-0.6 x 0.3-0.4cm (when spread), decurved at base, 3-lobed; lateral lobes long, narrow, margins serrate-lacerate; mid-lobe recurved, obdeltoid to obovate, margins serrate-crisped, 1.5-2 mm long; disc with an obscurely 3-ridged from base to centre of mid-lobe. *Column* 3 mm long; foot angled to column, curved, hispid, 6 mm long; anther cap margins denticulate.

Colour Plate 13

Flowering: November - December

Habitat and Ecology: Epiphytic and found growing on main trunk of trees with diffused or full head sunlight, 1800-2200m

Distribution: India (Arunachal, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura, West Bengal) Bhutan, Myanmar, Nepal, Thailand, Vietnam.

Specimens examined: Chiang mai & Melangkiur village (Tuensang district) HYJ247 (NUH), Sangphure village (Kiphire district) HYJ262 (NUH) , Asukhomi, Nitoi and Naltoqa village (Zunheboto district) HYJ269 (NUH).

7. Dendrobium devonianum Paxt. in Bot. Mag. 7: 169. 1840; Hook.f., Fl. Brit. Indian. 5:743. 1890; Seidenf. & Smitnd. Orch. Thailand, 2(2): 37. 1960; Hynniewta, Katka & Wadhwa, Orch. Nagaland, 146. 2000; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh 298. 1998. *Dendrobium pictum* Griff. ex Lindl. in J. Proc. Linn. Soc., Bot. 3:12. 1859. *Dendrobium pulchellum var. devonianum* (Paxton) Rchb. f. in Walpers, Ann. Bot. Syst. 6: 284. 1861. *Callista devoniana* (Paxton) Kuntze, Revis. Gen. Pl. 2: 654. 1891.

Plant 40-65cm. *Roots* fasciculate. *Stem* 40-62 cm, pendulous, elongate, slender, swollen at base, erect or weakly zig-zag, often pendent at apex, jointed, glabrous, bearing alternate leaves; internodes 2-4cm long. *Leaves* 8-13 x 0.8-1.3cm, narrowly ovate-lanceolate to linear-lanceolate, leathery, acute to acuminate, sessile, sheathing at base; sheaths 2-4cm long, tubular. *Inflorescence* 18-24flowered, lateral, arising from nodes, clustered; peduncle green, ca 4mm; floral bracts lanceolate, acute, membraneous, 4-5 x ca 2mm. *Flowers* 2-4 cm long and wide; sepals cream to white, purple-tinged, petals cream to white with pink-purple towards apex, lip cream or white tinged with pink, yellow in centre; pedicel and ovary 2-3cm long, slender, glabrous,. *Sepals* 1.6-2.0 x 0.5-0.7cm, similar, oblong-lanceolate, acute, 5-veined;

lateral sepals adnate at base to form a mentum; mentum 4 mm long. *Petals* 1.9-2.3 x 0.8-1cm,,lanceolate-ovate, acute, margins fimbriate. *Lip* 2-2.4 x 2-3.2 cm when spread, simple, orbicular-cordate, shortly clawed at concave base, margins deeply fimbriate. *Column* ca 6 mm long, erect, widening and 2-winged towards apex. *Pollinia* oblong.

Colour Plate 13

Flowering: May - June

Habitat and Ecology: Epiphytic or lithophytic and found growing on main trunk of trees with shaded sunlight and on rockscovered with moss, 1400-2200m

Distribution: India (Arunachal, Assam, Meghalaya, Mizoram, Nagaland, Sikkim, West Bengal) Bhutan, Myanmar, China, Thailand.

Specimens examined: Chomi village-Pungro (Kiphire district) HYJ307 (NUH), Tronger village- Chare (Tuensang district) HYJ237 (NUH), Sukhalu village (Zunheboto district) HYJ245 (NUH).

8. Dendrobium falconeri Hook. in Bot. Mag. t. 4944, 1856; Hook. f., Fl. Brit. India 5: 742. 1890; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh 298. 1998; Hynniewta, Katka & Wadhwa, Orch. Nagaland, 147. 2000. *Callista falconeri* (Hook. f.) Kuntze, Revis. Gen. Pl. 2 : 654. 1891. *Dendrobium erythroglossum* Hayata, Icon. Pl. Formos. 4: 36, t. 13a. 1914.

Plant 30-75 cm. *Roots* fasciculate; *Stems* 30-70cm, pendulous, cylindric, slender, ca 3 mm in diam., fleshy, many branched, swollen at branched nodes and moniliform, internodes often dilated above middle. *Leaves* 2-5, 4-7 x 0.3-0.6cm, alternate on upper part of branches, narrowly lanceolate, leathery, base sheathing, apex obtuse or acute and slightly hooked; leaf sheath usually pale pink, tubular, papery. Inflorescences lateral, 1- flowered from each peduncle, sometimes a second peduncle arising creating a 2-flowered inflorescence; peduncle 0.5-1.5cm, slender; basal sheaths 1 or 2, tubular, membranous; floral bracts 3-4 mm, white, ovate, membranous; pedicel and ovary 1-1.2cm, green, ovary yellowish green with purplish red spots, slender. *Flowers* 2.5-4cm across, spreading, large, thinly textured; sepals pinkish white to pale purple with deep purple tip, petals white with purple apex, lip white with purple tip, yellow on both sides at base, disk with a deep purple blotch, column foot pale red to deep purple, anther cap creamy white. *Dorsal sepal* 2.6-2.8 x 0.7-0.8cm, ovate-lanceolate, 8- or 9-veined, base slightly contracted, apex acuminate;

lateral sepals sub-similar to dorsal sepal, base oblique, apex acuminate; mentum subglobose, ca 6 mm. *Petals* 2.8-3.4 x 1.4-1.6cm, ovate-rhombic, main veins 5 or 6, secondary veins many, base cuneate, apex subacute. *Lip*, ca 3.4cm, ovate-rhombic, adaxially densely barbellate, margin denticulate, apex obtuse or slightly acute. *Column* ca 2 mm; foot ca 6 mm; anther cap subconic, ca 2 mm, densely bristly, front margin lacerate, apex broadly obtuse and concave.

Colour Plate 13

Flowering: May - June

Habitat and Ecology: Epiphytic or lithophytic and found growing on main trunk of trees in undisturbed forests with shaded sunlight, 1800-2500m.

Distribution: India (Arunachal, Assam, Meghalaya, Nagaland, Sikkim) Bhutan, China, Myanmar, N Thailand, Vietnam.

Specimens examined: Tsutoho and naghuto village (Zunheboto distrcit) HYJ039 (NUH), Old tsadang village-Chare, Anangba village-longkhim and Chiang mai village (Tuensang distrcit). Pungro & Mimi village (Kiphire district),

9. Dendrobium fimbriatum Hook., Exot. Fl. 1: t.71.1823; Hook.f., Fl. Brit. Indian. 5:745. 1890; King & Pantl. in Ann. Roy. Bot. Gard. Calcutta. 8: 58. Pl. 82. 1898; Pradhan, Indian Orch. 2: 309. 1979; Kataki, Orch. Meghalaya, 49. 1986; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh 301. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland, 147. 2000. *Dendrobium paxtonii* Paxton in Paxton's Mag. Bot. 6: 169. 1839. *Dendrobium fimbriatum* var. *oculatum* Hook. f. Bot. Mag. 71: t. 4160. 1845. *Callista oculata* (Hook.) Kuntze, Revis, op. cit. 655. 1891.

Plants 60-110cm. *Stems* rigid, decumbent and arching, cylindric to slightly fusiform above base, 50-110 cm, stout, 0.8-2cm in diam., unbranched, with many nodes; internodes 3.8-5cm, longitudinally grooved, pale yellow or pale yellowish brown when dry, sheathed.. *Leaves*, 8-16 x 2-3.4cm, oblong or oblong-lanceolate to narrowly ellipticlanceolate, leathery, many veined, with tightly clasping leathery sheaths at base, apex acute to acuminate, sessile. *Inflorescences* racemose, 5-16 cm, laxly 8-15 flowered, from leafless stem, arising from nodes, sheathed at base, pendent; peduncle 2-4cm; sheaths 3-5, tubular, overlapping, shorter at base; rachis thin, ± curved; floral bracts ovate-triangular, 3-5 mm, membranous, apex acute; pedicel and ovary pale green, 2.5-3cm. *Flowers* 3.5-4cm across, slightly fragrant, spreading, thinly textured; sepals and petals golden yellow; lip a deeper yellow hue,

dark maroon blotch unseperated on disc. *Dorsal sepal* oblong, 1.3-1.9.x 0.6-0.9cm, 5-veined, margin entire, apex obtuse; lateral sepals ovate-lanceolate, ca. as long as dorsal sepal adnate at base to from a mentum; mentum rotund, ca. 4 mm.. *Petals* 1.2-1.9 x 0.7-1cm, oblong-elliptic, 5-veined, margin slightly erose, apex obtuse. *Lip* 1.6-2 x 1.8-2.1 when spreadsuborbicular, adaxially densely pubescent, base narrowed into a claw ca. 3 mm, margin compound fimbriate. *Column* ca. 2 mm, foot ca. 4 mm; anther cap conic, glabrous.

Colour Plate 14

Flowering: March - May

Habitat and Ecology: Epiphytic or lithophytic and found growing on trunk of trees in forests with full head sunlight, 1800-2600m.

Distribution: India (Arunachal, Assam, Meghalaya, Nagaland, Sikkim, West Bengal) Bhutan, China, Myanmar, N Thailand, Vietnam.

Specimens examined: Chare, Anangba and chiang mai village (Tuensang district) HYJ238 (NUH), Seyochung and Pungro (Kiphire district) HYJ297 (NUH), Yezashi village – Aghunato (Zunheboto district) HYJ272 (NUH).

10. Dendrobium formosum Roxb. ex Lindl. in Wall., Pl. Asiat. Rar. 1: t. 29. 1830. *Dendrobium formosum* Roxb., Hort. Bengal.: 63. 1814, *nom nud*. *Dendrobium infundibulum sensu* Rchb. f. in Gartenflora 36: t. 1253. 1887. *Callista Formosa* (Roxb. ex Lindl.) Kuntze, Revis. Gen. Pl. 2. 1891.

Plant large, pendent. *Stems* thick, woody, terete, sheathed, swollen Pseudobulbous at base; internodes 2-4 x 0.8-1cm, black pilose, sheaths black pilose, appressed. *Leaves* 4-8 x 1.5-3 cm, oblong, obliquely subacute, emarginated, sessile, distichous. *Inflorescence* 3-4 flowered, terminal, sometimes lateral; peduncle 3-4cm long, sheathed; sheaths funnel shaped, prominently veined; floral bracts 1-1.2 x ca 0.4 cm, ovate, obtuse. *Flowers* 6-10 cm long when spread, fragrant, white, lip with central yellow patch; pedicel and ovary4- 5 cm long. *Dorsal sepal* 3.5-4 x 1.3-1.5 cm, lanceolate, acute to acuminate, finely reticulate; lateral sepals 3.5-4.3 x 1-1.6 cm, oblong-lanceolate, subacute, adnate at base; mentum ca 0.7 cm long, conical. *Petals* 4-5 x 3.5-4 cm, suborbicular, cuspidate, finely reticulate, margins undulate. *Lip* 5 – ca 5 x 3.5 -5 cm when spread, obcuneate to broadly obovate, shortly clawed at base, 3-lobed; lateral lobes subtriangular, midlobe obscurely 2-lobed, emarginated to minutely mucronate, surface tuberculate especially along veins, margins undulate;

disc 2-lamellate, tuberculate pappilose centrally. *Column* 0.8-1 x 0.3-0.7 cm, foot short. *Fruit* broadly ovoid, 2- 3 x ca 2 cm diam.

Colour Plate 14

Flowering: June - July

Habitat and Ecology: Epiphytic and found growing on branch of tree in forest under diffused light, 1000m.

Distribution: India (Arunachal, Assam, Manipur, Meghalaya, Nagaland, Sikkim) Bhutan, Myanmar, Thailand, Vietnam.

Specimens examined: Lumami village (Zunheboto district) HYJ246 (NUH).

11. Dendrobium gibsonii Lindl. in Paxt., Bot. Mag. 5: 169. 1838; Hook. f., Fl. Brit. India 5:746. 1890; King & Pantl. in Ann. Roy. Bot. Gard. Calcutta 8:58, t. 81. 1898; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh 302. Fig. 178. *Dendrobium fuscatum* Lindl. in. J. Proc. Linn. Soc., Bot. 3:8. 1859. *Callista gibsonii* (Lindl.) Kuntze, Revis. Gen. Pl. 2:654. 1891. *Dendrobium fimbriatum* var. *gibsonii* (Lindl.) Finet in Bull. Mus. Hist. Nat. (Paris) 9: 299. 1903.

Plant 40-70cm. *Roots* fasciculate. *Stems* 40-65 cm. *Stems* swollen at base, pendent, weakly zigzag, jointed, tapering, bearing many alternate leaves; internodes bearing green sheaths, yellowish, nodes swollen and rooting, 2-3cm long. Leaves ovate- lanceolate, acute to acuminate, many veined, sessile, sheathing at base, 6-14 x 0.9 – 2.8cm. *Inflorescence* lateral, arising from nodes, leaf present on flowering stem, pendent, 6-14 flowered; peduncle slenderr, glabrous, sheathed, 1-2.5 cm long; sheaths 1-3, ovate, acute, tubular, 6-8mm long; rachis slender, glabrous, pendent, 8-12cm long; floral bracts ovate, acute, 6-8 x 2-3mm. *Flowers* 2.1-2.5cm across, pure yellow to orange-yellow, lip with two round, purple black spots towards base, column greenish-yellow; pedicel and ovary slender, glabrous, 1.5-3cm long. *Sepals* 1.2-1.8 x 0.4- 0.8 cm subequal, broadly ovate, obtuse; lateral sepals adnate at base to form a mentum; mentum broad, 3-5 mm long. *Petals* , 1.3-1.5 x 0.4-0.7cm, broadly ovate, weakly hooded, obtuse. *Lip* 1.4-1.9 x 1.2-1.8cm (when spread), simple, clawed at base, orbicular-reniform, apex broad, pappillose, margins shortly erose – fimbriate. *Column* broad, 7-8 x 3-3.5mm. fruit ovoid, ca.5 x 2 cm.

Colour Plate 14

Flowering: May - June

Habitat and Ecology: Epiphytic or lithophytic found growing on main trunk of tree as well as lithopytic on streamside among rocks, 900-1600m.

Distribution: India (Arunachal, Assam, Meghalaya, Nagaland, Sikkim) Bhutan, China, Myanmar, Nepal Thailand.

Specimens examined: Chendang saddle and chiang mai village (Tuensang district) HYJ239 (NUH).

12. Dendrobium heterocarpum Lindl., Gen. Sp. Orchid. Pl.: 78.1830; Bot. Mag, t. 4708. 1853; Hook. f., Fl. Brit. India 5 : 737. 1890; King & Pantl. in Ann. Roy. Bot. Gard. Calc. 8 : 53. T. 74. 1898; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh 302. Fig. 179. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland, 148. 2000. *Callista heterocarpa* (Lindl.) Kuntze, *op. cit*. 654. 1891;

Plant 15-30cm. *Roots* clustered. *Stems* 8-12 cm, fusiform, erect or pendent, widening upwards, swollen at base, caespitose, yellow with age, bearing many, alternate leaves; internodes sheathed, 2-3 x 0.2-1.2cm. *Leaves* 6-10 x 1.0-1.8cm oblong-lanceolate to oblong, acute, many veined, sessile, jointed. *Inflorescence* lateral, arising from nodes once leaves have fallen, 2 or 3 flowered; peduncle short, sheathed, 2-3mm long; sheaths scarious, tubular, ca 4 mm long; floral bracts scarious, oval, retuse to emarginated or obtuse, 6-8 x 3-4 mm. *Flowers* fragrant, long-lived, 4-6 cm across, yellow, pale creamy-yellow to cream, lip cream or yellow with a central maroon to crimson blotch or striations, column cream with a yellow base; pedicel and ovary glabrous, slender, 2.0-2.6cm long. *Sepals* oblong - lanceolate, obtuse to acute, 6-7 veined, 2.0-3.6 x 0.6- 0.8cm; lateral sepals adnate to form a mentum; mentum obtuse, 4-7mm long. *Petals* 2.2-3.4 x 0.7-1.2cm, ovate, obtuse to acute, 7 veined, *Lip* obscurely 3-lobed, ovate-lanceolate, base wedge-shaped, convolute and hooded around the column, acute and reflexed at apex, margins minutely serrulate-fimbriate, pilose centrally, 2.4-3.7 x 1.0-1.8cm. *Column* 3-4mm long; foot 0.6-0.8mm long. *Fruit* 2.5-3.5 x 0.9-1.8 cm obconical.

Colour Plate 14

Flowering: March – April

Habitat and Ecology: Epiphytic and found growing on main trunk of trees in disturbed forests with full head sunlight, 650-1800.

Distribution: India (Assam, Manipur, Meghalaya, Nagaland, Sikkim) Bhutan, Sri Lanka, China, Myanmar, Nepal, Thailand, Laos, Vietnam, Malaysia, Sumatra, Java and Sulawsi.

Specimens examined: Pungro & Mimi village (Kiphire district) HYJ279 (NUH), Sumi Shettsu (Zunheboto district) HYJ319 (NUH).

13. Dendrobium jenkinsii Wall. ex Lindl. in Bot. Reg. 25:t.37. 1839; Reichb. f. in Walp., Ann. 6:307, 1861; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh 305. 1998. *Dendrobium aggregatum* var. *jenkinsii* (Wall. ex. Lindl.) King & Pantling in Ann. Roy. Bot. Gard. (Calcutta) 8:61, t. 85. 1898. *Callista aggregata* var. *jenkinsii* (Wall. ex Lindl.) Brieger in Schlechter, Orchideen 3(1): 704, t. 517. 1981.

Plant 6-8cm. *Roots* fasciculate. *Pseudobulb* 1.5 – 2 cm long, aggregated, appressed to substrate, ovoid, 4-angled, compressed, ridged. Leaf 1, 1.5-3.2 x 0.9-1.3cm, apical from pseudobulb, oblong-ovate, obtuse, shortly petiolate. *Inflorescence* lateral from pseudobulb, 1-2 flowered; peduncle glabrous, 1.4 cm long; floral bract 1.3-2.2 x 0.3-0.5mm, membraneous, lanceolate, acute. *Flower* 2-2.5cm long, uniformly yellow-orange; pedicel and ovary slender, 4 – 5 cm long. *Dorsal sepal* 1.3-1.4 x 0.3-0.5cm, oblong-elliptic, obtuse, 5-veined; lateral sepals adnate at base to from a mentum; mentum 3-4mm wide. *Petals* 1-1.6 x 0.5-0.8 cm, elliptic-ovate to orbicular, 5-veined. *Lip* 1.5-2.0 x 1.5-1.5 cm (when spread), simple, transversely obcordate, margins erose, surface pubescent centrally. *Column* thick, 5 mm long.

Colour Plate 14

Flowering: March – May

Habitat and Ecology: Epiphytic or lithophytic and f ound growing on main trunk of trees by the roadside in a disturbed forest with full head sunlight as well as by the stream on moist rocks with moss, 1000-1400m.

Distribution: India (Arunachal, Assam, Manipur, Meghalaya, Nagaland, Sikkim) Bhutan, Myanmar, China.

Specimens examined: Sikimi village (Kiphire district) HYH099 (NUH), V. K. Area (Zunheboto district) HYJ030 (NUH).

14. Dendrobium lituiflorum Lindl. in Gard. Chron. 372 1856; Wall. Ex Lindl. in Bot. Reg. 25:t.37. 1839; Reichb. f. in Walp., Ann. 6:307, 1861; H.J. Chowdhery Orchid diversity in north-east India.J. Orchid Soc. India 15: 1–17. 2001. *Callista*

lituiflora (Lindl.) Kuntze. Revis. Gen. Pl. 2: 655 1891. *Dendrobium hanburyanum* Rchb.f. Bonplandia (Hannover) 4: 329 1856.

Plant 35-50cm. *Roots* fasciculate. *Stems* erect, cylindric, 30-45cm or longer, 0.7-1cm in diam., slightly fleshy, unbranched, with many nodes, internodes 3-3.5 cm. *Leaves* 7.5-13 x 1.2- 1.5 cm, narrowly oblong, leathery, base sheathing, apex acuminate and slightly hooked on one side. *Inflorescences* many1or 2 flowered, arising from old leafless stems; peduncle 5-7mm, nearly perpendicular to stem; basal sheaths 3 or 4, ca 1.5 cm, pale white, papery, apex obtuse; floral bracts 1-13mm, pale white, ovate, apex subacute; pedicel and ovary ca. 2.5 cm. *Flowers* 3-3.5cm across, spreading, purple, large, membranous; inner surface of lip with a deep purple spot surrounded by a white circle and pinkish line on the edge. *Dorsal sepal* 2-2.2 x 1-1.3cm, oblong-lanceolate, 7-veined, apex acute; lateral sepals similar to dorsal sepal and equal in length but smaller in breadth, 7-veined, base slightly oblique; mentum subglobose, ca 4 mm. *Petals* 2.1-2.3 x 1.2-1.6cm, subelliptic, 7-veined, margin entire, apex acute. *Lip*1.8-2 x 1.3-1.4cm when spread, subobovate, shorter than petals, embracing column on both sides and trumpet-shaped below middle, adaxially densely barbellate, margin irregularly denticulate. *Column* ca. 4 mm, base dilated.

Colour Plate 14

Flowering: February - April

Habitat and Ecology: Epiphytic and found growing on main trunk of trees by the roadside in a disturbed forest with full head sunlight, 1400m

Distribution: India (Arunachal, Assam, Manipur, Meghalaya, Nagaland, Sikkim) Laos Myanmar, Vietnam.

Specimens examined: Iponger village-Pungro (Kiphire district) HYJ267 (NUH).

15. Dendrobium longicornu Lindl., Gen. Sp. Orchid. Pl.: 80. 1830; King & Pantl. in Ann. Roy. Bot. Gard. Calcutta 8: 46, t. 64. 1898; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh 308. fig. 183. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland, 150. fig 45. 2000. *Dendrobium hirsutum* Griff., Notul. 3:328. 1851. *Dendrobium longicornu* var. *hirsuta* (Griff) Hook.f.,Fl. Brit. India 5:720. 1890. *Callista longicornis* (lindl.) Kuntze, Revis. Gen. Pl. 2:655. 1891.

Plant 10-45cm. *Stems* erect, 10-40 cm; *roots* fasciculate. *Stems* erect, zigzag to weakly zigzag, sheathed, 2-4 mm thick; internodes yellow, 2.5-4 cm long; sheaths tubular, funnel shaped, black hairy, 2.8-4.5 cm long. *Leaves* 2.5-7.5 x 1-2.5cm,

distichous, ovate-elliptic to oblong-lanceolate, subacute, emarginated, puberulous, sessile. *Inflorescence* axillary, arising from near apex of stem, usually 1-flowered; peduncle 2-3 x 1.5-2mm attenuate, sheathed; sheaths short, overlapping, scarious; floral bract 8 x 3 mm, lanceolate, subacute, black hairy. *Flower* fragrant, 3-4.5cm across; sepals and petals white, lip white to orange white, veined with yellow or red-orange; pedicel and ovary slender, 2.2-3.5cm. *Sepals* 1.7-2 x 0.5-0.7cm, sub-similar, ovate-lanceolate, acuminate, keeled; dorsal sepal 5-veined; lateral sepals 2.5-3 x 0.6-0.7cm (towards base) adnate to form a long spur-like mentum, 5-7 veined; mentum 1.5-2 cm long slender, attenuate. *Petals* 1.5-2.0 x 0.4-0.7cm, ovate to ovate - lanceolate, acute to acuminate, keeled, 3-veined. *Lip* 3-lobed, 2.3-3.0 x 2.3-2.8cm, broadly triangular (when spread); lateral lobes rounded, 2.0-2.5 x 1-1.2cm, margins entire to weakly undulate; mid-lobe 6-9mm wide small, suborbicular, fimbriate-lacerate; disc with a broad central ridge from base to mid-lobe where it divides into 3 or 4 branches. *Column* with 2 stelidia at apex, 5-8mm long; foot 1-1.2cm long.

Colour Plate 15

Flowering: October - December

Habitat and Ecology: Epiphytic and found growing on main trunk of trees in an undisturbed forest, 2000-2800m

Distribution: India (Arunachal, Manipur, Meghalaya, Nagaland, Sikkim) Bhutan, Nepal, Myanmar.

Specimens examined: Thanamir village (Kiphire district) HYJ050 (NUH), Tsutoho village (Zunheboto district) HYJ072 (NUH).

16. Dendrobium moschatum (Buch.- Ham.) Swartz in Schrad., Neu. Jour. Bot. 1:94. 1805; King & Pantl. in Ann. Roy. Bot. Gard. Calc. 8:60. t. 84. 1898; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh 311. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland, 150 - 152. 2000. *Dendrobium calceolaria* Carey ex Hook. f., Fl. Brit. India 5: 744. 1890. *Epidendrum moschatum* Buchanan-Hamilton in Symes, Emb. Kingdom Ava: t. 26. 1800; ed. 2(3): 315. 1800. *Callista moschata* (Buchanan-Hamilton) Kuntze, revis. Gen. Pl, 2:653. 1891.

Plant 40-150cm. *Stem* 50-145 cm; *roots* fasciculate, woody. *Stems* 2-3.4 x 0.4-0.7cm, clustered, stout, terete, erect to pendent, ridged, jointed; internodes sheathed. *Leaves* 8-20 x 1.4-3.8cm, lanceolate to elliptic-lanceolate, acute, subsessile, many-veined, distichous, jointed. *Inflorescence* laxly 8-14 flowered, lateral, arising

from nodes of leafy or leafless stem,; peduncle sheathed at base, glabrous, 5-6cm long; sheaths 3-5, tubular, ovate, subacute, many veined, 1-1.8cm long; rachis weakly zigzag, glabrous, 5.5-10cm long; floral bracts 1.3-2 x 0.4-0.5cm, persistent, oblong - lanceolate, acute. *Flowers* showy, fragrant, 6-8cm across, colour variable, sepals and petals yellow to apricot coloured with dark pinkish tip, lip yellow to white with two brown-purple or red spots inside, column yellow, anther purple; pedicel and ovary glabrous, 3- 4cm long. *Sepals* 2.6-3.2 x 0.8-1.8cm, subequal, ovate-lanceolate to lanceolate, acute to subacute; lateral sepals adnate at base to form a mentum; mentum broad, gibbous, 5-8 mm long. *Petals* 2.8-3.3 x 1-1.8cm, ovate-lanceolate to broadly ovate, subacute to obtuse, 7-veined. *Lip* 2-2.3 x 1.6-2.1 cm when spread, simple, slipper shaped (margins incurved), globose to pyriform, margins entire, pilose. *Column* broad with a foot, 4-7mm long. *Fruit* 2.6-3.2 x 1-1.3cm. ovoid-pyriform, crenately ridged.

Colour Plate 15

Flowering: July - September

Habitat and Ecology: Epiphytic and found growing on main trunk of trees in an undisturbed forest, 600-1800m

Distribution: India (Arunachal, Assam, Meghalaya, Nagaland, Sikkim) Bhutan, Nepal, Myanmar, Thailand, Laos, Vietnam.

Specimens examined: Tronger village-Chare (Tuensang district) HYJ256(NUH) Longmatra village (Kiphire district) HYJ308 (NUH), Ghokimi village, Asukhomi village, lumami village (Zunheboto district) HYJ287 (NUH).

17. Dendrobium nobile Lindl., Gen. Sp. Orch. Pl.: 24. 1830; Hook. f., Fl. Brit. India 5 : 740. 1890:King & Pantl. in Ann. Roy. Bot. Gard. Calc. 8: 51. t. 71. 1898; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh 314. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland, 152. 2000. *Dendrobium coerulescens* Wall. in Lindl., Sert. Orchid. 3: t.18. 1838. *Dendrobium lindleyanum* Griff., Notul. 3: 309. 1848. *Callista nobilis* (Lindl.) Kuntze, Revis. Gen. Pl. 2: 655. 1891.

Plant 30-45cm. *Roots* clustered, woody, ca 2mm wide. *Stems* 30-40cm long, clustered, compressed, swollen at base, covered with sheaths, beaded, wavy to weakly zigzag, grooving with age, jointed, yellowish; internodes 2.5-3.4cm; sheaths tubular, 2-4cm long. *Leaves* 7-12 x 1-3 cm, oblong to spathulate, emarginated, many veined, sessile, coriaceous, distichous, persistent. *Inflorescence* 2-4 flowered, lateral, arising

from nodes; peduncle attenuated, 6-9mm long, bracteates at base, 1-flowered from each node; peduncle bract ovate, membraneous, 0.7-1cm long; floral bracts oblong-ovate, obtuse, scarious, tubular, 7-8mm long. *Flowers* 6-8cm across, waxy, fragrant, 4-5cm across; sepals and petals white at base, pinkish towards tip, lip dark maroon at base white and purple at margins; pedicel and ovary glabrous, 34.8 cm long. *Sepals* 3-3.5 x 1.0-1.5cm, oblong-lanceolate, subacute to obtuse, 7-veined; lateral sepals similar to dorsal sepal, united at base to from a mentum; mentum 3-4 mm long, short, obtuse. *Petals* 3-3.5 x 1.5-2 cm, ovate-oblong, obtuse, margins weakly undulate, 7-veined. *Lip* 3-3.4 x 2-3cm when spread, shortly clawed, convolute at base, ovate-oblong in outline, pubescent above and below, margins entire. *Column* 7-9 mm long, acute stelidia; anther cap serrulate in front. *Fruit* ca 6 x 1.2 cm.

Colour Plate 15

Flowering: March - May

Habitat and Ecology: Epiphytic or lithophytic and found growing on main trunk of trees in an undisturbed forest. 1200-2400m

Distribution: India (Arunachal, Assam, Manipur, Meghalaya, Nagaland, Sikkim) Bhutan, Nepal, Myanmar, Thailand, Laos, Vietnam.

Specimens examined: Pungro and mimi village (Kiphire district) HYJ313 (NUH), Naltoqa area (Zunheboto district) HYJ257 (NUH).

18. Dendrobium ochreatum Lindl. in Bot. Reg. t. 1756. 1835; Hook. f., Fl. Brit. India 5: 748. 1890; Seidenf. & Smitnd. Orch. Thailand, 2(2):198. 1960; Hynniewta, Kataki & Wadhwa, Orch. Nagaland, 152. 2000. *Dendrobium cambridgeanum* Paxt., Bot. Mag. 6:t. 265. 1839. *Callista ochreata* (Lindl.) Kuntze 1891.

Roots clustered, ca 2mm wide. *Stems* 20-40cm long, stout, cylindric, pendulous, many leaved. *Leaves* 5-10 x 1.6-3 cm, oblong or oblong-lanceolate, acuminate or acutely bifid. *Inflorescence* 1-3 flowered, 3-5 cm, lateral, arched and drooping. *Flowers* ca 5-7 cm across, dark yellow; bracts ca 2mm long, ovate, acute, greenish; pedicel and ovary ca 3.5cm long. *Dorsal sepal* 3- 3.5 x 1.2-1.5 cm, oblong-lanceolate, acute; lateral sepals similiar; mentum ca 5 mm long. *Petals* 3-3.5 x ca 1.2 cm, elliptic-lanceolate, apex obtuse or notched. *Lip* ca 3 cm long, yellow with 1 red to violet blotch at centre, patch of reddish nerves at the base, sub-orbicular; upper surface pubescent, margins erose. *Column* ca 3.5 mm long. *Pollinia* oblong .

Colour Plate 15

Flowering: April - May

Habitat and Ecology: Epiphytic and found growing on main trunk of trees in an undisturbed forest. 2200m

Distribution: India (Arunachal, Manipur, Meghalaya, Nagaland, Sikkim) Bhutan, Nepal, Myanmar, Thailand, Laos, Vietnam.

Specimens examined: Asukhomi, Litsami and Naltoqa village (Zunheboto district) HYJ042 (NUH).

19. Dendrobium parishii Rchb. f. in Bot. Zeit. 21(31): 237. 1863. *Callista parishii* (Rchb. f.) Kuntze, Revis. Gen. Pl. 2: 655. 1891.

Plant 10-25cm. *Stems* ascending or pendulous, cylindric, stout, 1-1.6 cm in diam., stems often curved, unbranched, with several nodes, internodes ca 4 cm. *Leaves* 8-12 x 1.5-1.7 cm, narrowly oblong, leathery, apex obtuse and unequally bilobed; leaf sheath white, membranous. *Inflorescence* lateral on old leafless stem, 1-3 flowered; peduncle ca 0.5cm; basal sheaths 3 or 4, overlapping, short; floral bracts ca 0.6 cm, ovate-lanceolate, acute; Pedicel and ovary ca 5cm. *Flowers* spreading, large, Pinkish to purplish, disk with a deep purple blotch on either side, column white, anther cap purple. *Dorsal sepal* ca 2.2-2.4 x 0.7-0.9 cm, 5-veined, obovate-lanceolate, apex obtuse; lateral sepals sub-similar but slightly thinner, ovate-lanceolate, 5-veined, apex acuminate; mentum ca 0.5 cm, narrowly conic, obtuse. *Petals* 1.8-2 x 0.9-1.1 cm, broadly elliptic, 5-veined, base shortly clawed, margin ciliate or denticulate, apex acute. *Lip* ca. 1.9-2 x ca 1.8 cm, rhombic-orbicular, both surfaces densely pilose, clawed on both sides embracing column below middle, margin densely ciliate, apex acute. *Column* ca 0.7 cm; anther cap conic, front margin irregularly denticulate, surface papillate.

Colour Plate 15

Flowering: April - May

Habitat and Ecology: Epiphytic and found growing on tree trunk with full head sunlight. 1600m.

Distribution: India (Arunachal, Assam, Nagaland), China, Laos, Myanmar, Thailand, Vietnam.

Specimens examined: Longmatra village (Kiphire district) HYJ309 (NUH).

20. Dendrobium polyanthum Wall. ex Lindl., Gen. Sp. Orchid. Pl. 81. 1830. *Dendrobium primulinum* Lindl.Gard. Chron. 18: 400 1858; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 319. 1998. *Callista primulina* (Lindl.) Kuntze, Revis. Gen. Pl. 2:655. 1891. *Dendrobium nobile* var. *pallidiflorum* Hook., in Bot. Mag. 83: t.5003. 1857.

Plant 20-40 cm. *Stems* 0.8-1.5 cm in diam., cylindric, pendulous, usually stout, fleshy, unbranched, deciduous, with many nodes, internodes 2-2.4 cm. *Leaves* 8-10 x 2-3 cm, alternate along entire stem, lanceolate or ovate-lanceolate, papery, apex obtuse and unequally bilobed; leaf sheath papery or membranous. *Inflorescence* on old stems after leaves have fallen, many flowered along stem, singly; peduncle ca 0.2 cm, penetrating 2 sheaths, cymbiform-concave; basal sheaths 3 or 4, ca 0.3 cm, membranous; floral bracts 0.5-0.7 cm, pale white, ovate, membranous, apex obtuse; Pedicel and ovary ca 2.5 cm long, yellowish green. *Flowers* spreading, pendulous; sepals and petals pale roseate or pinkish white, lip pale yellow with pale roseate margin, disk with purplish red stripes, column white, anther cap purple. *Dorsal sepal* ca. 2-2.5 x 0.7-0.9 cm, 3-5-veined, narrowly lanceolate, subacute; lateral sepals sub-similar, 3-5-veined, base oblique, apex subacute; mentum ca 0.4cm, narrowly conic obtuse. *Petals* 2-2.5 x 0.7-0.9 cm, 3-5-veined, narrowly oblong, margin entire, apex obtuse. *Lip* 2.3-2.6 x ca 3 cm when open, broadly obovate, both sides embracing column in lower half, both surfaces densely pubescent, margin irregularly denticulate. *Column* ca 0.3cm; anther cap elliptic-conic, densely papillate-hairy, front margin broadly emarginate, apex ± concave. *Pollinia* 4, ca 1 mm long, equal.

Colour Plate 15

Flowering: March - April

Habitat and Ecology: Epiphytic and found growing on main tree trunk with full head sunlight. 600-1200m.

Distribution: India (Arunachal, Assam, Manipur, Meghalaya, Nagaland, Sikkim), China, Laos, Myanmar, Nepal, Thailand, Vietnam

Specimens examined: Sikimi village (Kiphire district) HYJ301 (NUH), Mukhami, Chishilimi, Litsami, Rotomi (Zunheboto district) HYJ108 (NUH), Thronger village (Tuensang district) HYJ258 (NUH).

21. Dendrobium porphyrochilum Lindl. in J. Proc. Linn. Soc., Bot. 3:18. 1858; Hook. f., Fl. Brit. India 5: 716. 1890; King & Pantl. in Ann. Roy. Bot. Gard. Calc.

8:44. t. 59. 1898; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh 319. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland, 153. 2000. *Dendrobium caespitosum* King & Pantl. in Jour. Asiat. Soc. Bengal 64:332. 1895. *Callista porphyrochila* Lindl. Kuntze, Revis. Gen. Pl. 2:654. 1891.

Plant 8-12cm. *Roots* caespitose. *Stems* attenuate, pseudobulbous; *pseudobulbs* cylindric-conical, slender, yellowish, covered by overlapping sheaths 0.6-1.8 x 0.3-0.4cm; leaf sheath 1.0-1.2 x 0.5-0.7cm, membrabeous, veined. *Leaves* 3 or 4, 3-5 x 0.8-1cm, linear-oblong, obtuse to obliquely emarginate, sessile, jointed. *Inflorescence* terminal from pseudobulb, solitary, pendent, 6-10 flowered; peduncle slender, sheathed at base, glabrous, 2-3cm long; basal sheath 1, lanceolate, acute, membraneous, ca 3 mm long; rachis weakly zigzag, glabrous, 3.5-5cm long; floral bracts linear-lanceolate, acuminate, 1-veined, 3-5 x 1-1.5mm. *Flowers* 1-1.5 cm across; sepals and petals pale-green yellow with red veins, lip purple to brownish purple edged with yellow or green; pedicel and ovary slender, glabrous, 5-7 mm long. *Dorsal sepal* 7-9 x 2-3mm, spreading, lanceolate, acute, 3-veined; *lateral sepals* spreading, linear-lanceolate, acute, 3-veined,slightly longer than dorsal sepal, widened and adnate at base; mentum short, obliquely rounded, obtusely angled. *Petals* 7-8 x 1-2 mm. oblong-lanceolate, acute, *Lip* 6-7x ca 4mm when spread, elliptic-sagittate, subacute, decurved from base, flat, margins entire, weakly undulate, surface glandular, pappilose at base; disc keeled from base to apex, thickened centrally, glandular-papillose. *Column* broad, 1-2 mm long, foot concave.

Colour Plate 16

Flowering: May - July

Habitat and Ecology: Epiphytic and found growing on main trunk of trees in an undisturbed forest, 2200m

Distribution: India (Arunachal Pradesh, Nagaland, Sikkim) Bhutan, Nepal, Myanmar, China, Thailand.

Specimens examined: Chendang saddle (Tuensang district) HYJ318 (NUH).

22. Dendrobium sociale J.J. Sm.in Bull. Buitenz. 2. Ser. 3:61, 1912; J.J. Sm in Fed. Repert. 32: 297. 1933; Seidenf. in Op. Bot. 83:248, f. 167, 1985; Seidenf. in Op. Bot. 114:224. 1992; C. Deori., R. Shanpru & S. Phukan. The Orchid review. Jan-Feb issue, 44-45: 2007. *Dendrobium batakense* J.J. Sm. in Bull. Buitenz. 3. Ser. 5:90. 1922.

Dendrobium nhatrangense Gagnep. In Bull. Mus. Nat. Hist. Paris 2. Ser. 2(2):237, 1930. *Dendrobium alleizettei* Gagnep. In Bull. Mus. Paris 2. Ser. 21(6):740. 1949.

Roots ca 1.5mm diam, slender, branched. *Stems* 12-40 cm long, base narrower than middle, curved towards apex, yellowish brown to green, suberect, cylindrical, grooved , covered with leaf sheaths, apex leafy, internodes 1-4 cm long. *Leaves* 2.5-8 x 0.8-1.4 cm, distichous, oblong-lanceolate, glabrous, entire, 4-7 nerved; apex obliquely notched, obtuse to sub-acute; sheaths ca 1-3 cm long, transparent. *Inflorescence* axillary, usually arising from nodes of leafless stem, 2-3-flowered on a short peduncle; floral bracts ca 6 mm long, lanceolate, acute, entire, transparent, three-nerved. *Flowers* slightly sweet fragrant, pale lemon green to dull yellow, sepals and petals bordered with light pink, lip tinged with red-purple with red to purple veins in centre, hairy on the centre of lip; pedicel and ovary ca 2.5 cm long, green. *Dorsal sepal* 1.2- 1.4 x ca 0.5cm, lanceolate, acute; lateral sepals ca 1.3 x 0.3-0.7 cm, wide at base. *Petals* 1.2-1.4 x 0.4-0.6 cm, ovate-lanceolate. *Lip* 1.2 cm long, recurved, three-lobed, attached to base of curved column foot; side lobes 10 mm long, semicircular, upcurved, entire on basal half, dentate towards epichile; mid-lobe ca 5 x 4 mm, triangular, acute, entire, sparsely hairy; disck with 3 laterally branched veins from base of hypochile to centre of epichile, scattered hairs along main veins. *Column* curved, foot ca 7 mm long; stelidia 2, acute. Anther 1.4 x 1.3 mm, ovoid, white, pappilose, front erose-subdentate. Pollinia ca 1 mm long, 4, 2 paired, yellow, transparent, narrowly ellipsoid.

Colour Plate 16

Flowering: March - April

Habitat and Ecology: Epiphytic and found growing on branch of tree, 2400m

Distribution: India (Nagaland) Sumatra, Thailand, Vietnam.

Specimens examined: Hutanger village- Amahotor (Kiphire district) HYJ344 (NUH).

23. Dendrobium spatella Rchb. f. in Hamburger Garten-Blumenzeitung 21: 298 (1865); H.J. Chowdhery, Orch. Fl. Arunachal Pradesh 283.fig. 166. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland, 138. 2000. *Dendrobium acinaciforme sensu* Hook. f., Fl. Brit. India 5(2) : 723 (1890), *non* Roxb. (1832). *Callista spatella* (Rchb. f.) Kuntze, Revis. Gen. Pl. 2:265 (1891). *Dendrobium acinaciforme* var. *minus* T.

Tang & F.T. Wang in Acta Phytotax. Sin. 1 : 40, 80 (1951). *Dendrobium banaense* Gagnepain in Bull. Mus. Natl. Hist. Nat., ser. 2(2): 232. 1930.

Plant 30-40cm. *Roots* clustered, basal, branched. *Stem* erect, 8-12cm long weakly fusiform, yellowing, covered by leaf sheaths, leaves absent (or rudimentary) in upper half; internodes widening towards apex, 0.8-1.2 cm long. *Leaves* 2-3.5 x 0.7-1cm, many, overlapping, laterally flattened, distichous, equitant, curved, lanceolate, acute, sessile; sheaths 1-1.4cm long. *Inflorescence* lateral, arising from nodes; peduncle attenuate, ca 1 mm long; floral bracts lanceolate, subacute, ca 2 x 1 mm. *Flowers* 7-9mm across; sepals and petals creamish yellow, lip yellowish white; pedicel and ovary curved, 5-6 mm long. *Dorsal sepal* 3-4 x 2-3mm, ovate-lanceolate, obtuse, 5-veined; lateral sepals 4-5 x 3-4mm, ovate-lanceolate, subacute, connate at base to form a mentum, 5veined; mentum curved, 3-4mm long. *Petals* 3 -4 x ca 2mm, ovate, obtuse, 3-veined. Lip 4-5 x 4-5 mm when open, simple, clawed at base, widening to quadrate or wedge-shaped apex, margins crenulate. *Column* erect, recurved at apex, 1-2mm long; foot 2-2.5mm long. Fruit ovoid, stalked, 5-6 x 2-2.5 mm.

Colour Plate 16

Flowering: May - July

Habitat and Ecology: Epiphytic and found growing on tree trunk in a disturbed forest, 600-1200m

Distribution: India (Arunachal, Assam, Meghalaya, Nagaland, Sikkim) Bhutan, Nepal, Myanmar, Thailand, Laos, Cambodia, Vietnam and Peninsular Malaysia.

Specimens examined: Lumami village, Mukhami & Izheto village (Zunheboto district) HYJ271 (NUH).

24. Dendrobium tamenglongense R. Kishor, Y.N. Devi, H.B. Sharma, J. Tongbram & S.P. Vij, Nordic J. Bot. 32(2): 150–153. 2013.

Plant 20-45cm. *Roots* thick, arising from the base. *Pseudo-bulbs* 20-42 x 0.2-0.5cm, angular distally, green, glabrous; young parts covered by pubescent leaf-sheaths; prominent ridges and grooves present; internodes 1.0-4.3cm long, glabrous. *Leaves* 5-10 per pseudo-bulbs, distichous, thinly coriaceous; lamina 5.4-8.5 x 0.6-1.8cm, green, lanceolate, acute, unequally bi-lobed at apex, both surface glabrous; pubescent tubular leaf sheaths 1.4-4.4cm long, enclosing the younger pseudo-bulbs. Racemes 1-2 flowered, terminal or axillary on leafless pseudo-bulbs; peduncle and

rachis upto 1 cm long, dark green, glabrous. Floral bracts 0.6-0.8 x 0.3-0.4cm, green, ovate-lanceolate, acuminate, externally keeled. Pedicillate ovary 3-3.9cm, long curved, slender, glabrous, white with green base and slightly greenish near the column. *Flowers* non-fragrant, 2.0-2.5 cm across with orange green lamellae of lip with green sepal apices. *Dorsal sepal* 1.8-2.1 x 0.8-1.0 cm, oblong, acuminate at apex, keeled externally; lateral sepals 1.0-1.2cm wide, 2.1-2.3 cm long on upper margin, 4-4.3cm long on lower margin and adnate to the foot to form a mentum, acute at apex, keeled, green. *Petals* 1.9-2.0 x 1-1.1cm, white elliptic, margin subserrate near the acute apices not keeled. Labellum 2.8-3 x 3.4-4 cm, rhomboid when flattened with part of spur forming a tail, trilobed, with larger side lobes and triangular dentate dorsal margins, white with 7 orange red veins; midlobe ca 0.5 x 0.4cm, shortly fimbriate along margin. *Column* 0.6-0.7cm long, white; foot 3-3.5cm long with red colour in upper half. Anther cap ca 0.2 x 0.3cm, white with ciliate margin towards the stigma; stigmatic opening white; pollinia ca 0.20cm long, 4 in numbers, oblong, yellow in colour.

Colour Plate 16

Flowering: June - July

Habitat and Ecology: Epiphytic and found growing in a subtropical semi-evergreen forest and was growing on *Schima wallichii* Choisy (Theaceae), 1900m

Distribution: India (Manipur, Nagaland).

Specimen examined: Pangsa village (Tuensang district) SDNU207 (NUH).

25. Dendrobium thyrsiflorum Rchb. f. ex E. andre in Ill. Hort. 22:88, t. 207. 1875. *Callista thyrsiflora* (H. G. Reichenbach ex André) M. A. Clements. *Dendrobium densiflorum* var. *alboluteum* Hook. f. in Bot. Mag. 95: t. 5780. 1869.

Plant 50- 0 cm tall. *Stems* 25-50 cm, erect or ascending, cylindric, stout, 8-1.6 cm in diam., base contracted and narrowly cylindric, with several nodes, with several longitudinal ridges, yellowish green and glossy. *Leaves* 4 or 5, 10-17 x 3-5 cm on upper part of stem, alternate, oblanceolate, leathery, base not decurrent into clasping sheaths, but narrowed into a stalk ca 0.5 cm, apex acute. *Inflorescence* 11-16 cm, arising laterally on previous year's leafy stem, pendulous, densely many flowered; peduncle with 3 or 4 papery basal sheaths; floral bracts 1-1.3 x 0.5-1cm, pale white, obovate, papery, with several veins, not convolute when dry, apex bluntly rounded. *Pedicel* and *ovary* ca 3 cm with pale white stripes tinged with purple. *Flowers*

spreading, thin; sepals and petals white, lip golden yellow to almost orange. *Dorsal sepal* ca 1.3 x 0.9 cm, 5-veined, ovate, entire, obtuse; lateral sepals , ca. 1.7 x 0.8 cm, 5-veined, slightly obliquely ovate-lanceolateentire, obtuse; mentum subglobose, ca 4 mm wide. *Petals* ca 1.3 x 1.2 cm, 7-veined with many secondary veins, suborbicularbase, apex bluntly rounded. *Lip* ca 1.5 x 1.8 cm, suborbicular to triangular, abaxially sparsely pubescent, adaxially densely pubescent, bluntly rounded, base with claw ca 3 mm; claw ornamented with a ligulate structure. *Column* foot ca 0.4 cm; anther cap compressed.

Colour Plate 16

Flowering: April - May

Habitat and Ecology: Epiphytic and found growing on tree trunk by the side of a road. 1400-2100m

Distribution: India (Arunachal, Assam, Manipur, Meghalaya, Nagaland, Tripura), China, Laos, Myanmar, N Thailand, Vietnam.

Specimens examined: Aquaba village, Khughutomi village (Zunheboto district) HYJ266 (NUH), Pangsha village (Tuensang district) HYJ320 (NUH).

26. Dendrobium transparens Wall. Ex Lindl. Gen. & Sp. Orch. 79. 1830; Bot. Mag. t. 4663. 1852; Hook.f., Fl. Brit India 5: 738. 1890; King & Pantl. in Ann. Roy. Bot. Gard. Calcutta 8:50. T. 70. 1890; Deb, Bull. Bot. Surv. India, 3(2): 115- 138. 1961; Pradhan, Indian Orch. 2:316. 1979; Kataki, Orch. Meghalaya, 61. Pl. 13(1). 1986; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh 327. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland, 154. Fig. 46 2000. *Dendrobium henshalli* Reich.f. in Bonplandi 3: 226 1855. *Callista transperens* (Wall. ex Lindl.) Kuntze, Revis. Gen. Pl. 2: 655. 1891.

Plant 25-60 cm long. *Stems* erect, slender, swollen at nodes, pseudobulbs at base; internodes 2-4.5cm, covered by leaf shetahs, yellowing with age; sheaths tubular, funnel shaped, fibrous when old. *Leaves* 5-12 x 1- 2cm, linear lanceiolate to oblong-elliptic, acute to oblique, sessile , jointed, many-veined. *Inflorescence* lateral, 2-flowered, flowering from leafless stem; peduncle attenuate; floral bracts 6-8 x 4-5mm, broadly lanceolate, scarious. *Flowers* 3-4.5cm across; petals and sepals white to pinkish, lip dark purple patch on either side of disc and pinkish on margins, column greenish to yellow; pedicel and ovary 1.8-2.4cm, slender. *Sepals* subequal, similar, lanceolate, acute, 5-veined; dorsal sepal 2-2.2 x 0.5- 0.7cm; lateral sepals as equal as

dorsal sepal, adnate to base; mentum conical, obtuse, 5 x 4 mm. *Petals* 2-2.1 x 0.7-0.8cm, ovate, acute. *Lip* 2-2.2 x1.2-1.3 when spread, clawed, broadly elliptic-obovate to saggittate when spread, obscurely suborbicular, margins undulate, pubescent on upper surface. *Coulmn* with two horn like stelidia at apex, 6-8mm long along with foot. *Fruit* stalked, ovoid, 1.5-2.5 x 0.4-1.4cm.

Colour Plate 16

Flowering: May - June

Habitat and Ecology: Epiphytic and found growing in a disturbed forest by the roadside.

Distribution: India (Arunachal, Assam, Manipur, Meghalaya, Nagaland, Sikkim) Bhutan, Nepal, Myanmar.

Specimens examined: Sumi Shettsu, Zaphumi, Lumami village (Zunheboto district) HYJ291 (NUH).

27. Dendrobium wardianum Warner, Select Orchid. Pl. 1: t. 19. 1862; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 327. fig. 194. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 156. 2000. *Callista wardiana* (Warner) Kuntze, Revis. Gen. Pl. 2: 655. 1891.

Plant 20-40cm. *Stems* pendulous, 15-38 cm cylindric, fleshy, with many swollen nodes, internodes 2-2.5cm, pale yellow when dry. *Leaves* 8-12 × 1.6-1.9cm, oblong, leathery, base with clasping sheath, apex slightly obtuse and hooked on one side; leaf sheath papery when dry, sheath mouth open cupular. *Inflorescence* on old leafless stems, 1-3 flowered on single base; peduncle 3-4 mm; basal sheaths 2 or 3, pale white when dry, broadly ovate, 3-5 mm, papery, obtuse; floral bracts broadly ovate, 6-8 mm, papery, apex obtuse; pedicel and ovary pale purple, ca. 2 cm. *Flowers* 2.2-2.8cm across, fragrant, spreading, papery; sepals and petals white with pale purple tips, lip with many purplish red stripes on each side, disk with a pale yellow transverse semilunar central blotch, blotch separated purplish to maroon, column white, anther cap white. *Dorsal sepal* 2-2.7 x 0.6-0.8cm, ovate-lanceolate, 7-veined, apex acute or slightly obtuse; lateral sepals suborbicular, sub-equal in size, 7-veined, base oblique, apex acute; mentum subglobose, small, ca 3 mm. *Petals* 2.3-2.6 × 1.3-1.5cm, obliquely ovate, main veins 5, secondary veins many, base contracted into a short claw, margin entire, apex obtuse; lip ca 2.2 × 1.8 mm, nearly broadly obovate, adaxially densely barbellate, base cuneate, margin ciliate, apex rounded. *Column* ca

4mm; anther cap subconic, densely finely papillate, front margin irregularly dentate. *Capsule* ovoid, ca. 3 x 1.3-1.6 cm.

Colour Plate 17

Flowering: May – June

Habitat and Ecology: Epiphytic and found growing on tree trunk, 2000-2600m

Distribution: India (Arunachal, Assam, Manipur, Meghalaya, Nagaland, Sikkim), Thailand, Vietnam.

Specimens examined: Satoi village, Tsutoho village (Zunheboto district) HYJ280 (NUH), Anangba village (Tuensang district) HYJ334 (NUH).

28. Dendrobium wattii (Hook.f.) Rchb. f., Gard. Chron., ser. 3., 4: 725. 1888. *Dendrobium cariniferum* var. *wattii* Hook. f., Bot. Mag. 109: ad t. 6715. 1883. *Callista wattii* (Hook.f.) Kuntze., Revis. Gen. Pl. 2: 655 1891.

Plant upto 60 cm. *Stems* 12-60 cm, 0.4-0.7 cm in diam. sometimes curved, cylindric, equally thick above and below, rigid, unbranched, with many nodes, internodes ca 4.5 cm, with longitudinal ribs. *Leaves* 8-10, 6-9 x 1-1.8 cm, oblong, leathery, abaxially black hirsute when young, base decurrent forming clasping sheaths, apex obtuse and slightly unequally 2-lobed; leaf sheath densely black hirsute. *Inflorescence* apical on leafy stem, 1- or 2-flowered; peduncle ca 0.5 cm; basal sheaths 3 or 4, broadly ovate, ca 0.7 cm; floral bracts triangular with abaxially dense black rigid hairs, apex acute; Pedicel and ovary ca 3.5 cm. *Flowers* ca 3 cm in diam., spreading, white, lip with yellow veins on lateral lobes, disk with a yellow patch. *Dorsal sepal* ca. 1.9-2.2 x 0.8-1 cm, 5- or 6-veined, oblong, apex acute; lateral sepals sub-similar, obliquely lanceolate,7- or 8-veined, apex acute; mentum long and narrow, straight forming spur. *Petals* ca. 3.2-3.4 x 2.9-3.2 cm, 7- or 8-veined, oblanceolate, bluntly rounded and mucronate. *Lip* ca. 3.5 x 3cm when flattened; lateral lobes obovate, embracing column, front margin slightly undulate; mid-lobe orbicular, 1-1.3 cm wide, margin irregularly serrate, truncate, usually minutely mucronate, with only a indistinct sinus; disk with a broad median callus with 4 or 5 parallel small keeled ridges extending from base of lip to base of mid-lobe. *Column* ca 0.6 cm; anther cap subspherical, front margin denticulate.

Colour Plate 17

Flowering: December – January

Habitat and Ecology: Epiphytic and found growing on branches as well as on main tree trunk in a dense forest. 1900m

Distribution: India (Nagaland), China, Myanmar, Laos, Thailand, Vietnam.

Specimens examined: Pangsha village (Tuensang district) HYJ317 (NUH).

29. Dendrobium williamsonii Day & Rchb.f. in Gard. Chron. 78. 1869; Hook.f., Fl. Brit India 5: 721. 1890; Seidenf. & Smitnd. Orch. Thailand, 2(2): 222.1960; Hynniewta, Kataki & Wadhwa, Orch. Nagaland, 156. Fig. 47. *Callista williamsonii* (Day & Rchb. f.) Kuntze. Revis. Gen. Pl. 2: 655 1891.

Plant 18-20cm. *Stems* 4-6mm in diam., swollen and fusiform, unbranched, with several nodes, internodes 2-3cm, golden yellow when dry. *Leaves* 7-10 x 1.5-3cm, several, usually alternate on upper part of stem, oblong, leathery, with black rigid hairs on sheaths, base decurrent forming clasping sheaths, apex obtuse and unequally bi-lobed. *Inflorescences* subterminal, 1 or 2 flowered; peduncle 7-10mm; basal sheaths 3 or 4, short; floral bracts ca 5 mm, ovate, papery, acute; ovary not carinate. *Flowers* 4-4.5cm across, spreading; sepals and petals whitish pale yellow; lip whitish pale yellow, disk tinged with orange. *Dorsal sepal* 2.5-3.4 x 0.8-1cm, narrowly ovate-oblong, narrowly keeled abaxially, acuminate; lateral sepals similar to dorsal sepal, oblique at base; mentum rigid, straight, 1.6-2cm, forming spur. *Petals* similar to sepals. *Lip* 2-2.4 x 1.9-2 cm when spread, 3-lobed; lateral lobes embracing column, subobovate, front margin slightly undulate; mid-lobe suborbicular or broadly elliptic, margin undulate, apex acute; disk sparsely shortly fimbriate along veins. *Column* ca 5 mm; anther cap broadly conic, front margin densely shortly barbate.

Colour Plate 17

Flowering: March - April

Habitat and Ecology: Epiphytic and found growing on tree trunk, 1700m.

Distribution: India (Nagaland), Thailand, Vietnam

Specimens examined: Mimi village-Pungro (Kiphire district) HYJ095 (NUH), Nokyan village (Tuensang district) HYJ286 (NUH).

DIENIA Lindl.

Bot. Reg. 10: ad t. 825. 1824.

The genus was established by Lindley in 1824. The genus comprises of two species at present. 2 species in India and 1 sp. is reported by the author from Nagaland.

1. Dienia ophrydis (J. Koenig) Ormerod & Seidenfaden, Contr. Orchid Fl. Thailand. 13: 18. 1997; Kataki, orch. Megh. 30. 1986.; Hook.f., Fl. Brit. Indian. 5:689. 1890; King & Pantl. in Ann. Roy. Bot. Gard. Calcutta. 8: 19. t. 23. 1898; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh. 504. Fig. 309. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland, 217-219. 2000. *Epidendrum ophrydis* Koenig in Retzius, Observ. Bot. 6: 46. 1791. *Crepidium ophrydis* (Konig) M.A. Clem. & D.L. Jones, Lasianthera 1:38. 1996. *Malaxis latifoila* J.E. Smith in Rees, Cycl.: 22. 1822. *Dienia congesta* Lindl. in Bot. Reg. 10: sub t. 825 (1824). *Microstylis congesta* (Lindl.) Rchb.f. in W.G. Walpers, Ann. Bot. Syst. 6:206. 1861. *Neottia Plantaginea* D.Don, Prodr. Fl. Nepal: 27. 1825. *Malaxis Parvissima* S.Y. Hu in Chung Chi J. 13(2): 22, t. 10. 1976. *Malaxis latifolia* var *nana* S.S. Ying in Mem. Coll. Agric. Natl. Taiwan Univ. 25(2): 101. 1985.

Pseudobulbs 2-3 cm, cylindric,fusiform to oblong, fleshy, with several nodes, usually enclosed in membranous sheaths. *Leaves* 4 to 6, 8- 22 x 3-8 cm, arising from node near base of previous pseudobulb, obliquely ovate-elliptic, ovate to narrowly elliptic-lanceolate, sheathlike contracted base, amplexicaul petiole ca 4 cm, apex acuminate. *Inflorescence* erect, arising from between top leaves; peduncle erect, 15-35 cm; rachis 5-14 cm, many flowered; floral bracts ca 2.5mm long, usually reflexed, narrowly lanceolate. *Flowers* dark purplish to greenish yellow, extremely small; pedicel and ovary ca 3 mm. *Dorsal sepal* narrowly ca 0.3 x 0.12 cm, oblong, apex obtuse; lateral sepals ca 0.25 x 0.13 cm, obliquely ovate. *Petals* ca 0.3 x 0.1 cm, linear, apex obtuse. *Lip* ca 0.2 x 0.25 cm, usually broadly ovate, concave, subcordate to truncate at base, apex 3-lobed; mid-lobe entire, narrowly ovate to oblong, 0.7-1 mm, much longer than lateral lobes; lateral lobes with auricles distinctly abbreviated, rounded.. *Column* ca 1.2 mm, stout. *Capsule* ca 0.7 x 0.4 cm, erect, obovoid-ellipsoid.

Colour Plate 17

Flowering: July - August

Habitat and Ecology: Terrestrial or lithophytic, found growing as an undergrowth by the side of the road as well as on moss covered rock by the streamside.

Distribution: India (Arunachal, Assam, Manipur, Meghalaya, Nagaland, Sikkim, West Bengal) Bhutan, China, Cambodia, India, Indonesia, Japan (Ryukyu Islands), Laos, Malaysia, Myanmar, Nepal, New Guinea, Philippines, Sri Lanka, Thailand, Vietnam; Australia.

Specimen examined: Zaphumi village, Khashito village (Zunheboto district) HYJ073 (NUH).

EPIGENEIUM Gagnep.

Bull. Mus. Hist. Nat. (Paris) 2, 4:593. 1932.

The genus was described by F. Gagnepain in 1932. The generic name is derived from the Greek words '*epi'*(upon) and '*geneion'*(chin) referring to the position of petals and lateral sepals on the column foot.

5 species in India, 4 species in Nagaland, and 3 species reported by the author.

Key to species

1. Pseudobulb more than 2.5cm broad; leaves elliptic-oblong, more than 3 cm broad; flowers ca 7 cm across, purple spotted, lip margin crisped ... *E. amplum*
- Pseudobulb less than 1.5 cm broad; leaves elliptic-lanceolate, less than 2.5 cm broad; flowers less than 5 cm across without purple spots, lip entire 2
2. Leaf apex notched; mid-lobe of lip orbicular-ovate, larger than hypochile…… ……*E. fuscescens*
- Leaf apex acute; mid-lobe of lip sub-reniform, smaller than hypochile ……..... *E. rotundatum*

1. Epigeneium Amplum (Lindl.) Summer. In Kew Bull. 260. 1957; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 337. fig. 201. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 161. fig. 49. 2000. *Dendrobium amplum* Lindl., Gen. & Sp. Orch. 74. 1830; Hook. f., Fl. Brit. India 5: 711. 1890; King & Pantl. in Ann. Roy Bot. Gard. Calc. 8:63. T. 89. 1898. *Bulbophyllum amplum* (Lindl.) Reichb. f. in Walp. Ann. 6:224. 1861.

Rhizome stout, creeping, branched. *Roots* arising from nodes. *Pseudobulbs* 3.5 – 4.8 x ca 2.6 cm, obliquely ellipsoid, grooved, 5.10 cm apart on rhizome, sheathed; sheaths, many veined, ovate, acute. *Leaves* 2, 10-14 x 1.5-4.5 cm, broadly elliptic-

oblong, obtuse, notched at apex, sessile to shortly petiolate; petiole 1.5-2.3 cm long. *Inflorescence* 1-flowered; floral bracts large, ovate-oblong, acute, sheathing, 1.5-4 x 0.6-0.8 cm. *Flower* 7-8cm across, creamish mottled with purple-red, lip deep purple to chocolate-brown; pedicel and ovary 3.5-5 cm long. *Dorsal sepal* 4-6 x 1-1.3 cm, lanceolate, acute to acuminate; lateral sepals 4-4.2 x 1.2-1.5 cm, lanceolate, falcate, acute, saccate at base. *Petals* linear-lanceolate, acute, 4.3-4.8 x 0.3 -0.8 cm. *Lip* 3-lobed, porrect, 3-4.5 x 1.5- 2 cm, margin saccate; lateral lobes sub-orbicular, erect; mid-lobe rhombic-ovate, recurved at apex, margins crisped; disc 3-lamellate. Column weakly curved, narrowly winged, 2 cm long.

Colour Plate 17

Flowering: October - November

Habitat and Ecology: Epiphytic or lithophytic, found growing on tree branch and rocks. 1700 m.

Distribution: India (Arunachal, Meghalaya, Nagaland, Sikkim), Bangladesh, Bhutan, Nepal.

Specimens examined: Seyochung village (Kiphire district) HYJ292 (NUH).

2. Epigeneium fuscescens (Griff.) Summer. in Kew Bull. 12: 262. 1957. *Dendrobium fuscescens* Griffith, Not. Pl. Asiat. 3: 308. 1851; Hook. f., Fl. Brit. India 5: 712. 1890; King & Pantl. in Ann. Roy. Bot. Gard. Calc. 8 : 62. t. 88. 1898; Balak. & Chowd. In Bull. Bot. Surv. India, 8(3&4): 315. 1966; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 160. fig. 50. 2000. *Dendrobium fuscescens* griff., Not. Pl. Asiat. 3: 308. 1851. *Sarcopodium fuscescens* (Griff.) lindl., Fol. Orchid. Sarcopodium 2:2, no.2. 1853. *Bulbophyllum fuscescens* (Griff.) Rchb. f. in Walpers, Ann. Bot. Syst. 6: 244. 1861. *Katherinea fuscescens* (Griff.) A.D. hawkes in Lloydia 19:95. 1956.

Rhizome branching, densely covered with tubular sheaths, ca 0.4 cm in diam. *Pseudobulbs* 4-6 cm apart from one another, 2.5-3 x ca 0.7 cm, narrowly ovoid, slightly curved, covered with 2 or 3 brown sheaths. *Leaves* 2, 5-7 x 1.2-1.8cm, oblong, leathery, base subsessile or with a short petiole, apex slightly emarginated to bi-lobed. *Inflorescence* 1-flowered, arising between leaves; peduncle ca 1 cm, base covered with sheaths; floral bracts much shorter than pedicel and ovary. *Flowers* pale brown to dark brown; pedicel and ovary ca. 3.5 cm. *Dorsal sepal* 1.8-2.1 x 0.3-0.5cm, ovate-lanceolate, long acuminate; lateral sepals 2-2.3 x 0.3-1 cm, falcate-lanceolate, acuminate-caudate. *Petals* 2-2.5 x ca 0.2 cm, narrowly oblong or linear, acuminate-

caudate. *Lip* ca 1.5 cm long, ovate-oblong in outline, 3-lobed; lateral lobes erect, suboblong; mid-lobe ca. 1.1 x 0.6 cm, orbicular-ovate, often hooked aristate; disk with 3 lamellae, median shorter. *Column* and foot ca 0.9 cm.

Colour Plate 17

Flowering: September - November

Habitat and Ecology: Epiphytic or lithophytic, found growing on tree branch, as well as on rocks. 1800-2300m.

Distribution: India (Arunachal, Meghalaya, Nagaland, Sikkim), China, Bhutan, Nepal.

Specimens examined: Satoi village, tsutoho village (Zunheboto district) HYJ281 (NUH), Chendang saddle (Tuensang district) HYJ058 (NUH), Thanamir village (Kiphire district) HYJ345 (NUH).

3. Epigeneium rotundatum (Lindl.) Summer. in Kew Bull. 12:264. 1957; Hook. f., Fl. Brit. India 5: 712. 1890; King & Pantl. in Ann. Roy. Bot. Gard. Calc. 8 : 62. t. 87. 1898; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 339. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 164. fig. 52. 2000. *Sarcopodium rotundatum* Lind., Fol. Orch. 2. 1853. *Katherinea rotundata* (Lindl.)A.D.Hawkes, 19, (2):97.1956. *Bulbophyllum rotundatum* (Lindl.) Reichb. f. in Walp. Ann. 6 : 224. 1861. *Dendrobium rotundatum* (Lindl.) Benth & Hook. f., Gen. Pl. 3(2) : 499. 1883.

Rhizome many branched, covered with papery tubular sheaths ca 1 cm. *Pseudobulbs* 2.5-4 x 1.1-1.3cm, narrowly ovoid, partly sheathed, 5-10cm apart on rhizome, 2-leaved, with scalelike basal sheaths. *Leaves* oblong or elliptic, 6.5-9 × 1.2-1.5cm, leathery, apex acute. *Inflorescence* 1- flowered, floral bracts lanceolate, subacute, 3-3.3 x 0.8-1.2cm, peduncle ca. 5 mm, enclosed in large membranous sheaths. *Flowers* 4-4.5cm across, yellowish brown; pedicel and ovary ca. 3 cm. *Dorsal sepal* ovate, fleshy, spreading, 9-veined, 2.3-3.0 x 0.8-1.1cm. *Petals* oblong-lanceolate, acuminate, ca. 2.0 x 0.5-0.6cm. *Lip* 1.4-1.9 x 1-1.5 cm (spread), 3-lobed, obovate-oblong, attached at base of column; lateral lobes subovate; lateral lobes broadly orbicular; mid-lobe sub-reniform, obscurely 2-lobed, apex emarginated, margins thin, undulate, with triangular thickening; disc with 3 lamellae, median much shorter. *Column* curved, toothed, 7-9mm long; tooth 6-7mm long.

Colour Plate 18

Flowering: March - May.

Habitat and Ecology: Epiphytic or lithophytic and found growing on the base of tree trunk, present on large logged wood, in open forests, as well as found lithophytic on rocks, 1200 – 2300.

Distribution: India (Arunachal, Assam, Manipur, Meghalaya, Nagaland, Sikkim), Nepal, Myanmar, China.

Specimens examined: Nitoi village, Aghunato & Asukhomi village (Zunheboto district) HYJ277 (NUH) Chare, Helipong, Melangkiur & Chendang saddle (Tuensang district) HYJ036 (NUH) Thanamir village (Kiphire district) HYJ096 (NUH).

EPIPOGIUM J.G. Gmelin ex Borkhausen

Tent. Disp. Pl. German. 139. 1792.

The genus was established by Borkhausen in 1972. The generic name is derived from the Greek words '*epi*' (upon) and '*pogon*' (beard) referring to the presence of hairs on the lip giving appearance of a beard.

6 species in India, 1sp. in Nagaland and 1 sp. reported by the author.

1. Epipogium roseum (D. Don) Lindl. in J. Proc. Linn. Soc. 1: 177. 1857; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 343. fig. 205. 1998. *Limodorum roseum* D. Don, Prodr. Fl. Nepal. 30. 1825. *Ceratopsis rosea* (D. Don) Lindl., Gen. Sp. Orchid Pl. 384. 1840. *Podanthera pallid* Wight, Icon. Pl. Ind. Orient. 5:t. 1795. 1852. *Epipogium sinicum* Tso in Sunyatsenia 1(2-3). 132. 1933.

Rhizome 3 - 5cm, 1.0-1.5cm in diameter, tuberous, narrowly fusiform to ovoid, noded. *Stem* glabrous, erect with 4-8 sheaths, white to tinged pale pink; sheaths 0.9-1.5cm, broadly ovate, membranous. *Inflorescence* pale pink, several flowered; Rachis 8-12cm long, suberect, sometimes pendent especially toward apex; floral bracts 0.8-1.2 × 0.4-0.5cm, ovate – elliptic. *Flowers* resupinate, pendulous, opening widely or not, white with faint purple spots on lip; pedicel 0.4-0.8cm; ovary 0.5-0.7cm long. *Sepals* 1.0-1.2 × 0.2-0.25cm, spreading, linear-lanceolate, 3-veined, margin undulate, apex subacute. *Petals* 0.9-1.0 × 0.25-0.3cm spreading, often slightly shorter and wider than sepals, slightly oblique, apex acute to acuminate, 3 –veined. *Lip* 1.0-1.2 × 0.7-1.0cm, elliptic-ovate when flattened, concave, spurred at base, entire, margins erose-denticulate; disc with 2 longitudinal densely papillose ridges, and occasionally with a shorter central ridge, or ridges sometimes reduced and inconspicuous; spur , 0.3-0.5 × 0.3- 0.4cm projecting backward, nearly parallel to

ovary, cylindric, shorter than ovary, apex obtuse. *Column* 0.3-0.5cm, stout. *Pollinia* ca 0.3 mm.

Colour Plate 18

Flowering: May - June.

Habitat and Ecology: Saprophytic and found as an undergrowth in a moist broad-leaved forests, shady place along streamside.

Distribution: India (Arunachal, Assam, Meghalaya, Nagaland, Sikkim, West Bengal), Nepal, Myanmar, China, Malaysia and Philippines

Specimen examined: Chiang mai village (Tuensang district) HY263 (NUH).

ERIA Lindl.

Bot. Reg. 11: t. 904. 1825

The genus was established by John Lindley in 1825. The generic name is derived from the Greek word '*erion*' (wool) in allusion to the wooly appearance of the inflorescence.

7 species are found in Nagaland and 3 reported by the author.

Key to species

1. Inflorescence 2-6 flowered ……..…….. *E. coronaria*
- Inflorescence densely many flowered ……....…… 2
2. Inflorescence subterminal, pendulous, racemose, arising from pseudobulb apex, Lip simple ……..... *E. vittata*
- Inflorescence decurved, axillary, broadly cylindric, densely many-flowered, Lip 3-lobed ……..……..…. *E. spicata*

1. Eria coronaria (Lindl.) Rchb. F. in Walpers, Ann. Bot. Syst. 6. 271.1864 ; King & Pantl. In. Ann. Roy. Bot. gard. Calcutta 8: 124, t. 172. 1898; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 361. fig. 215. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 174. fig. 56. 2000. *Coelogyne coronaria* Lindl. in Bot. Reg. 27. 83, no. 178. 1841. *Eria cylindropoda* Griff., Not. Pl. Asiat. 3:299, 404. 1851. *Trichosma coronaria* (Lindl.) Kuntze, Revis. Gen. Pl. 2. 681. 1891.

Plants glabrous, green, sometimes green brownish black. *Rhizome* creeping, 0.4-0.6cm in diam., often with funnel-shaped sheaths 0.5-0.7cm. *Pseudobulbs* cylindric, slender, with a single node, contiguous and 1-2.5 cm apart from each other,

6-15 × 0.3-0.5cm. *Leaves* 2, 7-13 × 2-4cm, subterminal, subsessile, narrowly elliptic or obovate-elliptic, rarely ovate-lanceolate, acute or obtuse, thickly membraneous. *Inflorescence* 2-6 flowered, 10-22 cm, arising between leaves, erect to arching; floral bracts lanceolate or linear, rarely ovate-lanceolate, 0.6-0.8cm. *Flowers* white, yellow with purple stripes on lip; pedicel and ovary ca 1.4cm. *Dorsal sepal* ca 1.7x 0.7 cm, elliptic-lanceolate, obtuse; lateral sepals ca 1.6-0.6 cm, falcate-lanceolate, obtuse; mentum conspicuous. *Petals* ca 1.8 x 0.5 cm, oblong-lanceolate, obtuse. *Lip* 1.4-1.5 x 1.0-1.2cm, oblong, 3-lobed; lateral lobes divaricate, suborbicular or suboblong; mid-lobe triangular or subsquare, ca 0.6 x 0.4 cm, acute or slightly subtruncate; disc with 3 entire or undulate lamellae running from base to mid-lobe and with 2-4 additional crenate or undulate lamellae on mid-lobe. *Column* stout 0.5-0.6cm, foot tapering, short. *Pollinia* ovate.

Colour Plate 18

Flowering: October - December

Habitat and Ecology: Epiphytic sometimes lithophytic and found growing epiphytic on tree trunks and lithophytic on rocks in forest, 1800-2300m.

Distribution: India (Arunachal, Manipur, Meghalaya, Nagaland, Sikkim), Bhutan, Myanmar. Nepal, Thailand, Vietnam.

Specimens examined: Asukhomi, Aghunato & Tsutoho village (Zunheboto district) HYJ264 (NUH), Chiangmai, Pangsha and Melangkiur Village (Tuensang district) HYJ316 (NUH), Yangzitong village (Kiphire district) HYJ299 (NUH).

2. Eria spicata (D.Don) Hand.- Mazz.. in Symb. Sin. 7. 1353. 1936; Seidenf. & Smitnd. Orch. Thailand, 2 (2): 306. t. 229. 1960; ; Hook. f., Fl. Brit. India 5: 791. 1890; Pradhan, Indian Orch. 365. 1979; Hegde, orchids of Arunachal Pradesh, 54. Fig. 62. 1984; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 318. Fig 229; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 181.fig . 60. 2000. *Octomeria spicata* D. Don, Prodr. Fl. Nepal. 31. 1825. *Eria convallarioides* Lindl., Gen. Sp. Orch. 70. 1830.

Plant 25-30 cm. *Pseudobulbs* 4-9 x 0.9-1.8cm, compressed, tufted, sheathed when young; sheaths 5-8 x 1.2-1.8cm, membraneous, overlapping, elliptic-lanceolate, acute. *Leaves* 3-5, 10 – 18 x 1.7-4.2cm, elliptic-lanceolate, oblong-lanceolate to oblonceolate, acute, plicate slightly, subcoriacious, many veined, petiolate; petiole 0.3-0.5cm. *Inflorescence* decurved, axillary, broadly cylindric, densely many-

flowered; peduncle 4-8 cm, glabrous; rachis 3-10cm; floral bracts 0.3-0.4 x 0.3-0.4cm, ovate-lanceolate, acute, concave, glabrous. *Flowers* 0.5-0.6cm across, subglobose, glabrous, cream white coloured, lip tinged with yellow, column tinged with red; pedicel and ovary 0.2-0.4 cm , puberulent. *Sepals* 0.3-0.5 x 0.2-0.4 cm, broadly ovate, obtuse, subsimiliar; lateral sepals concave. *Petals* 0.3-0.4 x 0.2-0.3cm, oblanceolate-oblong, spreading. *Lip* 0.3cm long, 3 –lobed, wedge shaped, concave, apex subacute; disc without lamellae. *Column* 0.3-0.5 cm; foot incurved. *Pollinia* linear-clavate.

Colour Plate 18

Flowering: March - April

Habitat and Ecology: Epiphytic and found growing on tree trunk in closed forest, 1200-1800m.

Distribution: India (Arunachal, Assam, Meghalaya, Manipur, Nagaland, Sikkim), Bhutan, China (Yunnan), Nepal, Myanmar, Thailand.

Specimens examined: Chare village (Tuensang distrcit) HYJ045 (NUH), Mishilimi village (Zunheboto disrict) HYJ041 (NUH), Hokiye village (Kiphire district) HYJ063 (NUH).

3. Eria vittata Lind. in. jour. Linn. Soc. 3. 51. 1859; Hook, f. Fl. Brit. India. 5. 794. 1890; King & Pantl. in. Ann. Roy. Bot. Gard. Calcutta. 8. 120. T. 165. 1898; Pradhan, Indian Orch. 2. 365. 1979; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 183. 2000. *Pinalia vittata* (Lindl.) Kze., Rev. Gen. 2: 679. 1891.

Plant 12-27cm. *Rhizome* slender, glabrous, with a funnel-shaped sheath on each node. *Pseudobulbs* distant and 2-3 cm apart from each other, 3-6 x 0.6-1.1 cm, ovoid conical to slightly curved-cylindric, apex 2-leaved. *Leaves* 15-18 x 2- 4 cm, elliptic or elliptic-lanceolate, with 8 or 9 main veins, acute to acuminate, membraneous, tapering to petiolate base; petiole 0.7-2 cm long. *Inflorescence* 13-17cm, 23-30 flowered, subterminal, pendulous, racemose, arising from pseudobulb apex; peduncle glabrous, sheathing at base; sheaths lanceolate, acute, 1-2 cm long; rachis 6-8cm long; floral bracts 0.2-0.4mm , persistent, minute, triangular, lanceolate to subulate. *Flowers* 1-1.3cm across, grayish green, with purplish brown stripes on sepals and petals, fragrant, glabrous; sepals and petals strongly striped purple red; lip-lamellae red pink; pedicel and ovary 0.9-1.1cm. *Dorsal sepal* 0.8-1.2 x 0.3-0.4cm, obtuse, sub-acute, 5 veined; lateral sepals 0.8-1.1x 0.5-0.7cm, obliquely triangular-

oblong, falcate, acute; mentum ca. 0.7mm. *Petals* 0.8-1.2 x 0.3-0.4cm, 3-veined, narrowly oblong, obtuse, decurved, margins crenulate towards apex. *Lip* 0.9-1.1cm, oblong in outline, base attenuate, margin entire, apex subtruncate and slightly mucronulate, with 5 undulate lamellae running nearly from base to apex. *Column* ca 0.7cm, curved; foot 0.6-0.7cm, purple; rostellum elongate, cylindric; *Pollinia* ovoid.

Colour Plate 18

Flowering: January - March

Habitat and Ecology: Epiphytic or lithophytic and found growing on tree trunk in semi-dense forest and also lithophyticon sloping rock, 1700m

Distribution: India (Arunachal, Manipur, Meghalaya, Nagaland, Sikkim), Myanmar, Thailand.

Specimens examined: Mtsugho & Khughuto village (Zunheboto district) HYJ265 (NUH).

ERIODES Rolfe

Orchid review. 23: 326. 1915

The genus was established by Robert Allen Rolfe in 1915 in the 'Orchid Review'. Griffith collected a plant from Khasia hills that he called *Erioidea sp.* later described as *Tainia barbata* in 1857 by Lindley. In 1915 Schlechter transferred this species to a new genus *Tainiopsis* having overlooked the earlier use of this name by Hayata in 1914. The genus is monotypic. The genus derived its name from the resemblance to the related orchid genus *Eria*. 1 species in India, 1 in Nagaland and reported by the author.

1. Eriodes barbata (Lindl.) Rolfe in Orchid Rev. 23:326. 1915. *Erioidea* sp. Griff., Itin. Pl. Khasyah Mts.: 83. 1848. *Eriae* Sp. Griff., Not. Pl. Asiat. 3:304. 1851. *Tainia barbata* Lindl. in Gard. Chron. 1857: 68. 1857. *Eria barbata* (Lindl.) Rchb. f. in Walpers, Ann. Bot. Syst. 6: 270. 1861. *Pinalia barbata* (Lindl.) Kuntze, Revis. Gen. Pl. 2:679. 1891. *Tainiopsis barbata* (Lindl.) Schltr. in Orchis 9: 9. 1915. *Coelogyne nigrofurfuracea* Guillaumin in Bull. Mus. Natl. Hist. Nat. ser.2, 27(2): 143. 1955. *Neotainiopsis barbata* (Lindl.) Raizada & Bennet in Indian forester 107: 433. 1981.

Plant 40–80cm tall. *Pseudobulb* 2- 6 x 1.8-3.6cm, fibrous-sheathed at base. *Leaves* usually 1-3, 15- 32 x 2.6-5.5cm, elliptic-lanceolate, acute to acuminate, 3-5 main veins, petiolate; petiole 4-7cm long. *Inflorescence* 4 to 9 flowered, ca 40 cm

long; peduncle 25-35cm long, narrow from broad base, sheathed, pubescent; sheaths 2.5-3 x 0.5-0.8cm , lanceolate, acute, pubescent; rachis 22-34cm, weakly zigzag, slender, pubescent; floral bracts 0.7-1.3 x ca 0.4 cm, lanceolate, acute, pubescent. *Flowers* ca 2.5 cm across, dirty yellow with burgundy to red stripes; pedicel and ovary 3-4.5cm long, pubescent with flat, brown hair like ramentae. *Sepals* 1-1.4 x 0.2-0.5cm, elliptic-lanceolate, subsimiliar, acute, 5 veined, reflexed and spreading, pubescent externally; lateral sepals 1-1.4 x 0.2-0.6cm, falcate, connate at base to from a mentum; mentum ca 3 mm long. *Petals* 1.2-1.5 x ca 0.2cm, linear oblong, obtuse, 3-veined, glabrous. *Lip* 0.4-0.7 x 0.2-0.3 cm, simple, attached to column foot, recurved strongly, broadly ovate, veined clearly, apex sagittate with 2 small side projections. *Column* 3-5 mm long, curved, sharply angled, broadly winge; column foot long. *Fruit* 1.6-2.2 x 0.8-0.8cm, ellipsoid.

Colour Plate 18

Flowering: September - November

Habitat and Ecology: Epiphytic or lithophytic and found growing on tree trunk with diffused or full head sunlight, 1300m.

Distribution: India (Arunachal, Assam, Meghalaya, Nagaland) Bhutan, Myanmar, China, Thailand, Vietnam.

Specimens examined: Mishilimi village - Pughoboto (Zunheboto district) HYJ112 (NUH).

ERYTHRODES Blume

Bijdr. 410. 1825

The genus was established by Carl Blume in 1825 and comprises about 100 species. The genus is reported as a first generic report for the state of Nagaland by the author.

1. Erythrodes blumei (Lindl.) Schltr. in K. Schum. & Lauterb., Nachtr. Fl. Deut. Schutzgeb. Sudsee: 87. 1905; Seidenf., Dansk Bot. Arkiv 32(2): 10, fig. la, 2. 1978; Ormerod in Lindleyana 17: 194, fig. 3A-B. 2002; Chen *et al.* in Z.Y. Wu *et al.* (eds.), Fl. China 25: 56. 2009. *Physurus blumei* Lindl., Gen. Sp. Orchid. Pl. 504. 1840; Hook.f., FI. Brit. India 6: 94. 1890. *Erythrodes chinensis*(Rolfe) Schltr. in Orchideen: 117. 1915.

Plants terrestrial. *Stem*-like rhizome creeping and rooting from its nodes. Flowering shoots erect from a decumbent base, 15-25cm tall. *Leaves* 3-5, 12–13 x 4.0-4.3cm, scattered on the lower part of the stem, obliquely ovate to elliptic-lanceolate, acute; petiole 1.5-3.4cm long. *Inflorescence* glandular-pubescent, cylindric; rachis 2–10cm long, densely 10 to many-flowered; bracts 5–8 mm long, boat-shaped, acute to acuminate, shorter than or subequal to the ovary. *Flowers* greenish brown with brownish-orange lip and purple streaks on the petals. *Sepals* densely glandular-pubescent on the dorsal side; dorsal sepal 4.0-4.3 x 1.2-1.4mm, boat-shaped, lanceolate oblong, obtuse, 1-veined; lateral sepals 4.8-5.0 x 2.0-2.1mm, spreading, obtuse, 1–3-veined. *Petals* 4.0-4.2 x 1.0-1.2mm, obliquely linear lanceolate. *Lip* 3.1-3.4 mm long (excluding spur); spur 1.5–2.0 mm long, protruding ca. 1.5mm below the lateral sepals, apex emarginate; epichile elliptic, rounded to subacute. *Column* 3.0-3.2mm long, subclavate. *Ovary* 7-10mm long. *Capsule* 8–10mm long, subsessile, glandular-pubescent.

Colour Plate 19

Flowering: March - April

Habitat and Ecology: Terrestrial on humus rich soil in a sub-tropical forest. 970-1500m

Distribution India (Andaman & Nicobar Islands, Arunachal Pradesh, Manipur, Meghalaya, Nagaland), Bangladesh, Bhutan, China, Indonesia, Malaysia, Sri Lanka, Taiwan, Thailand, Vietnam.

Specimens examined: Alaphumi village and Asukhomi village (Zunheboto district), HYJ172 (NUH); HYJ057 (NUH).

ESMERALDA Rchb. f.

Xen. Orchid. 2:38. 1862.

The genus was established by H.G. Reichenbach in 1874 in his '*Xenia Orchidaceae*'. the genus comprises of 2 species. 2 species found in India and Nagaland, 1species reported by the author.

1. Esmeralda clarkei Rchb. f. in Gard. Chron. n.s. 26: 552. 1886. Type: Indian Himalayas, Clarke s.n., cult. Low (Holo. W! Herb. No. 3921, 3922); H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 387. Fig. 233. 1998; Hook.f., Fl. Brit. India 6:28. 1890. *Vanda clarkei* (Rchb. f.) N.E. Brown in Bull. Misc. Inform. Kew 1888: 112. 1888.

Arachnanthe clarkei (Rchb. f.) Rolfe in Gard. Chron. ser.3, 4: 567. 1888. *Arachnis clarkei* (Rchb. f.) J.J. Smith in Natuurk. Tijdschr. Ned.- Indie. 72: 73. 1912.

Plants 30 cm to 1 m tall. *Stem* covered with 3-4cm long tubular leaf sheaths. *Leaves* many, distichous, oblong, 13-24 x 1.6-3.6cm, unequally bilobed at apex, coriaceous. *Inflorescence* erect, lateral, up to 33cm long; rachis 12.14cm long, laxly 3-4 flowered. *Flowers* 5.5-7.6cm in diameter, slightly fragrant, opening widely; sepals and petals yellow with red or brown transversal stripes on inner surface and white externally. *Dorsal sepal* 3.3-3.9 x 0.9-1cm erect, oblong, obtuse; lateral sepal oblong, falcate, 3-3.2 x 0.9-1.2 cm. *Petals* falcate, oblong, obtuse, 2.9-3.5 x 0.7-0.8cm. Lip free, pendent, 3-lobed, to 1.7 cm long with reniform midlobe and small erect side lobes, unspurred; disk with several longitudinal keels and 2 raised calli in the centre of the lip. *Column* stout, clavate, 0.9-1.4cm long. Fruit not seen.

Colour Plate 19

Flowering: December - February

Habitat and Ecology: Epiphytic or lithophytic and found growing on tree trunk with diffused sunlight, 1900m

Distribution: India (Meghalaya, Nagaland, Sikkim, West Bengal) Nepal, NE India, Myanmar and China.

Specimens examined: Pangsha village (Tuensang district) HYJ043 (NUH).

EULOPHIA R. Br. ex. Lindl.

Bot. Reg. 8: t. 686. 1823.

The genus was established by John Lindley in 1823. The generic name is derived from the Greek words ‘eu’ (well, true) and ‘lophos’ (Plume), in reference to the crest on the lip. 32 species is found in India, 5 in Nagaland and 1 reported by the author.

1. Eulophia zollingeri (Rchb.f.) J. J. Smith, Orch. Java. 228. 1905; Pradhan, Indian Orchids, 2: 450. 1979; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 398. 1998; Hegde in Jour. Bombay Nat. Hist. Soc. 81(1): 120. 1985. *Cyrtopera zollingeri* Reichb. f. in Bonplandia 5: 38. 1857.

Plant mycotrophic and leafless, 40-80 cm tall. *Pseudobulb* 5-14 × 1.5-3cm subterranean, tuberous, suboblong, pale yellow, many noded, with many stout roots. *Inflorescence* racemose, stout, laxly 8-25 flowered; peduncle 40-50 x 0.6-0.8 cm,

erect, broad, sheathed; sheaths 2-4 , 3-5cm long, lanceolate-ovate, acuminate, clasping; rachis 5-14cm, laxly 8-20 flowered; floral bracts 1.0-2.5cm, narrowly lanceolate to almost subulate, , subequal in length to or exceeding ovary, apex acuminate. *Flowers* 2.5-3.0 cm in diam.; suberect, spreading, or nodding, dull purple-red to brownish yellow, medium-sized, pedicel and ovary 1.6-2.0 cm. *Dorsal sepal* elliptic-oblong, 1.5-2.5 × 0.4-0.7cm, apex acuminate; lateral sepals 1.4-2.3 × 0.6-1.0cm, suboblong, slightly oblique, adnate at base to column foot, apex acuminate. *Petals* 1.0-1.6 × 0. 5-0.7 cm, oblanceolate, apex mucronate. *Lip* 1.2-1.4 × 1.4-1.6cm, adnate to column foot, subobovate or oblong-obovate, shortly saccate-spurred at base, 3-lobed; lateral lobes erect and loosely embracing column, subovate or oblong, 0.3-0.4 × ca 0.5 cm, apex rounded; mid-lobe ovate, 0.5-0.7 × 0.3-0.5cm, with 5-7 thickened, papillose veins, margin undulate, apex apiculate; disk sparsely papillose, with 2 central, suborbicular lamellae; spur broad, conic, ca. 2 mm. *Column* ca 0.5 cm; foot ca 0.4 cm. *Pollinia* 2, oblong.

Colour Plate 19

Flowering: May - June

Habitat and Ecology: Saprophytic and found growing in between organic litter in a semi - shaded area, 1800m.

Distribution: India (Arunachal, Assam, Meghalaya, Nagaland, Sikkim), Australia, Indonesia, Malaysia, Philippines, Sri Lanka, Thailand, Vietnam.

Specimens examined: Asukhomi village (Zunheboto district) HYJ282 (NUH).

GALEOLA Lour.

Fl. Cochinch. 2: 520. 1790.

The genus was established by Juan Loureiro in 1790. The generic name is derived from the Latin words *'galea'* (a helmet) and 'galeola' (a helmet shaped vessel) referring to the shape of the lip. 6 species in India, 1 in Nagaland and 1 reported by the author.

1. Galeola lindleyana (Hook. f. & Thomson) Rchb.f., Xenia Orchid. 2: 78. 1862; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 406. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 187. 2000. *Erythrorchis lindleyana* (Hook. f. & Thomson) Rchb. f. in Bonplandia 5. 37. 1857.

Plant erect, upto 2 m tall; *Rhizome* stout, 2 - 3 cm in diam., reddish with sparse ovate scales at nodes. *Stem* 1 - 2 m tall erect, reddish brown, scurfy; bearing numerous short, acute sheaths in the basal half. Inflorescence paniculate, laxly few-flowered; branches pendent; floral bracts ca 3 mm long, sessile, ovate, withering as the flower develops. *Flowers* upto 4 cm across , thick, spongy, subglobose; sepals and petals bright yellow with a reddish patch on the lip at each side of the column; pedicel and ovary cylindric, pubescent, 1 – 2 cm long. Sepals subequal with denticulate external ribs; dorsal sepal 1 – 3 x 1.2 – 1.4 cm, subacute, elliptic-oblong; lateral sepals ca 3.2 x 2.0 cm, elliptic, acute. Petals 1.2 – 3.5 x 2.3 – 2.5 cm, obtuse, broadly ovate, margins ciliate, exceeding the sepals. *Lip* 1.0 – 2.0 cm, simple, cup-shaped, obscurely 3 –lobed; upper surface pappilose; disc lamellate, margins ciliate. *Column* 0.6 – 0.8 cm long, clavate, with 2 erect granular processes near the base. *Pollinia* cleft at base.

Colour Plate 19

Flowering: May - June

Habitat and Ecology: Terrestrial and lithophytic and found growing in a moss covered forest nearby rocks. 1600m.

Distribution: India (Arunachal, Assam, Meghalaya, Nagaland, Sikkim, West Bengal), China, South – East Asia and Sumatra.

Specimens examined: Chiang mai village (Tuensang district) HYJ315 (NUH).

GASTROCHILUS D. Don

Prodr. Fl. Nepal. 32. 1825

The genus was established in 1825 by David Don. The generic name is derived from the Greek words '*gaster*' (belly) and '*cheilos*' (lip) referring to the shape of the lip.

12 species are found in India, 4 in Nagaland and 4 reported by the author.

Key to species

1. Leaves terete ……..... *G. inconspicuus*
- Leaves flattened …… 2
2. Leaves more than 6 cm long ……..…….. *G. calceolaris*
- Leaves less than 3 cm long …….. 3
3. Epichile of lip semi circular with deflexed edges, base with 2 conic calli…..... ……...*G. distichus*
- Epichile of lip broadly cordate; hypochile cuplike. ……. *G. pseudodistichus*

1. Gastrochilus calceolaris (Buch.-Ham. ex Sm.) D. Don, *Prodr.* Fl. Nepal. 32. 1825; Hook. f., Fl. Brit. India 6: 60. 1890; King & Pantl. in. Ann. Roy. Bot. Gard. Calc. 8 : 225. t. 300. 1898; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 413. fig. 247. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 188. 2000. *Aerides calceolaris* Buch.- Ham. Ex J.E. Smith in Rees, Cycl. (Addenda): 39. Aerides, no.11. 1819. *Saccolabium calceolare* (J. E. Sm.) Lindl. Gen. & Sp. Orch. 223. 1833. *Aerides calceolare* Buch.-ham.ex J.E. Sm. in Rees Cycl. 39. 11. 1818.

Plant pendant. *Stems* often arching, 15-20cm, 5.5-8 mm in diam., with many leaves. *Roots* 2-3mm thick, ridged. *Leaves* 6-18 x1.5-2cm, distichous, stongly falcate, linear-lanceolate to oblong-lanceolate, apex acutely, unequally 2-lobed. *Inflorescence* 2-3 cm, 8-10 flowered, pendent, from upper part of stem, opposite to leaves, corymbose to subracemose; peduncle 2-2.5cm, glabrous, sheathed; sheaths 2-3mm long, distant, ovate; floral bracts 2.5-3mm, ovate, acute. *Flowers* 1.0-1.5cm, fragrant, widely opening; sepals and petals yellow, with red brown markings; lip with white epichile and yellow hypochile, both with purple-red marks; pedicel and ovary 1-1.3cm long, slightly compressed. *Sepals* 0.5-0.7 x 0.2-0.3cm, similar, obovate-oblong, base contracted, apex obtuse-rounded. *Petals* sub-similar to sepals, slightly smaller, apex obtuse-rounded. *Lip* 0.5-0.6 x 0.5-0.7cm, with an epichile and a saccate hypochile; epichile spreading forward, suborbicular-triangular or lunate-triangular, adaxially with long white hairs except on yellow and purple-spotted central cushion and with a cavity at base of cushion, margin irregularly fimbriate or erose; hypochile yellowish green with purplish red margin, helmetlike.

Colour Plate 19

Flowering: April - June

Habitat and Ecology: Epiphytic and found growing in the main tree trunk with diffused sunlight. 1500-1900m.

Distribution: India (Arunachal, Assam, Meghalaya, Nagaland, Sikkim, West Bengal), China, South – East Asia and Sumatra.

Specimens examined: Pangsha village (Tuensang district) HYJ022 (NUH), Asukhomi village (Zunheboto district) HYJ114 (NUH).

2. Gastrochilus distichus (Lindl.) Kuntze, Revis. Gen. Pl. 2: 661. 1891; Hook. f., Fl. Brit. India 6: 64. 1890; King & Pantl. in. Ann. Roy. Bot. Gard. Calc. 8 : 227. t. 303. 1898; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 413. 1998; Hynniewta, Kataki &

Wadhwa, Orch. Nagaland (BSI), 188-189. fig. 62. 2000. *Saccolabium distichum* Lindl. in J. Proc. Linn. Soc., Bot. 3: 36. 1858.

Plant pendent. *Stems* pendulous, usually. *Roots* filiform, long. *Stems* 15-24cm long, slender, clustered, pendent, branched, covered by leaf sheaths *Leaves* 2-2.8 x 0.4-0.5cm, sessile, distichous, narrowly lanceolate or falcate-lanceolate, fleshy, acuminate with 2 or 3 needle like points at apex. *Inflorescence* 2-4 flowered, racemose, leaf-opposed; peduncle 1-3 cm, glabrous, slender, sheathed, upper part enlarged, lower part with 2 cupular sheaths; floral bracts 1-2 x 0.4-0.5mm, ovate-lanceolate; pedicel and ovary ca. 8 mm. *Flowers* pale green, with reddish brown spots. *Sepals* similar, 4.5-5 x 2.5-3 mm, usually concave, oblong-elliptic, apex obtuse. *Petals* subobovate, slightly smaller than sepals, apex obtuse. *Lip* 3-6x x4-4.5mm, with an epichile and a saccate hypochile; epichile nearly suborbicular, ca. 3 x 5 mm, adaxially glabrous, with a central cushion, near base with 2 conic calli, entire, obtuse at apex; hypochile subcupular, ca. 4 mm tall, 2-3 mm in diam., apex rounded. *Column* ca. 2.5 mm; anther cap narrowed into a beak toward apex.

Colour Plate 19

Flowering: May - August

Habitat and Ecology: Epiphytic and found growing in the branch of tree with diffused sunlight. 2400m.

Distribution: India (Arunachal, Nagaland, Manipur, Meghalaya, Sikkim, West Bengal), China, South – East Asia and Sumatra.

Specimens examined: Satoi village (Zunheboto district) HYJ089 (NUH).

3. Gastrochilus inconspicuus (Wall. ex Hook. f.) Kuntze, Rev. Gen. Pl. 2:661. 1891; Seidenf. in Dansk Bot. Ark. 27(4): 94. 1971; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 416. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 189. 2000. *Saccolabium inconspicum* Hook. f., Fl. Brit. India 6: 56. 1890. *Luisia inconspicua* (Wall. ex Hook.f.) King & Pantl. in Ann. Roy. Bot. Gard. Calc. 8 : 203. T. 272. 1898.

Plant 15-28 cm. *Roots* basal. *Stem* terete, flexuous, unbranched or occassionaly branched, covered by leaf sheaths; sheaths overlapping, striate-rugose. *Leaves* terete, weakly curved, sessile, rugose-striate. *Inflorescence* lateral, racemose, 1-4 flowered; peduncle short, sheathed; rachis 1-2 mm long; floral bracts acuminate, membraneous. *Flowers* 4 mm across; sepals and petals greenish-white with lateral

lobes suffused with purple. *Dorsal sepal* 1.4-2.8 x 1-1.2 mm, ovate to ovate-lanceolate, sub-oblique, acute, spreading; *lateral sepals* similar. *Petals* 2-3 x 1-1.2 mm, oblong to ovate-elliptic, acute, spreading. *Lip* 2-3 x 1.5- 2 mm, 3-lobed; hypochile saccate, lateral lobes rounded; mid-lobe flat, decurved, weakly cordate to reniform, surface minutely hispid with 6-7 striate, apex 2-lobed, lobules rounded; sac 1-1.6 mm across. *Column* erect, lacking a foot, ca 0.5 mm long; anther cap shortly beaked; viscidium sub-quadrate. *Pollinia* ca 0.3 mm across. *Fruit* clustered, ovoid.

. **Colour Plate 20**

Flowering: June - July

Habitat and Ecology: Epiphytic and found growing in the branch of tree with full head sunlight. 1850m.

Distribution: India (Arunachal, Meghalaya, Nagaland, Sikkim), Bhutan, Nepal.

Specimens examined: Tsaphimi village (Zunheboto district) HYJ303 (NUH).

4. Gastrochilus pseudodistichus (King & Pantl.) Schltr. in Feddes Repert. Spec. Nov. Regni Veg. 12: 315. 1913; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 191. fig. 63. 2000. *Saccolabium pseudodistichum* King & Pantl. in J. Asiat. Soc. Bengal, Pt. 2, Nat. Hist. 64(3): 341. 1895. *Gastrochilus hoyopse* (Rolfe ex Downie) Seidenfaden & Smitinand, Orch. Thail. 4(1):623, t. 468. 1963.

Plant pendent. *Stems* pendulous or creeping, 15-37 cm, ca 0.2 cm in diam., slender, sometimes branched, internodes 0.4-0.6 cm. *Leaves* distichous, many, fleshy, green with purplish red spot, 1.5-2.0 x 0.4-0.6 cm, ovate-lanceolate or oblong, apex acute and with 2 or 3 awns. *Inflorescence* subumbellate, 4-5-flowered; peduncle green, with purplish red spots, ca 1.5cm, upper part enlarged, usually 2 sheaths at base; floral bracts ca 2 mm, ovate-lanceolate; pedicel and ovary ca. 1 cm. *Flowers* yellow, with purplish red marks or spots. *Dorsal Sepal* ca. 0.3-0.35 x ca 0.18 cm, oblanceolate-oblong, , apex obtuse; lateral sepals similiar. *Petals* 0.3-0.35 x ca 0.15 cm subobovate, slightly smaller than sepals, apex obtuse. *Lip* with an epichile and a saccate hypochile; epichile nearly suborbicular, concave, narrower than hypochile, ca 3 mm wide, fleshy, adaxially glabrous, entire, obtuse at apex; hypochile cuplike ca 3.5 mm tall, ca 4 mm in diam. *Column* ca 2 mm; anther cap narrowed, beaked at apex.

Colour Plate 20

Flowering: August - October

Habitat and Ecology: Epiphytic and found growing on the base of a large creeper. 1500- 1700m

Distribution: India (Nagaland, Sikkim, West Bengal), China, Bhutan, Thailand, Vietnam

Specimens examined: Anangba and chare village (Tuensang district) HYJ071 (NUH), Tsutoho (Zunheboto district) HYJ117 (NUH)

GOODYERA R. Br.

W.& W.T. Aiton, Hort. Kew. Ed. 2.5:197.1813

The genus was established by Robert Brown in 1813 and the genus is named in honour of John Goodyer (1596-1664), an early English Botanist. 17 Spp. in India, 8 spp. in Nagaland and 2 spp. documented by the author

Key to species

1. Lateral sepals spreading ……...… *G. viridiflora*
- Lateral sepals not spreading ……..……..……. *G. schlechtendaliana*

1. Goodyera schlechtendaliana Rchb.f. Linnaea. 22: 861. 1849; Seidenf. in Dansk Bot. Ark. 32(2): 26.t. 11. 1978; Hook. f., Fl. Brit. India 6: 113. 1890; King & Pantl. in Ann. Roy. Bot. Gard. Calc. 8: 283.t. 376. 1898; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 434. fig. 260. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 194. fig. 64. 2000. *Georchis schlechtendaliana* (Rchb.f.) Rchb. f. in Bonplandia 5:36. 1854. *Goodyera secundiflora sensu* Lindl. in J. Proc. Linn. Soc., Bot. 1: 182. 1857, *non* Griff. *Epipactis schlechtendaliana* (Rchb.f.) Eaton in Proc. Biol. Soc. Wash. 21:68. 1908. *Epipactis labiata* (Pampanini) Hu in Rhodora 27: 106. 1925.

Plant 7-30 tall. *Rhizome* creeping, slender to stout, several noded. *Stem* erect 2-6 cm. *Leaves* 4-6, 2-5 x 0.7-2.3 cm, subrosulate and spaced along stem, adaxially green with irregular white markings, abaxially pale green ovate to ovate-lanceolate, base subrounded or broadly cuneate, apex acute; petiole-like base sheathed ca 1.2cm. *Inflorescence* 8-11cm, pubescent, pale green, peduncle with 2-4 sterile bracts; rachis 7-10 cm; floral bracts 0.7-1.2 cm, lanceolate, pubescent, apex acuminate. *Flowers* 8-17-flowered, semi-opening, white, sometimes tinged with light pink; pedicel and ovary cylindric-fusiform, 0.7-1.0 cm, pubescent. *Dorsal sepal* 0.6-0.8 x 0.3-0.4 cm, pubescent on outer surface, 1-veined, narrowly elliptic-lanceolate, cymbiform, apex acute; lateral sepals 0.6-0.8 x ca 0.3 cm, ovate-lanceolate, apex acute. *Petals* 0.6-0.8 x

0.2-0.3 cm, rhombic-oblanceolate, 1-veined, apex obtuse or subacute. *Lip* 0.6-0.8 x ca 0.5 cm, ovate; hypochile concave-saccate, inside papillose; epichile ligulate, ca 3 mm, recurved. *Column* ca 3 mm; anther ovoid, acuminate.*Pollinia* ca 1.5mm; rostellum ca 2 mm.

Colour Plate 20

Flowering: August - September

Habitat and Ecology: Terrestrial and found growing in humus rich moss covered soil, 2300-2700m.

Distribution: India (Arunachal Pradesh, Manipur, Meghalaya, Nagaland, Sikkim), China, Bhutan, Japan, Thailand, Vietnam.

Specimens examined: Tsutoho (Zunheboto district) HYJ283 (NUH), Saramati range (Kiphire district) HYJ333 (NUH).

2. Goodyera viridiflora (Blume.) Lindl.ex Dietrich, Syn. Pl. 5: 165. 1852; Seidenf. in Dansk Bot. Ark. 32(2): 20.t. 6. 1978; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 434-438. fig. 261.1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 196. 2000. *Neottia viridiflora* Bl., Bijdr. 415. 1825. *Georchis cordata* Lindl., Gen. Sp. Orchid. Pl.: 496: 1840.

Plants 8-30 cm. *Rhizome* slender, creeping, several noded. *Stem* ascending 5-8 cm. *Leaves* 2-5, 2-6.5 x 1-3 cm, widely spaced or clustered toward apex of stem, thinly textured, surfaces silvery green, ovate or ovate-lanceolate, rounded at base, apex acute; petiole-like base sheathed ca 3 cm. *Inflorescence* 8-11 cm, with pale red-brown peduncle, pubescent, with 2 sterile bracts; rachis 2-5 cm, laxly flowered, secund; floral bracts pale reddish brown, ovate-lanceolate, margin ciliate, apex acute. *Flowers* 5-7, opening widely, pale green to pale reddish brown; pedicel and ovary cylindric-fusiform, 0.5-0.7 cm, pubescent. *Dorsal Sepal* 0.6-0.7 x ca 0.4 cm, glabrous, 1-veined, elliptic, concave, apex acute; lateral sepals 0.6-0.8 x ca 0.4 cm, widely spreading or reflexed, elliptic, apex acute. *Petals* 0.7-0.8 x ca 0.4 cm, rhombic, oblique, 1-veined, base attenuate, apex acute. *Lip* 0.7-0.9 x 0.6-0.7 cm, creamy white at apex, ovate, cymbiform, membranous; hypochile concave-saccate, inside densely papillose; epichile recurved or spreading forward, ligulate ca 3 mm, apex acute. *Column* ca 3 mm; anther lanceolate. *Pollinia* ca 1 mm, viscidium linear.

Colour Plate 20

Flowering: September

Habitat and Ecology: Terrestrial and found growing in humus rich soil. 1500m.

Distribution: India (Arunachal, Assam, Manipur, Meghalaya, Nagaland, Sikkim, Western Himalayas) Bhutan, China, Indonesia, S Japan, Malaysia, Nepal, New Guinea, Philippines, Thailand, Vietnam.

Specimens examined: Asukhomi village (Zunheboto district) HYJ268 (NUH).

HABENARIA Willd.

Sp. Pl. 4:5. 44. 1805

The genus was established by C.L. Willdenow in 1805. The generic name is derived from the latin word '*habena'* (rein) referring to the long, strap like dividions of the petals and lip. 66 species in India, 10 spp. in Nagaland and 2 spp. reported by the author.

Key to species

1. Flowers clear white; side lobes of lip entire ……..…..… *H. dentata*
- Flowers greenish to white; side lobes of lip lacinate ……...… *H. arietina*

1. Habenaria arietina Hook. f., Fl. Brit. India. 6: 138. 1890; King & Pantl. in Ann. Roy. Bot. Gard. Calc. 8: 311. T. 407. 1898; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 441. Fig. 265. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 197. 2000. *Habenaria pectinata sensu* Lindl., Gen. Sp. Orchid. Pl.: 321. 1835, *non* (J.E.Smith) D.Don. *Habenaria pectinata* var. *arietina* (Hook. f.) Kranzlin, Orchid. Gen. Sp. 1: 405. 1898. *Habenaria intermedia* var. *arietina* (Hook. f.) Finet in Rev, Gen. Bot. 13:530. 1901. *Habenaria pectinata* var. *khasiana* Pradhan, *loc. cit*. 1976.

Plants 57-65 cm tall. *Tubers* 3-5 x ca 2 cm, oblong, fleshy. *Stem* erect, terete, robust. *Leaves* 5-7, laxly arranged on the stem, 6-10 x 2-3 cm, ovate-lanceolate or oblong-lanceolate, base amplexicaul, apex acuminate. *Inflorescence* upto 32 cm, raceme densely about 8-15 flowered; floral bracts ca 2 cm, ovate-lanceolate, usually as long as ovary, apex acuminate; ovary twisted, terete, 2.8-3.3 cm including pedicel. *Flowers* greenish to white. *Sepals* 5-veined, ciliate; dorsal sepal 1.8-1.9 x ca 0.6 cm, erect, oblong, concave, apex acute; lateral sepals subequal, reflexed, obliquely falcate-lanceolate, apex acute. *Petals* 1.7 – 1.9 x ca 0.8 m, forming a hood with dorsal sepal, obliquely subovate-falcate, 5-veined, adaxially pubescent, margin ciliate, unlobed. *Lip* ca 3 cm, base spurred, deeply 3-lobed above base; lobes linear, nearly equal in length, ciliate to lacinate; lateral lobes ca 2 cm, outer margin with 10 filiform

lobules; mid-lobe ca 0.2 cm wide; spur 3.2-3.8 cm, pendulous, cylindric-clavate, slightly longer than ovary, dilated below middle, apex obtuse; connective ca 0.4 cm wide; pollinia ovoid; caudicles linear; viscidia orbicular; rostellum with elongate arms.

Colour Plate 20

Flowering: August - September

Habitat and Ecology: Terrestrial, growing on the side of road 1400m

Distribution India (Arunachal, Assam, Manipur, Meghalaya, Nagaland, Sikkim, West bengal) Bhutan, China, Nepal.

Specimens examined: Waoshu village (Tuensang district) HYJ284 (NUH)

2. Habenaria dentata (Sw.) Schltr., in Feddes Repert. Spec. Nov. Regni Veg. Beih. 4: 125. 1919; Hook. f., Fl. Brit. India. 6: 138. 1890; King & Pantl. in Ann. Roy. Bot. Gard. Calc. 8: 310. t. 405. 1898; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 444. fig. 267. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 199. 2000. *Orchis dentata* Sw. in Kongl. Vetensk. Acad. Nya Handl. Stockh. 21:207. 1800. *Platanthera geniculata* Lindl. in Wall. Cat.: 7042. 1832, *nom. nud*. *Habenaria geniculata* D. Don, Prodr. Fl. Nepal: 25. 1825. *Habenaria geniculata* var. *ecalcarata* King & Pantl. in Ann. Roy. Bot. Gard. Calc. 8: 310. t. 405. 1898.

Plants 40-90 cm tall. *Tubers* 2-5 x 1.5-3 cm, oblong-ovoid to oblong, fleshy. *Stem* erect, terete, stout. *Leaves* 3-5, 6-14 x 2-4 cm along with bract-like leaflets, oblong to narrowly elliptic, base amplexicaul, margin white when dried, apex acute or acuminate. *Inflorescence* long, raceme 6-12 cm, many flowered upto 15; floral bracts 2-3 cm, lanceolate, almost as long as ovary, apex acuminate; ovary twisted, terete, 2-3 cm including pedicel. *Flowers* clear white. Sepals and petals ciliate; dorsal sepal 1-1.3 x ca 0.8 cm, 5-veined,forming a hood with petals, erect, broadly ovate, concave, apex acute; lateral sepals 1.2-1.4 x ca 1.4-1.5 cm, 5-veined,spreading or reflexed, obliquely ovate apex acute. *Petals* 0.7-0.9 x ca 0.25 cm, falcate-lanceolate, 2-veined, unlobed. *Lip* 1.4-1.8 x 1.2-1.5 cm, broadly obovate, 3-lobed; lateral lobes subrhombic or flabellate, entire, ca 0.8 cm wide, apical margin serrate; mid-lobe 0.5-0.7 x ca 0.25 cm, 3-veined, linear-lanceolate or ligulate-lanceolate, apex obtuse; spur ca 4 cm long, pendulous, green below middle, cylindric-clavate, longer than ovary, slightly curved, apex obtuse, stigmas oblong.

Colour plate 20

Flowering: September - October

Habitat and Ecology: Terrestrial, found growing in between forest undergrowth 1700m.

Distribution India (Arunachal, Meghalaya, Nagaland, Sikkim, West Bengal) China, Cambodia, Japan, Laos, Myanmar, Nepal, Thailand, Vietnam**.**

Specimens examined: Chendang saddle (Tuensang district) HYJ327 (NUH).

HYGROCHILUS Pfitzer

Engler & Prantl, Nat. Pflanzenfam. Nachtr. 1: 112. 1897

The genus Hygrochilus was established by Ernst Pfitzer in 1897. Earlier it was under the genus Vanda. The species is named after Charles Parish who discovered the species from Myanmar in 1862. 1 species in India and 1 species recorded by the author

1. Hygrochilus parishii (Veitch & Rchb.f.) Pfitzer in Engler, Nat. Pflanzenfam. Nachtr. 1: 112. 1897. *Vanda parishii* Veitch & Rchb.f. Xenia Orchid. 2: 138 1868; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 686. 1998. *Stauropsis parishii* (Veitch & Rchb.f.) Rolfe. Orchid Rev. 27: 97 1919. *Vandopsis parishii* (Veitch & Rchb.f.) Schltr.Repert. Spec. Nov. Regni Veg. 11: 47 1912. *Hygrochilus mariottiana* (Rchb.f.) Christenson. J. Orchideenfr. 12: 343 2005.

Plant 20-35cm. *Root* ca 1cm diam., *Stems* 5-10cm or more 0.9-1.4 cm diam., stout and enclosed in persistent leaf sheaths. *Leaf* 4-5 or more, 15-22 x 3.5-6cm, oblong or obovate-oblong, unequally bilobed. *Inflorescences* 1 or more, 5-8 flowered; peduncle 5-18cm with 3 or 4 sheaths; floral bracts broadly ovate, 1.3-1.5cm. *Flowers* 3.5-5cm across; sepals and petals yellow with deep purple spots, lip white, tinged with lilac on mid-lobe; pedicel and ovary 3-4cm. *Sepals* 2-2.4 x 1.3-1.7cm, broadly ovate, dorsally carinate, 10-veined, obtuse. *Petals* 1.5-2.2 x 1.2-1.6cm broadly ovate, 10-veined, obtuse. *Lip* 1-1.3 cm, fleshy, 3-lobed; lateral lobes suborbicular, small; mid-lobe cuneate-flabellate, ca. 1.2 x 1 cm, obtuse, with a central longitudinal keel and an erect appendage at base near entrance of sac; sac ca. 3 mm. *Column* ca. 1 cm, winged; stelidia deltoid; rostellum with ligulate lobules ca. 2.5 mm; anther cap beaked at apex.

Colour Plate 21

Flowering: May - July

Habitat and Ecology: Epiphytic and found growing on tree trunk, 1400-2200m

Distribution: India (Arunachal, Assam, Nagaland), Laos, Myanmar, Thailand, Vietnam.

Specimens examined: Tsutoho village (Zunheboto district) HYJ062 (NUH).

LIPARIS Rich.

Orch. Eur. Annot. 21, 30. 38. 1817

The genus was established in 1817 by L.C. Richards. The generic name is derived from the Greek word '*liparos*' (shiny or greasy) referring to the shiny, glossy, and smooth leaves.

45 species are found in India, 12 in Nagaland, and 7 reported by the author.

Key to species

1. Pseudobulbs 1-leaved ……..…… *L. bootanensis*
- Pseudobulbs 2-6-leaved ……..… 2
2. Pseudobulbs 3 - 6 leaved, plants terrestrial…… *L. nervosa*
- Pseudobulbs 2 - 3 leaved (Usually 2-leaved), plants epiphytic (usually)… 3
3. Pseudobulbs less than 6 cm long, Inflorescence zig-zag…… 4
- Pseudobulbs more than 6 cm long, Inflorescence not zig-zag……..… 5
4. Pseudobulbs flattened, Leaves oblong to oblanceolate, acute, peduncle compressed ……..…….... *L. elliptica*
- Pseudobulbs bulbous, Leaves linear-lanceolate, acute to acuminate, peduncle slender ……..…….…. *L. resupinata*
5. Flowers very small, sepals with 1 vein……...… *L. viridiflora*
- Floweres relatively larger, sepals 3- veined……...……....6
6. Leaves elliptic or elliptic-lanceolate to elliptic-oblong, peduncle short, ebracteate, margined or winged; rachis more than 20-flowered …. *L. bistriata*
- Leaves oblanceolate or linear-oblanceolate, peduncle somewhat compressed, with 2 or 3 subulate sterile bracts; rachis up to 10-flowered ……..… *L. distans*

1. Liparis bistriata E.C. Parish & Rchb. f. in Trans. Linn. Soc. London 30:155. 1874; Hook.f., Fl. Brit. India 5:702.1890; King & Pantl. in Ann .Roy. Bot. Gard. Calcutta 8 : 30. t.39. 1898; Seidenf. in Dansk Bot. Ark. 31(1): 73. T. 47. 1976; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 468. fig. 281.1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 205. 2000. *Liparis saltucola* Kerr in Bull. Misc. Inform. Kew

1927: 216. 1927. *Leptorchis bistriata* (E.C. Parish & Rchb. f.) Kuntze, Revis. Gen. Pl. 2:671. 1891.

Pseudobulb 8-15 x 0.6-9 cm diam., densely arranged, elongate, stem-like, cylindric, *Leaves* 2, 5-9 x 2.5-3.5 cm, from apex of pseudobulb, sub-coriaceous, elliptic or elliptic-lanceolate to elliptic-oblong, base contracted into a short petiole, articulate, apex acuminate. *Inflorescence* 12-25 cm long, laxly many-flowered; peduncle short, ebracteate, margined or winged; rachis more than 20-flowered; floral bracts lanceolate, 3-5 mm, lanceolate, acute. *Flowers* pale green; pedicel and ovary ca 1 cm. *Dorsal Sepal* 5-6 x ca 1.5 mm, nearly narrowly oblong, 3-veined, margin revolute, apex obtuse; lateral sepals similiar. *Petals* 4-5 cm x ca 0.5 mm, linear, , 1-veined, apex obtuse. *Lip* 4.5-5 x ca 2.5 mm, quadrate-oblong to panduriform, recurved below middle, ; base with 2 indistinct, confluent calluses; apex truncate, emarginated, minutely erose. *Column* ca 3 mm long, slightly curved, wings narrow, rounded near the apex, base broad.

Colour Plate 21

Flowering: June - July

Habitat and Ecology: Epiphytic or lithophytic and found growing on main tree trunk as well as on tree branch 2200m.

Distribution: India (Arunachal, Meghalaya, Nagaland, Sikkim), Bhutan, China, Myanmar, Thailand.

Specimens examined: Sheyipu village (Zunheboto district) HYJ349 (NUH).

2. Liparis bootanensis Griff., Itin. Not. 98. 1848 (descry.) & Not. Pl. 3: 278. 1851; Hook.f., Fl. Brit. India 5:700.1890; King & Pantl. in Ann .Roy. Bot. Gard. Calcutta 8 : 30. t. 40. 1898; Pradhan, Indian Orchids. 2 : 228. 1979; Kataki, Orch. Meghalaya 35. Pl. 7 (2a & 2b) & j (iv). 1986; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 468. fig. 282. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 206. 2000. *Liparis lancifolia* Hook. f. Icon Pl. t. 1855. 1889. *Liparis pachypus* E.C.Parish & Rchb.f. Trans. Linn. Soc. London 30: 155 1874.

Plant 15-35cm. *Roots* narrow. *Pseudobulbs* 3-5 x 1-1.4cm densely arranged, ovoid, ovoid-oblong, tapering. *Leaf* 1, 8-12 x 2.0-2.4cm, slightly undulate at margins, acute, coriaceous papery, apex acuminate. *Inflorescence* 10-17cm, 10-19 flowered,; peduncle somewhat compressed, both sides with very narrow wings; rachis arching or pendulous, 5-12cm; floral bracts 0.3-0.4cm, linear-lanceolate, acute, *Flowers* often

yellowish green, sometimes slightly tinged with brown, rarely nearly white; pedicel and ovary 0.8-1cm. *Dorsal sepal* 0.5-0.8 x ca 0.2cm, ovate-lanceolate to oblong-lanceolate, apex subacute to obtuse; lateral sepals 0.5-0.8 x ca 0.2cm, obliquely oblong - lanceolate to elliptic, apex obtuse. Petals 0.6-0.9x ca 0.15cm, narrowly linear. *Lip* 0.5-0.7 x ca 0.6cm, wedge shaped, deflexed from below the middle, broadly oblong-obovate; base 2-auriculate with 2 erect globose to tooth like calluses; apex broad, truncate, mucronate. *Column* 0.2-0.3cm, curved, with 2 long, subpendent, elongate hook like wings at apex. *Fruit* ca 0.8 x 0.5cm, obovoid, stalked. *Pollinia* oblong.

Colour Plate 21

Flowering: August - September

Habitat and Ecology: Epiphytic and found growing on tree branch, 1400-2200m

Distribution: India (Arunachal, Assam, Meghalaya, Nagaland, Sikkim, West Bengal), Bhutan, Cambodia, China, Japan, Malaya, Myanmar, Philippines, Thailand, Vietnam.

Specimens examined: Asukhomi village (Zunheboto district) HYJ065 (NUH), Pangsha village (Tuensang district) HYJ336 (NUH).

3. Liparis distans Clarke in J. Linn. Soc. 25: 71. T.29. 1889; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 476. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 209. 2000. *Liparis macrantha* Hook. f., Fl. Brit. India 5: 704. 1890; Seidenf. In Dansk Bot. ark. 31 (1): 76. t. 50. 1976. *Liparis yunnanensis* Rofle, in Jour. Linn. soc. 36: 8. 1903.

Plant 25-35cm. *Pseudobulbs* 8-10cm long, densely arranged, subcylindric or narrowly ovoid-. *Leaves* 2, 17-24 x 2-2.8cm long; petiole 2-6 cm, articulate; blade oblanceolate or linear-oblanceolate, papery, apex acuminate. *Inflorescence* 15-20cm; peduncle somewhat compressed, with narrow wings 1-2 mm wide on both sides, with 2 or 3 subulate sterile bracts; rachis 8-12cm, several to 10-flowered; floral bracts nearly subulate, 07-0.9cm. *Flowers* yellowish green or orange; pedicel and ovary 1.5-1.8cm. *Sepals* 1.2-1.4 cm long, sub-similar, 3-nerved; dorsal sepal ca 2 mm broad, linear lanceolate; lateral sepals ca 1.8 mm, lanceolate, sub-falcate, often slightly shorter than dorsal sepal. *Petals* 1.2–1.4 cm, nearly filiform, apex obtuse. *Lip* ca 1.3 cm long, obovate to semicircular, base narrowed into very short claw and with a frontally grooved callus, margin somewhat irregularly denticulate, apex rounded or

obtuse. *Column* 0.5-0.6cm, slightly arcuate, base slightly dilated, upper part narrowly winged. *Pollinia* oblong.

Colour Plate 21

Flowering: October - November

Habitat and Ecology: Epiphytic and found growing in forests on shaded trees, 600-2200m.

Distribution: India (Arunachal, Assam, Manipur, Nagaland), Cambodia, China, Myanmar.

Specimens examined: Lumami village (Zunheboto district) HYJ024 (NUH), Anangba (Tuensang district) HYJ053 (NUH).

4. Liparis elliptica Wight, Icon. Pl. Ind. Orient 5: t. 1735 .1852; Seidenf. In Dansk Bot. ark. 31 (1): 79. 1976. King & Pantl. in Ann. Roy. Bot. Gard. Calcutta 8: 35. T. 47. 1898; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 476. fig. 287.1998. *Liparis hookeri* Ridl. in J. Linn. Soc., Bot. 22: 288. 1886. *Leptorkis elliptica* (Wight) Kuntze. Revis. Gen. Pl. 2: 671 1891.

Plant 15-25cm. *Pseudobulbs* 2-3 x 0.8-1.2cm , clustered, compressed, flattened, rugose, ribbed. *Leaves* 2, 7-12 x 1.5-2cm, from apex of pseudobulb, oblong to oblanceolate, acute, tapering and shortly petiolate at base, central vein strong; petiole 0.4-1cm long, chanelled. *Inflorescence* 10-15cm, laxly to sub-densely many flowered; peduncle compressed, zig-zag, bracteates, 2 –winged; peduncle bracts 0.4-0.5 x 0.8-1.0cm long, distant, narrowly lanceolate, acute to acuminate; rachis 8-12cm long, glabrous, winged; floral bracts 0.3-0.5 x ca 0.1cm long, lanceolate, apiculate. *Flowers* 3-4mm long, pendant, uniformly greenish; pedicel and ovary curved, glabrous, ca 5 mm long. *Sepals* 3-4 x 1-1.5mm, similar, subacute, oblong, with a central vein. *Petals* 3-3.5 x 0.1- 0.2 mm long, filiform to linear. *Lip* 3- 4 x 2-3mm long, suborbicular, irregularlr 3-lobed, lobes undulate, tapering to an acute apex. *Column* 2-2.2mm long, weakly curved.

Colour Plate 21

Flowering: November - December

Habitat and Ecology: Epiphytic and found growing on main tree trunk by the side of the road, 2000m

Distribution: India (Arunachal, Assam, Manipur, Meghalaya, Nagaland), Sri Lanka, Nepal, China, Myanmar, Thailand.

Specimens examined: Longkhim village (Tuensang district) HYJ304 (NUH).

5. Liparis nervosa (Thunb.) Lindl., Gen. Sp. Orchid. Pl.: 26. 1830; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 483. fig. 291. 1998. *Ophrys nervosa* Thunb. Syst. Veg. ed. 14 814 1784. *Cymbidium bituberculatum* Hook.Exot. Fl. 2: t. 116 1824. *Liparis bituberculata* (Hook.) Lindl.Bot. Reg. 11: t. 882 1825. *Liparis macrocarpa* Hook. f., Fl. Brit. India 5(2): 696. 1890.

Plant 15-60 cm. *Pseudobulbs* 3- 5 cm long, conical, enveloped in leaf sheaths. *Stem* erect, longer than the leaves, glabrous. *Leaves* 2-6, 7-13 x 2.5-7cm, thin, plicate, ovate, ovate-elliptic to ovate-lanceolate, acute to subacuminate, sheathing the stem below. *Inflorescence* laxly many-flowered; peduncle 10-15cm long, ebracteate; rachis 6-16 cm long; floral bracts 3-5 x ca 3 mm, erect, spreading or reflexed, ovate, acute. *Flowers* purple with a tinge of yellowish green and yellow lip, opening in succession. *Dorsal sepal* 7-9 x 2-3 mm, oblong to elliptic oblong, acute to obtuse, margins revolute, 3-veined; lateral sepals 7-8 x 2-4mm, falcate-ovate, acute to obtuse, margins revolute, 3-veined. *Petals* 5-6 x ca 3mm, reflexed, linear-oblanceolate to linear-spathulate, 1-veined. *Lip* 5-7 x ca 3mm, simple, wedge-shaped, flabellate, 2-lobed in front, strongly recurved, 2 triangular obtuse calluses at base. *Column* ca 4 mm, curved, thin-margined, winged in front.

Colour Plate 21

Flowering: June - July

Habitat and Ecology: Terrestrial or lithophytic and found by the side of a stream, 1200m.

Distribution: India (Arunachal, Assam, Manipur, Meghalaya, Nagaland, Sikkim), Bhutan.

Specimens examined: Akuluto village (Zunheboto district) HYJ270 (NUH).

6. Liparis resupinata Ridl. in J. Linn. Soc., Bot. 22: 290. 1886; Hook. f. Fl. Brit. India 5: 705. 1890; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 487. fig. 294.1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 210. fig. 66. 2000. *Liparis resupinata var. ridleyi* King & Pantl. in Ann. Roy. Bot. Gard.Calcutta 8: 37, t.49. 1898.

Plant 15-20cm. *Pseudobulbs* 1.5-2.5 x 0.3-0.4 cm, tufted, ovoid - cylindric, sheathed. *Leaves* 2 - 4, 5-13 x 0.5-0.7cm, alternate, membraneous, linear-lanceolate,

acute to acuminate, sessile. *Inflorescence* 10-14cm long, laxly many flowered; peduncle 5-6cm long, slender, bracteolate, zig-zag; rachis 5-9 cm long; floral bracts 3-4 x 1-1.5mm long, lanceolate, acute, concave. *Flowers* 2-4mm long, golden brownish; pedicel and ovary ca 5 mm long. Sepals 3-4 x ca 1 mm long, sub-similar, oblong, obtuse; dorsal sepal retroflexed; lateral sepals margins recurved, spreading. *Petals* 2-3mm long, linear, obtuse, spreading. *Lip* ca 3mm long; apex obtuse, margins incurved, pouched; calluses 2, at base. *Column* 1-2 mm long, 2-winged, with a pendent filiform process from each wing.

Colour Plate 22

Flowering: October - November

Habitat and Ecology: Epiphytic and found growing on tree trunk with partly or full head sunlight.

Distribution: India (Arunachal, Meghalaya, Nagaland, Sikkim, West Bengal), Nepal, China, Myanmar.

Specimen examined: Meliangkuir village-Shamator (Tuensang district) HYJ077 (NUH).

7. Liparis viridiflora (Bl.) Lindl., Gen. sp. Orchid. Pl.: 31. 1830; Hook. f., Fl. Brit. India 5:704. 1890; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 487. fig. 296.1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 213. 2000. *Malaxis viridiflora* Bl., Bijdr.: 392. 1825. *Liparis longipes* var. *spathulata* (Lindl.) Ridley in J. Linn. Soc., Bot. 22: 294. 1886.

Plant 23-30cm.*Pseudobulbs* 10-14 x 1-1.5 cm at base (0.3 – 0.5 cm above), stem like, ovoid ay base, cylindric above, clustered. *Leaves* 2, 10–25 x 2-4cm, obtuse, obovate-oblong to oblanceolate, acute or acuminate. *Inflorescence* slender, cylindric, densely many flowered, with a few bracts below the raceme; peduncle 5-10cm long, glabrous; rachis 10-15cm long; floral bracts 3-5 x 0.5-0.75mm long, lanceolate, acuminate, scarious. *Flowers* 4-5 mm across; sepals and petals white with a yellow lip; pedicel and ovary 4 – 6 mm long, slender, slightly curved. *Sepals* 2.5-3 x 0.6-0.9 mm long, similar, revolute, linear to oblong, free, obtuse, 3-. *Petals* 2-2.5 x 0.3-0.4mm wide, linear, sub-acute, spreading to reflexed. *Lip* 2.5-3 x 1.3-2mm, simple, recurved, broadly ovate, subacute, spreading to reflexed. *Column* 1.4-1.6mm long, wings rounded.

Colour Plate 22

Flowering: October - November

Habitat and Ecology: Terrestrial or epiphytic and found growing on fallen tree trunk as well as on nearby rocks, 2200m

Distribution: India (Arunachal, Assam, Manipur, Meghalaya, Nagaland, Sikkim, West Bengal), Sri Lanka, Nepal, China to Indo-China and Malaysia.

Specimens examined: Pangsha village (Tuensang district) HYJ047 (NUH), Naltoqa village (Zunheboto district) HYJ054 (NUH)

LUISIA Gaud.

Voy. Uranie, Bot. 426. 1829

The genus was established by Charles Gaudichaud-Beaupre in 1826. The genus is named in honour of Don Luis de Torres, a Portuguese Botanist of the nineteenth century.

About 16 species are found in India, 6 in Nagaland and 1 species reported by the author.

1. Luisia trichorrhiza (Hook.) Bl., Mus. Bot. Lugd. Bot. 1:63. 1849; Hook. f., Fl. Brit. India 6 : 21. 1890; Seidenf. in Dansk Bot. Ark. 27 (4): 66. t. 35. 1971; H. J. Chowdhery, Orch. Fl. Arunachal Pradesh. 495. fig. 302. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 21. fig 67. 2000. *Vanda trichorrhiza* Hook., Exot. Fl. 1: t. 72. 1825. *Cymbidium triste sensu* Lindl., Gen. Sp. Orchid. Pl.: 167. 1833, *non* (Forster) Willdenow.

Roots basal, clustered. *Stem* 4-6 mm in diam., stout, usually unbranched (sometimes branched), covered by leaf sheaths; sheaths tubular, striate-rugose. *Leaves* 8 – 20 x ca 3mm diam., distichous, fleshy, terete, rugose, jointed. *Inflorescence* 3-5-flowered, leaf opposed, stout, short, fleshy; peduncle attenuate; rachis thick, 0.5-0.7 x ca 0.3cm; floral bracts ca 1.5 x 2 mm, persistent, broadly ovate-triangular, acuminate. *Flowers* 1.4 cm across; sepals pale green with faint purple streaks, lip dark purple, apical ridges green, column purple; pedicel and ovary ca 5 mm long. *Dorsal sepal* 0.4-0.5 x ca 0.2 cm, oblong, obtuse, 3-veined; lateral sepals ca 0.6 x 0.2 cm, spreading, obliquely ovate to spathulate, acute, keeled, 3-veined. *Petals* 0.9 x ca 0.15 cm, oblong, obtuse, spreading, 3-veined. *Lip* 0.8-0.9 x 0.6-0.7 cm, 3-lobed; hypochile deeply concave with erect, rounded to triangular, subacute lateral lobes; epichile

cordate, rigid, tapering to subtruncate, minutely emarginated apex. *Column* ca 2mm long, stout.

Colour Plate 22

Flowering: April - May

Habitat and Ecology: Epiphytic and found growing on main tree trunk, 900 -1200m

Distribution: India (Arunachal, Assam, Manipur, Meghalaya, Nagaland, Sikkim), Bhutan, Myanmar, Thailand.

Specimens examined: Alaphumi & Tsaphimi village (Zunheboto district) HYJ343 (NUH).

OBERONIA Lindl.

Gen. Sp. Orchid. 15. 1830 (*Nom. Cons*.)

The genus was described by John Lindley in 1830. The generic name is derived from 'oberon' the mythical king of the fairies.

About 50 species are found in India, 10 spp. in Nagaland and 4 spp. documented by the author.

Key to species

1. Leaves not exceeding 4 cm ……..……. *O. obcordata*
- Leaves exceeding 4 cm ……..... 2
2. Inflorescence stout, flowers embedded on fleshy rachis …..…. *O. pachyrachis*
- Inflorescence not stout, flowers pedicellate …… 3
2. Flowers uniformly pale green to yellow; rachis upto 6 cm …….. *O. mucronata*
- Flowers uniformly brown; rachis long upto 27 cm ……..……..… *O. acaulis*

1. Oberonia acaulis Griff., Itin. Pl. Khasyah Mts. 76. 1848; Seidenf., Dansk Bot. Ark. 25 (3): 107. 1968; Pradhan, Ind. Orch. 2:204. 1979; Kataki, Orch. Megh. 24. 1986; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh. 534. Fig. 324. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 221. 2000. *Oberonia myriantha* Lindl. Fol. Orchid. 8: 4 1859. *Oberonia sikkimensis* Lindl., Fol. Orchid. Oberonia 8:4, no. 22. 1859. *Malaxis sikkimensis* (Lindl.) Rchb. f. in Walpers, Ann. Bot. Syst. 6: 212. 1861. *Iridorchis myriantha* (Lindl.) Kuntze, Revis. Gen. Pl. 2: 669. 1891.

Plant 15- 25 cm. *Roots* fasciculate. *Leaves* 3-5, 6-22 x 1-1.5 cm, linear-ensiform, falcate, acumiate, unequal. *Inflorescence* densely many flowered, verticillate, long, slender, decurved; peduncle 4-6 cm, terete, bracteate, bracts ca 2.5

mm, linear; rachis 12- 27 cm long, floral bracts ca 1.5 x 2 mm, lanceolate, acuminate, erose-fimbriate. *Flowersca* 1.5 mm across, uniformly brownish; pedicel and ovary ca 1.5 mm long. *Dorsal sepal* ca 1 mm, ovate, entire, reflexed; lateral sepals similar. *Petals* ca 1 mm long, oblong, entire, truncate, reflexed. *Lip* ca 1.5 x 1.5 mm, warty, 3-lobed; lateral lobes oblong, crenulate, obtuse; midlobe large, divided into 2 broad oblong and obtuse lobules, separated by a sinus, sinus triangular to acute. *Column* ca 0.2 mm long, simple. *Fruit* ca 4 x 2 mm, pendent to erect, ridged.

Colour Plate 22

Flowering: October

Habitat and Ecology: Epiphytic and found growing on main tree trunk 1600m.

Distribution: India (Arunachal, Assam, Meghalaya, Nagaland, Sikkim, West Bengal), Bhutan, China, Nepal, Myanmar, Thailand, Vietnam.

Specimens examined: Aotsakilimi village (Zunheboto district) HYJ285 (NUH).

2. Oberonia mucronata (D. Don) Ormerod & Seidenfaden in Seidenfaden, Contr. Orchid Fl. Thailand 13: 20. 1997; Pearce & Cribb 2002. The Orch. Of Bhutan Vol. 3(3). 227. Pl.7. 2000. *Stelis mucronata* D. Don, Prodr. Fl. Nepal. 32. 1825. *Cymbidium iridifolium* Roxb., Hort. Bengal.: 63 (1814) nom. Nud.; Fl. Ind.ed. 1832, 2 (3): 458 (1832. *Malaxis iridifolia* lindl., Gen. So. Orchid. Pl.: 15 (1830). *Oberonia denticulata* var. iridifolia (Roxb.) S. Misra in J. Orchid Soc. India 3 (1-2): 69 (1989).

Plant 15-30 cm tall. *Roots* fasciculate. *Stem* very short or inconspicuous. *Leaves* 5- 6, 3.5- 25 x 0.8 – 1.5 cm, broadly ensiform, acute to mucronate, overlapping at base, fleshy, lower ones smaller. *Inflorescence* decurved, densely many flowered; peduncle 8-10 cm, widely winged, ebracteate, long; rachis 12-16 cm long, slender, ridged; floral bracts ca 1.5 x 0.5 mm minute, elliptic, obtuse, coarsely erose, convolute around ovary. *Flowers* ca 1 mm long, sub-verticillate, uniformly pale green to yellow; pedicel and ovary ca 1 mm long. *Sepals* similar, ovate, reflexed, overlapping the ovary, entire, ca 1 mm long. *Petals* ovate, reflexed , overlapping on the ovry, erose, ca 1 mm long. *Lip* ca 1.5 x 1 mm, orbicular, indistinctly 3-lobed; lateral lobes pectinate, erose; mid-lobe broad, transversely oblong, margins deeply fimbriate-erose to emarginated. *Column* very short. *Fruit* ca 3.5 x 2 mm, broadly ovoid.

Colour Plate 22

Flowering: October

Habitat and Ecology: Epiphytic and found growing on main tree trunk 1400m.

Distribution: India (Arunachal, Assam, Meghalaya, Nagaland, Sikkim, west Bengal), Bhutan, China, Nepal, Malaysia, Indonesia.

Specimens examined: Pangsha village (Tuensang) HYJ037 (NUH).

3. Oberonia obcordata Lindl., Fol. Orchid. Oberonia 8:7, no.43. 1859; Hook. f., Fl. Brit. India 5: 684. 1890; King & Pantl. in Ann. Roy. Bot. Gard. Calc. 8: 19. t. 11. 1898; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 547. Fig. 334. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 224. 2000. *Malaxis obcordata* (Lindl.) Rchb. d. in Walpers, Ann. Bot. Syst. 6:216. 1861. *Oberonia treutleri* Hook. f., Fl. Brit. India 5(2):684. 1890. *Iridorchis obcordata* (Lindl.) Kuntze, Revis. Gen. Pl. 2:669. 1891. *Iridorchis treutleri* (Hook. f) Kuntze, *loc.cit*. .1891.

Plants 6-9 cm long. *Roots* fasciculate. *Stem* 2-4 cm tall, leafy, compressed. *Leaves* 0.3-1.0 x 1.5-4 cm, linear, falcate, fleshy, acute, sheathing at base. *Inflorescecence* verticillate, erect, many-flowered; peduncle ca 1 cm long, bracts few; rachis upto 6 cm, slender; floral bracts ovate-ca 0.3 x 0.15 cm, lanceolate, acuminate, minutely toothed, verticillate. *Flowers* clustered within whorls of floral bracts, uniformly reddish-brown to pink; pedicel and ovary ca 1 mm long. *Sepals* ca 0.5 mm long , subsimiliar, broadly ovate; dorsal sepal acute; lateral sepals obtuse. *Petals* ca 0.5 mm, linear-oblong, subacute, spreading. Lip ca 1.5 mm long, 3-lobed; lateral lobes divergent, oblong , obtuse, entire; midlobe reniform, ridged in centre, lobules separated by a shallow sinus, margins entire. *Column* very short. Fruit ovoid, ca 2.5 x 1.5 mm.

Colour Plate 22

Flowering: August - September

Habitat and Ecology: Epiphytic and found growing on main tree trunk 1900m

Distribution: India (Arunachal, Assam, Meghalaya, Nagaland, Sikkim, West Bengal), Bhutan, China, Thailand.

Specimens examined: Melangkiur village (Tuensang district) HYJ297 (NUH).

4. Oberonia pachyrachis Rchb. f. ex Hook. f., Fl. Brit. India 5: 681. 1890; King & Pantl. in Ann .Roy. Bot. Gard. Calc. 8 : 4. t. 3. 1898; Pradhan, Indian Orchids. 2 : 193. 1979; Kataki, Orch. Meghalaya, 25. 1986; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 547. fig. 335. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI),

225. 2000. *Oberonia arbicularis* Hook. f., Fl. Brit. India 5(2): 677. 1890. *Iridorkis pachyrachis* (Rchb. f. ex Hook. f.) Kuntze. 1891. *Oberonia umbraticola* Rolfe in Bull. Misc. inform. Kew 1909:62. 1909.

Stem 3-4cm long. *Leaves* 6-10 x 0.8-1.2cm, few, ensiform, slightly falcate, tapering to base. *Inflorescence* 8-12cm long, many flowered, verticulate, stout; peduncle ca 1.5cm long, foliaceous, broad, compressed, adnate to leaf apex; rachis 2-10 x 0.2-0.6cm, fleshy, terete, tapering erect; floral bracts ca. 0.8 mm, ovate-orbicular, irregular, deeply serrate. *Flowers* ca 2 mm across, yellowish green, sessile, sunken in the rachis ; sepals and petals dull orange-yellow to brown. *Sepals* ca 0.5 x 0.25mm, similar, elliptic, obtuse, glandular at back. *Petals* ca 0.5 – 0.15mm, linear-oblong, obtuse. *Lip* ca 0.5 x 0.25mm, orbicular elliptic, obtuse, concave, slightly erose at apex; base with a deep depression under the column. *Column* ca 1 mm long. Pollinia linear-oblong.

Colour Plate 23

Flowering: March - April

Habitat and Ecology: Epiphytic and found growing on tree trunk in closed forests along with moss, 1800-2200m

Distribution: India (Arunachal, Assam, Meghalaya, Nagaland, Sikkim, Uttar Pradesh, West Bengal), Bhutan, China, Myanmar, Nepal, Thailand.

Specimens examined: Pangsha village (Tuensang district) HYJ076 (NUH), Naghuto village & Aotsakilimi village (Zunheboto district) HYJ026 (NUH).

OTOCHILUS Lindl.

Gen. Sp. Orchid. 35. 1830

The genus was described by John Lindley in 1830. The generic name is derived from the Greek words '*oto*s' (ear) and '*chelos'* (lip).

4 spp. is found in India, 4 spp. in Nagaland and 3 spp. documented by the author.

Key to species

1. Petals clearly linear; apex of floral bracts acute …….. *O. lancilabius*
- Petals narrowly oblong lanceolate to linear-oblanceolate; apex of floral bracts broadly obtuse……...… 2
2. Leaves ovate-lanceolate; lateral lobes of lip finely papillose ……..…. *O. albus*
- Leaves linear-lanceolate; lateral lobes of lip not finely papillose ….. *O. fuscus*

1. Otochilus albus Lindl., Gen. & Sp. Orch. 35. 1830; Hook. f., Fl. Brit. India 5 : 843. 1890; King & Pantl. in Ann .Roy. Bot. Gard. Calc. 8: 143. t. 200. 1898; Seidenf. in Bot. 71 : 10. T. 9. 1976; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 557. fig. 340. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 228. 2000. *Broughtonia pendula* Wall. ex Lindl., Gen. Sp. Orchid. Pl.: 35. 1830.

Pseudobulbs 4-6cm x 0.6-0.9cm enclosed in tubular sheaths when young, brownish yellow when dried, subcylindric, grooved, usually with roots at joint. *Leaves* 5-16 x 1.3-4cm, ovate lanceolate; petiole 1-2 cm long. *Inflorescence* laxly 8-15 flowered, synanthous; peduncle 3-7cm long, sheathed; sheaths 1-4 cm long, overlapping; floral bracts ca 0.8-1.2 x 0.5-0.8cm, caducous, ovate-lanceolate. *Flowers* 1-1.8 cm across, uniformly white; pedicel and ovary 0.8 – 0.9 cm long, slender, curved; dorsal sepal narrowly oblong, 0.6-0.8 x 0.1-0.2cm, 3-veined, acuminate; lateral sepals slightly oblique. *Petals* 0.6-0.7 x 0.1-0.2cm, narrowly oblong-lanceolate, 3-veined, acute. *Lip* 3-lobed, 4-6mm long, base saccate; lateral lobes broad, acute, papillose; mid - lobe oblong, apex apiculate. *Column* 5-6mm, slender, winged and dilated at apex. *Pollinia* sub-globose.

Colour Plate 23

Flowering: May - June

Habitat and Ecology: Epiphytic, sometimes lithophytic and found growing on tree trunk in closed forests along with other epiphytic plants, 1800-2300m.

Distribution: India (Arunachal, Meghalaya, Nagaland, Sikkim, Uttar Pradesh, West Bengal), Myanmar, Nepal, Thailand, Cambodia and Vietnam.

Specimens examined: Mimi village (Kiphire district) HYJ348 (NUH), Pangsha & Chiang mai village (Tuensang district) HYJ273 (NUH), Asukhomi and tsutoho village (Zunheboto district) HYJ302 (NUH).

2. Otochilus fuscus Lindl., Gen. & Sp. Orch. 35. 1830; Hook. f., Fl. Brit. India 5 : 844. 1890; King & Pantl. in Ann .Roy. Bot. Gard. Calc. 8 : 143. t. 199. 1898; Seidenf. in Bot. 71 : 8. t. 8. 1976; Pradhan, Indian Orch. 2: 287. 1979; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 557. fig. 341. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 229. 2000. *Broughtonia pendula* Wall. ex lindl., Gen. Sp. Orchid. Pl.: 35. 1830. *Coelogyne fusca* (Lindl.) Rchb. f. in Walpers, Ann. Bot. Syst. 6:236.1861.

Pseudobulbs 4-6 cm long, cylindric fusiform, pendulous, rugose, covered with fibrous sheaths. *Leaves* 7-16 x 0.8-1.5 cm, linear-lanceolate, acuminate; petiole 1.2-1.4 cm long. *Inflorescence* laxly 15 to many flowered, proteranthous, semi -erect; peduncle 3 – 6 cm long, sheathed; sheaths 0.8-5 cm long, overlapping, rugose; rachis 7 – 12 cm long, ridged, glabrous; floral bracts ca 0.6-0.8 x 0.1 -0.2 cm, persistent, linear-oblong, subtruncate, scarious, edges inrolled. *Flowers* 1.2 - 1.6 cm across, base of lip tinged pink, column orange-brown; pedicel and ovary 0.5 – 0.6 cm long. Sepals 0.6-0.8 x 0.1- 0.2 cm, free, sub equal, linear-oblong, obtuse, spreading. Petals 0.4-0.6 x ca 0.1 cm, linear oblanceolate, obtuse, spreading. *Lip* 0.4- 0.6 cm long, base shortly saccate; lateral lobeserect, short, rounded, acute; midlobe oblong, acute, concave, deflexed. *Column* 0.5-0.6 x ca 0.1 cm, short, curved, lacking a foot, slightly winged. *Pollinia* cuneately oblong.

Colour Plate 23

Flowering: March - April

Habitat and Ecology: Epiphytic and found growing gregariously on tree trunk in closed forests along with other epiphytic plants, 1800-2300m.

Distribution: India (Arunachal, Assam, Meghalaya, Nagaland, Sikkim, West Bengal), China, Myanmar, Nepal, Thailand, Vietnam.

Specimen examined: Tokiye, Asukhomi & Hokiye village (Zunheboto district) HYJ021 (NUH), Pangsha & Anangba village (Tuensang district) HYJ109 (NUH).

3. Otochilus lancilabius Seidenf., in Bot. Tidsskr. 71: 13, t.11. 1976; opera Bot. 89:94. 1986; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 230. 2000. *Otochilus porrectus sensu* Hook. f., Fl. Brit. India. 5(2):844. 1890, *non* Lindl.

Plant 30-50cm. *Roots* arising from internode. *Pseudobulbs* 4-10 x ca 1 cm diam., greenish yellow when dry, subcylindric, narrowly fusiform to clavate, sheathed at base, sparsely wrinkled. *Leaves* 2, 12-16 x 2.5-3.5 cm, elliptic-lanceolate to oblong-lanceolate, apex acuminate or shortly cuspidate; petiole ca 2 cm. *Inflorescence* decurve, proteranthous; peduncle sheathed when young; rachis laxly several flowered; floral bracts caducous, linear, acute. *Flowers* white, 1.9-2.2 cm across; pedicel and ovary ca 1.3 cm. *Dorsal sepal* 1.3-1.4 x ca0.2 cm, linear-oblong, cymbiform, 5-veined, acute; lateral sepals similar, somewhat oblique. *Petals* 1.2-14 x 0.1 cm, linear, 3-veined, acute. *Lip* 3-lobed; lateral lobes 1.4- 1.6 x ca. 0.05cm, erect, embracing column and ca 1/4 length of column, triangular-ovate; mid-lobe 0.9-1x ca

0.3 cm, oblong-lanceolate, base shortly clawed, apex acuminate; sac with 3 or 4 short thickened ridges. *Column* 1.2-1.4 cm, subclavate, upper part winged; anther cap ellipsoid, ca 1 mm; rostellum ligulate, ca. 0.7 mm. *Capsule* subobovoid-ellipsoid.

Colour Plate 23

Flowering: November - December

Habitat and Ecology: Epiphytic and found growing gregariously on tree trunk. 1800-2000m.

Distribution: India (Assam, Meghalaya, Nagaland, Sikkim, West Bengal), China, Bhutan, Laos, Nepal, Vietnam.

Specimen examined: Lizu Naghuto village, Asukhomi village (Zunheboto district) HYJ059 (NUH), Pangsha & Melangkiur village (Tuensang district) HYJ300 (NUH).

PANISEA Lindl.

Fol. Orchid. 5. 1854

The genus was described by John Lindley in 1854. The generic name is derived from the Greek words 'pan' (all) and '*isos*' (equal) referring to the similiarity between the sepals and petals of the flower.

3 species found in India, 2 spp. in Nagaland and 1 sp. reported by the author.

1. Panisea tricallosa Rolfe in Kew Bull.: 148. 1901; Balakr. & Chowdhury in Bull. Bot. Surv. India 9:90. 1967; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh. 565. fig. 344. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 232. fig. 71. 2000. *Stigmatogyne tricallosa* (Rolfe) Pfitzer in engler, Pflanzenr. (IV.50) Coelog.: 133.1907. *Stigmatogyne pantlingii* Pfitzer in Engler, op. cit. 134. 1907.

Plant with with short, creeping, branched rhizomes. *Pseudobulbs* 1.8-2 x 0.7-1cm, subglobose to ellipsoid, caespitose, smooth and covered with bracts when young, depressed and grooved when old; bracts pale brown. *Leaves* solitary on pseudobulb, very rarely 2 (one is abnormally developed and unequal), 2-6 x 0.8-1.5cm, ovate lanceolate to linear lanceolate acute at apex, 7 nerved with short petiole; petiole 4-8mm long. *Inflorescence* 2-4cm long, sub-erect. *Flowers* ca 2.5cm across, pale cream to greenish cream–yellow, solitary on scape arising from the base of pseudobulb; pedicel and ovary 1.5-2cm. *Sepals* 1.3-1.5 x 0.4-0.7cm lon. *Dorsal sepal* ovate-oblong, apiculate at apex, keeled at back; lateral sepals ovate, concave at base, apiculate at apex. *Petals* 1.1-1.3 x 0.3-0.7cm, oblong-elliptic, narrow and smaller than

the sepals. *Lip* 1.6-2.0 x 0.4-0.9cm, greenish yellow, lanceolate oblong; hypochile narrow, sub saccate, 2 calli at base; epichile broad, 3 calli in the middle. *Column* ca 0.8mm long. *Pollinia* quadrately oblong.

Colour Plate 23

Flowering: November - December

Habitat and Ecology: Epiphytic and found growing on tree trunk in a closed forests, 2400m.

Distribution: India (Arunachal, Assam, Nagaland), Bhutan, Nepal, Thailand, Laos and Vietnam.

Specimens examined: Tsutoho village (Zunheboto district) HYJ051 (NUH).

PAPHIOPEDILUM Pfitzer

Morph. Stud. Orchid. 11. 1886

The genus was described by E. Pfitzer in 1886. The generic name is derived from '*paphos*' a city in Cyprus and '*pedilum*' (slipper) in greek referring to the shape of the lip. The species of this genus are popularly referred as Lady's slipper or Venus's slipper orchids.

About 70 species and 9 species are recorded from India, 2 in Nagaland and both documented by the author.

Key to species

1. Floral bracts equaling the ovary; dorsal sepal bright green, heavily spotted with large blackish maroon marks ……..…… *P. villosum* var.*boxallii*
- Floral bracts much shorter than ovary; dorsal sepal greenish purple, densely spotted with small purple black dots ……..…. *P. hirsutissimum*

1. Paphiopedilum hirsutissimum (Lindl. ex Hook.) Stein, Orchid. 470. 1892; Hook. f., Fl. Brit. India 6: 171. 1890; Seidenf. in Bot. Tidsskr. 70: 64. T. 1. 1975; U.C. Pradhan, Indian Orchids: Guide to Ident. & Cult.1: 39. 1976; P. Cribb, the Genus *Paphiopedilum* 220-225. (ed.2). 1987; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 232. 2000. *Cypripedium hirsutissumum* Lindl. ex Hook. in Curtis's Bot. Mag. 83: t. 4990. 1857. *Cordula hirsutissimum* (Lindl. ex Hook.) Rolfe in Orchid. Rev. 20:2. 1912.

Plant upto 38 cm tall. *Stem* short, hidden by leaf bases. *Leaves* 15-30 x 2-3cm, linear-oblong or linear-ligulate, apex obtuse, obliquely bi-lobed. *Inflorescence* single flowered; scapes ca 25 cm long, erect, green, densely covered with dark purple hairs, subtended by a basal sheath upto 10 cm long; bracts 2.5-3 cm long, ovate, sub-acute to obtuse, densely purple hairy. *Flowers* ca 14 cm across when spread, ciliated. *Dorsal sepal* 4-5 x 3-3.5 cm, broadly cordate to orbicular-ovate, obtuse, greenish-purple, densely spotted with blackish purple dots in the central portion and pale green marginal area, margin wavy to deeply undulate, hairy purple at back; lateral sepals 3-3.6 x 2.2-2.4 cm, ovate, hairy, firmly connate, hairy purple at back. *Petals* 6-7 x 2-2.3 cm, spreading, broadly spathulate, margis crisped ciliate, deeply undulate from basal half and flat expanded in apical portion. *Lip* 4-5 x 2-3 cm, helmet shaped greenish with purple spots; side lobes small, truncate; mid-lobe oblong, apex conical. *Column* ca 5 mm long, greenish to purple. Staminode quadrate, apex undulate; anther sub globose. Ovary ca 7 cm long, cylindric.

Colour Plate 23

Flowering: April - May

Habitat and Ecology: Epiphytic or Terrestrial and found growing in between rocks near stream of forests, 1900m.

General Distribution: India (Meghalaya, Mizoram, Nagaland), Myanmar, Thailand.

Specimen examined: Area name witheld (Zunheboto district) HYJ105 (NUH).

2. Paphiopedilum villosum var. boxallii (Rchb. f.) Pfitzer in Engler, Die naturlichen Pflanz., II, (6): 83. 1888; U.C. Pradhan, Indian Orchids: Guide to Ident. & Cult. 1:37. 1976; P. Cribb, the Genus *Paphiopedilum* 254-260. (ed.2). 1987. *Cypripedium boxallii* Rchb.f., Gard. Chron.,n.s., 7: 367. 1877. *Cypripedium dilectum* Reichenbach fil. in Gardener's Chronicle, 3rd series, 3: 330-331. 1888. *Cordula boxallii* (Rchb.f.) Rolfe., Orchid Rev. 20: 2. 1912.

Plant 25-40cm. *Leaves* 5-8, 13-34 x 2.0-3.6cm, distichous, leaf blade abaxially green and with purple speckles toward base, adaxially uniformly dark green, linear-oblong or lorate, leathery, acute to obtuse and bilobulate at apex. *Inflorescence* 15-23cm long, single flowered, arising from between leaves; Scape sub erect to arching, terminating in a solitary flower; peduncle 10-20 cm, green with more purple and rarely whitish hairs; floral bract 4-5 x 2-3cm, green, elliptic, conduplicate, abaxially purple spotted and hairy toward base. *Flower* 10-12 x 8-10cm; sepals and

petals greenish or yellowish with purplish markings, lip yellow and purplish spotted; pedicel and ovary 4-5 cm, with purple or rarely whitish hairs. *Dorsal sepal* 5-6 x 4-5cm, greenish or yellowish white, broadly elliptic to obovate, minutely haired abaxially throughout and with long hairs on midvein and toward base and apex, ciliate, recurved on basal margin, apex obtuse, heavily spotted with large blackish maroon marks ; synsepal 4-4.5 x 2-2.5cm, greenish to yellowish white, elliptic-ovate to narrowly ovate. *Petals* 5.5-7 x 3-3.5cm, spathulate-obovate, adaxially purple villous at base, ciliate, obtuse to retuse at apex, deep maroon central stripe, upper side of central stripe pale maroon with deep maroon veins, lower side very pale maroon. *Lip* 4.5-6.5 x 4-4.5 cm, helmet shaped, pouched; staminode 1-1.3 x 0.8-1cm, obcordate obovate, adaxially with bubblelike papillae and a central umbo, subtruncate at apex. *Pollinia* 1-1.2mm in diameter.

Colour Plate 24

Flowering: February - April

Habitat and Ecology: Epiphytic or lithophytic and found growing on tree trunks in diffused sunlight areas, 1700m

General Distribution: India (Nagaland) , Myanmar, Thailand

Specimen examined: Area name Witheld (Tuensang district) bordering Myanmar HYJ075 (NUH).

Note: U.C. Pradhan (1976) mentioned this variety without any locality in India and Philip Cribb mentioned this variety as being endemic to Myanmar. The author verifies the variety as the original was encountered flowering in the wild.

PAPILIONANTHE Schltr.

Orchis 9: 78. 1915.

The genus was described by Friedrich Richard Rudolf Schlechter in 1915. The generic name is derived from the latin words ‘papilio’ (butterfly) and ‘ anthos’ (flower) in allusion to the butterfly like flowers in the genus.

4 species are recorded from India, 2 from Nagaland and both documented by the author.

Key to species

1. Lateral lobes of lip entire, semi circular ……..……..…. *P. teres*
- Lateral lobes of lip bifid to 2-lobulate; lobules of lateral lobes serrate denticulate ……..…… *P. vandarum*

1. Papilionanthe teres (Roxb.) Schltr. Orchis, 9:78. 1951; Hook. f., Fl. Brit. India 6 : 49. 1890; King & Pantl. in Ann .Roy. Bot. Gard. Calc. 8 : 214. t. 285 1898; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 570. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 234. 2000. *Dendrobium teres* Roxb., Fl. Ind. Ed. 1832, 3:485. 1832; Hook., Fl. Ind. 3 : 621. 1832. *Vanda teres* (Roxb.) Lindl., Gen. & Sp. Orch. 217. 1833.

Plant 30-100m. *Roots* piercing through leaf sheaths. *Stem* branched, long, terete, branched, covered by leaf sheaths, 4mm wide; sheaths ridged, tubular, 3-4cm long. *Leaves* 8-20 x 0.2-0.4 cm long, suberect, curved, terete, linear, ridged, jointed. *Inflorescence* reacemose, leaf opposed, laxly 3-6 flowered; peduncle 5-8cm long, ridged, sheathed; sheaths 2, 3 x 3mm, truncate, ovate; rachis ca 3 cm long, ridged, glabrous; floral bracts ca 4 x 1.5 mm, ovate. *Flowers* 8-10cm across; sepals and petals whitish pink, lip darker pink with a yellow base, veined with pink, spur with a yellow mouth; pedicel and ovary 2-3cm long. *Dorsal sepal* 3.2-3.5 x 2.8-3cm, spreading, ovate to sub-rhombic, obtuse, margins undulate; lateral sepals almost similar. *Petals* 2.7-4.3 x 2.4-3.6cm, rounded, suborbicular, margins undulate, base twisted. *Lip* 3.8-4.5 x 3.2-3.7cm, 3 –lobed, pubescent; lateral lobes entire, erect, semi-circular; mid-lobe ca 1.8 x 2 cm flabellate-obcordate, deeply cleft; spur 1.5-2.5cm, funnel shaped, compressed. *Column* 8-10mm long, pubescent in front.

Colour Plate 24

Flowering: April - May

Habitat and Ecology: Epiphytic and found growing on old growth tree in a disturbed jhum cultivated area along with *vanda testacea*, 600-1500m.

Distribution: India (Arunachal, Assam, Meghalaya, Nagaland, Sikkim, West Bengal), Bangladesh, Bhutan, Myanmar, Thailand, Cambodia and Vietnam.

Specimens examined: Mukhami village (Zunheboto district) HYJ029 (NUH), Chare village (Tuensang district) HYJ274 (NUH).

2. Papilionanthe vandarum (Rchb. f.) Garay in Bot. Mus. Leafl. 23 (10): 372. 1974; Pearce & Cribb 2002. The Orch. Of Bhutan Vol. 3(3). 539. 2000. *Aerides vandarum* Rchb. f. Gard. Chron. 1867:997. 1867. *erides cylindricum sensu* Hook. in Bot. Mag. 83: t.4982. 1857, *non* Lindl.1832. *Vanda vandarum* (Rchb.f.) K.Karas.Orchid Atlas 8: 199 1992.

Stems upto 60 cm or more, pendulous, branched, terete, flexuous, covered by leaf sheaths; sheaths 1.6-2.3cm, ridged, overlapping, tubular. *Leaves* 8-28 x ca. 0.3 cm, suberect, terete, grooved, acuminate, jointed. *Inflorescence* leaf-opposed, 1-4 flowered; peduncle ca 2.2 cm, sheathed; floral bracts 2-4 x ca 1.5mm, triangular. *Flowers* 3.8-5cm across, white with a purple-flushed base to lip and spur, pedicel pink; pedicel and ovary 1.4-3.2cm. *Dorsal sepal* 2 -3.5 x 0.8-1.5cm obovate - oblong, obtuse, margins undulate; lateral sepals similar, ca. 3 × 1 cm. *Petals* 2-2.5 x 1.1-1.9 cm subrhombic, reticulately veined, base twisted, margins undulate, apex obtuse. *Lip* ca 2.2 x 2.2 cm, 3-lobed; lateral lobes ca 9 x 4 mm, erect, unequally bifid, flexuous, narrowly ovate, falcate, dentate on apical margin; mid-lobe ca 8 x 8mm across apex clawed, obovate, dilated and bilobulate at apex; lobules ca 5 × 4 mm orbicular, serrate-denticulate; spur 1.6-2.4 cm, cylindric, base conic, straight. *Column* ca 6 mm fleshy; foot long.

Colour Plate 24

Flowering: March - April

Habitat and Ecology: Epiphytic and found growing on tree trunk in disturbed as well as undisturbed forests, 1800-2800m

Distribution: India (Arunachal, Assam, Manipur, Meghalaya, Nagaland, Sikkim) Bhutan, South China, Myanmar.

Specimens examined: Asukhomi, Sukhalu, Tsutoho, Tokiye village (Zunheboto district) HYJ046 (NUH), Melangkiur village (Tuensang district) HYJ085 (NUH), Sitimi Village (Kiphiri district) HYJ328 (NUH).

PECTEILIS Rafin.

Fl. Tellur. 2: 37. 1837

The genus was described by C.S. Rafinesque in 1837. The name is derived from the Greek word "*pectin*" – comb in reference to the comb-like or pectinate side lobes of the lip.

4 species in India, 2 spp. in Nagaland and 1 sp. reported by the author.

1. Pecteilis susannae (Linn.) Rafinesque, Fl. Tellur. 2: 38, no. 125. 1836; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 574. fig. 349. 1998. *Orchis susannae* Linn., Sp. Pl.: 939. 1753. *Habenaria susannae* (Linn.) R. Br., Prodr.: 312. 1810.

Platenthera robusta Lindl. in Wall. Cat.: 7036. 1828; Gen. Sp. Orchid. Pl.: 295. 1835. *Platanthera susannae* (Linn.) Lindl., Gen. Sp. Orchid. Pl.: 295. 1835. *Hemihabenaria susannae* (Linn.) Finet in Rev. Gen. Bot. 13: 532. 1901.

Plant 40-100 cm tall; *Tuber* 4-6 x 1.5-2.4 cm. ovoid-cylindric. *Stem* 0.5-1.1 cm diam., leafy, thick with tubular sheaths at base, many leaves intergrading into amplexicaul sterile bracts above. *Leaves* many, 6-12 x 3-6.5 cm, ovate-oblong, or lanceolate,sessile, apex acute, sheathed at base; sheaths 2-5 cm long, tubular, clasping. *Inflorescence* laxly 3-5 flowered, subumbellate; flora bracts lanceolate, acute to acuminate, margins minutely glandular-pubescent. *Flowers* fragrant, 4-9 cm wide, white; pedicel and ovary 4-6 cm, shallowly winged, margins of wings minutely dentate. *Dorsal sepal* 2.5-3 x 2-2.6 cm, erect, broadly ovate to rhombic-orbicular, apex obtuse-rounded; lateral sepals 2.5-3.8 x 1.2-2.3 cm, spreading, broadly ovate, slightly oblique, usually slightly longer than dorsal sepal, apex obtuse. *Petals* 0.8-1.2 x 0.25 cm, linear to oblong, acute. *Lip* 3-3.6 x 2.5-3 cm, spurred, 3-lobed; lateral lobes 1.4-2.2 x 1.7-2.3 cm, broadly triangular, truncate, lacinate-pectinate, lateral margins entire, apical margin lacerate-fimbriate; mid-lobe linear-oblong, 1.6-2.7 x 0.4-0.6 cm, slightly fleshy, linear spathulate; spur 5-12 x 0.3-0.5 cm, apex acute, straight to gradually curved forward. *Column* 0.7-1.1 cm, erect.

Colour Plate 24

Flowering: August – September

Habitat & Ecology: Terrestrial and found growing in between grasses by the side of a stream. 1200m.

Distribution: India (Arunachal, Assam, Manipur, Meghalaya, Nagaland, West Bengal) Bhutan, China, Myanmar, Thailand, Malaysia, Indonesia.

Specimens examined: Mangakhi (Tuensang district) HYJ347 (NUH).

PENDULORCHIS Z.J. Liu, Ke Wei Liu & G.Q. Zhang

Plos One 8 (4): 8.2013

The Pendulorchis Z.J. Liu, Ke Wei Liu & G.Q. Zhang (Orchidaceae) is a recently established genus based on molecular studies (Zhang *et al*., 2013).

There are two species under the genus viz., *Pendulorchis gaoligongensis* G.Q. Zhang, Ke Wei Liu & Z.J. Liu (type species of the genus) and *Pendulorchis himalaica* (Deb, Sengupta & Malick) Z.J. Liu, Ke Wei Liu & X.J. Xiao and distributed in India, Myanmar, China and Bhutan.

1 in India and reported by the author from the state

1. Pendulorchis himalaica (Deb, Sengupta & Malick) Z.J. Liu, Ke Wei Liu & X. J. Xiao, Plos One 8 (4): 8. 2013; L.M. Gardiner, Phytotaxa 61: 47–54. 2012. *Saccolabium himalaicum* Deb, Sengupta & Malick, Bull. Bot. Soc. Bengal 22 (2): 213. 1968. *Ascocentrum himalaicum* (Deb, Sengupta, & Malick) Christenson, Notes Bot. Gard. Edinb. 44: 256. 1987. *Holcoglossum himalaicum* (Deb, Sengupta, & Malick) Averyanov, Bot. J. (Leningrad) 73 (1): 101 – 107. 1988. *Holcoglossum junceum* Z. H. Tsi, Acta Phytotax. Sin. 20 (4): 442. 1982. *Vanda himalaica* (Deb, Sengupta & Malick) L.M.Gardiner, Phytotaxa 61: 47–54. 2012.

Plant Pendulous, with flattened roots arising from nodes. Stem 10-20cm long, 5-8 mm in diameter, enclosed by leaf sheaths, upper part with 3 – 6 leaves. Leaves slender, terete, green, fleshy, 20-55cm long, 0.3-0.6cm in diameter, sheathed at base, apex acute. Inflorescence racemose, arising from the axils of the lower leaves 4-13cm long with 15-26 light purple flowers; rachis 3-5cm long; floral bracts reflexed, oblong-ovate, 3 – 5 mm, yellowish. Flower 14-16mm long, not opening widely, sepals and petals purplish, lip purplish-white; pedicel and ovary 12-13mm long. *Dorsal sepal* oblong-oblanceolate, 3-veined, 4-4.5 mm x ca. 2mm; lateral Sepals broad, obovate, 3-veined, 4.5-5 x 2.5-2.8mm. *Petals* obovate-oblanceolate, 4-4.5 x ca. 2mm. Lip spurred, 3-lobed, adnate to column foot; lateral lobes rounded, ca. 2 x 1.5mm; mid lobe broadly obovate, 2.5-3 x ca. 2.5mm, 5 veined, apex subtruncate; spur curved, cylindric, 15-17 x ca. 1mm. *Column* stout ca. 1 x 1 mm. Anther cap hemispheric, shortly beaked ca. 1 mm in diameter; pollinia globose 2, attached by a common stipe to suborbicular viscidium. Fruit ellipsoid-cylindric.

Colour Plate 24

Flowering: September – December.

Habitat and Ecology: Epiphytic and found in a subtropical broad leaved forest

Distribution: India (Arunachal Pradesh, Nagaland), Myanmar, China and Bhutan

Specimen examined: Melangkiur village (Tuensang district) Melangkiur Village, 26°05′24.5″ N 94°50′12.6″E, alt.1790 m, 28.11.2014, H. Y. Jakha and S. Dey SDNU 467 (ASSAM).

PHAIUS Lour.

Fl. Cochinch. 517. 1790

The genus was described by Juan Loureiro in 1790. The generic name is derived from the Greek word 'phaios' (dusky) referring to its flowerwhich turns dark when mature.

About 7 species are recorded from India, 2 from Nagaland and 2 reported by the author.

Key to species

1. Inflorescence densely many flowered; sepals and petals yellowish, green tipped; lip apex retuse …….. *P. flavus*
- Inflorescence laxly many flowered; sepals and petals brownish brick red ; lip apex acute to apiculate ……..…… *P. tankervilleae*

1. Phaius flavus (Bl.) Lindl., Gen. Sp. Orchid. Pl.: 128. 1831; Hook. f., Fl. Brit. India 5 : 817. 1890; King & Pantl. in Ann .Roy. Bot. Gard. Calc. 8 : 107. t. 149. 1898; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 582. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 243. 2000. *Limodorum flavum* Blume, Bijdr. 8: 375. 1825. *Phaius maculates* Lindl., Gen. & Sp. Orchid. 127. 1831.

Pseudobulbs 7-12 x 2-4cm, ovoid-ellipsoid to cylindric. *Leaves* 4-6, 25-60 x 5-18cm, ovate-elliptic to elliptic-lanceolate, acute, margins weakly undulate; petiole 4-10cm long, grooved. *Inflorescence* lateral, densely many flowered; peduncle 18-32cm long, sheathed, angled, glabrous; sheaths 3-5cm long, elliptic-lanceolate, acute; rachis 6-18cm long, glabrous; floral bracts 2.5-4cm long, ovate, acute. *Flowers* 4-7cm across, showy; sepals and petals yellow, lip yellow with brownish orange markings; pedicel and ovary 2 – 3 cm long. *Sepals* 2.5-3.5 x 0.8-1.4cm, subsimiliar, spreading, concave; dorsal sepal oblong-elliptic, subspathulate, obtuse to subacute; lateral sepals elliptic, obtuse, oblique to falcate. *Petals* 2.5-3.5 x 0.8-1.3cm, oblong-elliptic, spathulate, obtuse to subacute. *Lip* 2.5-4 x 2.5-4cm, spurred, erect, apex retuse, 3-lobed; lateral lobes erect, oblong, obtuse, covering the column; mid-lobe ovate to suborbicular, slightly deflexed in front, margins crisped undulate; disc with 3 prominent keels; spur conical, 5-8mm long. Column 1.5-2cm erect, curved, pubescent.

Colour Plate 24

Flowering: March - April

Habitat and Ecology: Terrestrial sometimes lithophytic and found growing on soil with rocks by the side of a stream, 1800m

Distribution: India (Arunachal, Assam, Manipur, Meghalaya, Nagaland, Sikkim, West Bengal) Bhutan, China, Nepal, Myanmar, Thailand, Phillipines, Laos.

Specimens examined: Asukhomi village, Khashito village (Zunheboto district) HYJ084 (NUH).

2. Phaius tankervilleae (Banks ex L' Herit.) Bl., Mus. Bot. Lugd. Bat. 2:177. 1856; Hook. f., Fl. Brit. India 5 : 816. 1890; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 583. fig. 357 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 243. 2000. *Limodorum tancarvilleae* Banks ex L' Herit, Sert. Angl. 28. 1789. *Phaius wallichii* Lindl. in Wall., Asiat. Rar. 2 : 46, t. 158. 1831. *Phaius blumei* var. *assamica* Rchb. f. in Gard. Chron. n.s. 17: 558. 1882. *Phaius blumei* var. *pulchra* King & Pantl. in Ann .Roy. Bot. Gard. Calc. 8: 109. t. 151. 1898.

Pseudobulbs 4-10 x 1.5-4cm, conical to ovoid, green, sheathed by leaf bases. *Leaves* 4-7, 35-90 x 9-18cm, elliptic-lanceolate, acuminate, thin; petiole 15-23 cm long. *Inflorescence* lateral, laxly 10-22 flowered; peduncle 35-60cm long, stout, terete, sheathed,; sheaths 4 – 6 cm long, elliptic – lanceolate; rachis ca 18 cm long; floral bracts 4 – 5 cm long, spate-like, caducous. *Flowers* 8-12cm across; sepals and petals white to pale yellow on outer surface, brownish brick red within, lip apex dark pink to wine red and yellowish cream within; pedicel and ovary 2.5- 4cm long. Sepals and petals similar, 4.5-7 x 1-1.5cm, spreading, lanceolate to oblanceolate, acuminate. *Lip* 3.3 -4.8 x 2.5- 4.5cm, tubular, spurred, obovate, acute or apiculate (or truncate), margin cisped-undulate, recurved, 3-lobed; callus obscurely 3-ridged; spur 0.5-1.4cm, slender. *Column* 1.8-2cm long, clavate.

Colour Plate 25

Flowering: March - April

Habitat and Ecology: Terrestrial and found growing on soil with much organic litter and rocks by the side of a stream, 650-2200.

Distribution: India (Arunachal, Assam, Meghalaya, Nagaland, Sikkim, West Bengal) Bhutan, China, Nepal, Myanmar, Thailand, New Guinea, Australia and Pacific Islands.

Specimens examined: Hekiye & Aotsakili village (Zunheboto district) HYJ276 (NUH), Anangba village (Tuensang district) HYJ290 (NUH), Pungro (Kiphiri district) HYJ346 (NUH).

PHALAENOPSIS Blume

Bijdr. 6: t.4, f.44; 7:294. 1825

The genus was established by Carl Ludwig Blume in 1825. The generic name is derived from the Greek word '*Phalaina*' (moth) and '*opsis'* (appearance), referring to moth like flowers.

7 species is recorded from India, 2 spp. from Nagaland and 4 spp. reported by the author and 1 as a new record for the state by the author.

Key to species

1. Leaves 1 or 2, rarely three, deciduous ……..… 2
   Leaves 2 -4 or more …… 3
2. Mid-lobe of lip boat-shaped ……..... *P. braceana*
- Mid-lobe of lip flat ……...…… *P. taenialis*
3. Mid-lobe of lip with a fimbriate margin; column ± hairy …….….. *P. difformis*
- Mid-lobe of lip with crisped, crenulate margin; column glabrous ……
  ……*P. yingjiangensis*

1. Phalaenopsis braceana (Hook. f.) E.A.Christ. in Selbyana 9: 169. 1986. *Doritis braceana* Hook. f., Fl. Brit. India 6(1): 196. 1890. *Kingidium braceanum* (Hook. f.) Seidenfaden in Opera Bot. 95: 187. 1988.

Plant 30-45 cm. *Roots* 3-6mm wide, numerous, long, flattened. *Stems* sheathed ca 1.2cm long; sheaths brown, short. *Leaves* 1 or 2, 5-10 x 1.2-3.2cm, deciduous, coriaceous, linear-oblong, obtuse to subacute. *Inflorescence* basal, erect, racemose, unbranched, 5-8 flowered; peduncle thick, sheathed, glabrous, dark green, speckled with red-brown; sheaths 2.5-3 x 1.2-1.4mm, distant, triangular-ovate, acute; rachis 4 – 5 cm long, glabrous; floral bracts 2-3 x 1.2-1.4mm, triangular. *Flowers* 2.5-3cm across, pendent; sepals and petals yellowish bronze, with pink midrib, lip violet purple; pedicel and ovary ca 1.8 cm, decurved. *Dorsal sepal* 1-1.5 x 0.4-0.6 cm, obovate-oblong, obtuse; lateral sepals 1.3-1.5 x 0.3-0.5cm, ovate-oblong, weakly falcate. *Petals* 1.2-1.4 x 0.4-0.5cm, obovate-oblong, obtuse. *Lip* 3-lobed, spurred;

hypochile 0.7-1cm; lateral lobes ovate –lanceolate, subacute; epichile 5-6 x 2mm; disc with a forked callus; spathulate-obovate, rounded, boat shaped; disc with a forked callus; spur 1.5-3mm long, cylindric, straight. *Column* ca 6 mm, fleshy. Fruit cylindric.

Colour Plate 25

Flowering: April - May

Habitat and Ecology: Epiphytic and found growing on tree trunk by the side of a stream, 960m, N26°16' 20", E 94° 36' 04".

Distribution: India (Nagaland, Sikkim, West Bengal), China, Bhutan.

Specimen examined: Tsaru village (Tuensang district) HYJ135 (NUH).

2. Phalaenopsis difformis (Wall. ex Lindl.) Kocyan & Schuit. in Phytotaxa 161(1): 67. 2014. *Aerides difforme* Wall. ex Lindl., Gen. Sp. Orchid. Pl.: 242. 1833. *Ornithochilus fuscus* Lindl., Gen. Sp. Orchid. Pl.: 242. 1833, *nom. nud. Ornithochilus difformis* (Wall. ex Lindl.) Schltr. in Feddes Repert. Spec. Nov. Regni Veg. Beih. 4:277. 1919. *Sacrochilus difformis* (Wall. ex Lindl.) T. Tang & F.T. Wang in Acta Phytotax. Sin. 1(1): 92. 1951. *Trichoglottis difformis* (Wall. ex Lindl.) Ban & Huyen, Fl. Taynguyen: 206. 1984.

Plant 15-20 cm; roots clustered, ca 2mm in diam. *Stem*, 2-6 cm long, covered by leaf sheaths ca 1 cm. *Leaves* 5- 16 x 3-4.5 cm, oblong-elliptic, falcate, acuminate to obtuse, apex unequally 2-lobed. *Inflorescences* laxly many flowered; branches upto 17 cm, spreading, base sheathed; sheaths overlapping, tubular, 2-4 mm; rachis 8-15 cm long, glabrous; floral bracts ca 2 mm, triangular, acute. *Flowers* 0.8-1 cm across, opening widely; sepals and petals yellow with several longitudinal red-brown to maroon streaks, lip dark maroon with yellow markings at base and margin, spur maroon and greenish yellow, column purplish brown; pedicel and ovary ca 1 cm. *Dorsal Sepal* 4-5 x ca 2 mm, oblong, obtuse; lateral sepals similar in size, obliquely ovate-oblong, obtuse. *Petals* ca 4 x 1.3 mm, narrowly oblong, entire or scabrous, obtuse, slightly recurved. *Lip* shortly clawed at base, 3-lobed; lateral lobes suberect, subovate; mid-lobe slightly incurved, clawed at base, anchor-shaped, 3-lobulate; lateral lobules large, margins fimbriate; apical lobule smaller, abaxially slightly beaked, margin entire and incurved, apex obtuse; disk with 1 purplish red, fleshy callus centrally, a pilose callus at front of and a callus on back of spur entrance; spur

slightly curved, ca 3 mm. *Column* ca 2 mm, with or without hairy, ventrally pappilose.

Colour Plate 25

Flowering: June - July

Habitat and Ecology: Epiphytic and found growing on branches of tree 2000m.

Distribution: India (Arunachal, Assam, Manipur, Meghalaya, Nagaland, Sikkim, West Bengal), Bhutan, China, Myanmar, Nepal, Thailand, Vietnam.

Specimens examined: Noksen village (Tuensang district) HYJ310 (NUH).

3. Phalaenopsis taenialis (Lindl.) E. A. Christ. & Pradhan in Selbyana 9: 168. 1986; Indian Orchid J. 1: 154 1985. *Aerides taeniale* Lindl., Gen. Sp. Orchid. Pl.: 239. 1833. *Doritis taenialis* (Lindl.) Hook. f., Fl. Brit. India 6(1): 31. 1890. *Kingidium taeniale* (Lindl.) P.F.Hunt. Kew Bull. 24: 98 1970; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 463. fig. 279. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 202. 2000.

Plant 15-20cm. *Roots* 3-5mm wide, long, numerous, flattened. *Stems* inconspicuous. *Leaves* 1-2, rarely 3, 3-10 x 1-3.5cm, coriaceous, usually only 1 leaf persistent, semi-deciduous, elliptic to elliptic-obovate, acute-sub acute, sessile, jointed. *Inflorescence* basal, pendent, racemose, unbranched, 4-6 flowered; peduncle 2-2.5cm, ridged, sheathed; sheaths 2-2.5mm, distant,tubular at base; rachis 6-12mm, ridged, glabrous; floral bracts 2-3 x 0.5-0.8mm, ovate-triangular, acute. *Flowers* 1-1.5cm across, opening widely; sepals and petals pale pink, lip and anther cap rose-purple; pedicel and ovary ca 1.5cm. *Dorsal sepal* oblong, 0.8-0.9 × 0.3-0.4cm, obtuse; lateral sepals 0.7-0.8 x 0.4-0.5 cm, subelliptic, base adnate to column foot, apex obtuse. *Petals* 0.7 – 0.8 × 0.4 – 0.5 cm, obovate-spatulate, obtuse. *Lip* 3-lobed; lateral lobes erect, ca 5 x 1.5mm, subfusiform, adaxially with a slightly thickened longitudinal ridge close to proximal margin, apex subtruncate; mid-lobe flat, ca 7 x 3mm, spatulate, base with a broad furcate-lobed appendage, apex rounded; spur ca. 3 mm; callus biseriate, posterior callus fleshy, bidentate, on back wall of spur, anterior callus ligulate, deeply bifid, attached to front wall at base of mid-lobe. *Column* ca 5 mm, stout, broadly dilated at stigma, foot ca 3 mm.

Colour Plate 25

Flowering: April - May

Habitat and Ecology: Epiphytic and found growing on tree trunk by the side of a road, 2000-2200m

Distribution: India (Meghalaya, Nagaland, Sikkim, West Bengal), Bhutan, Myanmar, Nepal, Thailand

Specimens examined: Naltoqa village (Zunheboto district) HYJ275 (NUH), Mangakhi village (Tuensang district) HYJ293 (NUH).

4. Phalaenopsis yingjiangensis (Z.H.Tsi) Kocyan & Schuit. in Phytotaxa 161(1): 67. 2014. *Ornithochilus yingjiangensis* Z.H. Tsi in Acta Phytotax. Sin. 22: 479. 1984.

Plant 15-20cm. *Roots* long fleshy, cylindrical, 8-20cm long. *Stem* 2-4.5 x 0.4-1.2cm, concealed by leaf base. *Leaves* 2-4, obliquely elliptic-oblong, 8-19 x 2.4-4.6cm, apex acute and curved, glabrous, upper surface green, lower pale green. *Inflorescence* 10-23cm long, 1-2 axillary racemes, pendulous; loosely 8-18 flowered; peduncle and rachis slender, rachis 8-13cm long; floral bracts triangulate, 2-2.3 x 1.6-2mm, apex acute, persistent. *Flowers* resupinate, 1.2-1.5cm across; pedicellate ovary 0.7-0.9cm long, slender, straight. Sepals and petals obtuse, spreading. *Dorsal sepal* ovate, 6-7 x 3-3.5mm, apex obtuse and incurved, 3-veined.; lateral sepals obliquely ovate, 6-8 x 4–4.4mm, apex obtuse, greenish, 4-veined. *Petals* oblong, 4.5–6 x 1.4-2mm, apex obtuse, 1-veined. *Lip* 3-lobed; side lobes auriculate, margin irregular, suberect; midlobe reniform-cordate, 5-6.2 x 6-6.4mm, apex broadly emarginate, margin crenate-undulate, incurved; spur subcylindric. *Column* whitish, 4.3–5 x 2.4-3mm, glabrous. *Fruits* not seen.

Colour Plate 25

Flowering: June - July.

Habitat and Ecology: Epiphytic and found growing on tree trunk in an undisturbed forest, 1800-2100m.

Distribution: NE India (Mizoram, Nagaland), China and Thailand.

Specimen Examined: Helipong village area (Tuensang district) by Temjennokcha in 2016, Mtsugho, Tsutoho an Aotsakilimi village (Zunheboto district) HYJ294 (NUH).

PHOLIDOTA Lindl. ex Hook.

Exot. Fl. 2:138. 1825

The genus was described by John Lindley in 1825. The generic name is derived from the Greek word "*Pholidotos*" (scaly) referring to large inflorescence bracts or large sheaths surrounding the pseudobulbs.

10 species in India, 10 in Nagaland and 3 spp. documented by the author.

Key to species

1. Inflorescence terminal to pseudobulb, arising between leaves..…... *P. articulata*
- Inflorescence lateral to pseudobulb …….. 2
2. Leaves solitary, broadly elliptic, lanceolate; lip 3-lobed ……..…… *P. pygmaea*
- Leaves 2, narrowly elliptic; lip entire, not lobed ……...… *P. convallariae*

1. Pholidota articulata Lindl., Gen. Sp. Orchid. Pl. 38. 1830; Hook. f., Fl. Brit. India 5 : 844. 1890; King & Pantl. in Ann .Roy. Bot. Gard. Calc. 8: 146. t. 205. 1898; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 589. fig 358. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 245. 2000. *Pholidota khasyana* Rchb. f. in Bonplandia 4: 329. 1856. *Coelogyne articulata* (Lindl.) Rchb. f. in Walpers, Ann. Bot. Syst. 6: 238.1862.

Pseudobulbs connected to each other at both ends, subcylindric, 4-7 x 1-1.4cm, narrowed towards apex, branching usually from one pseudobulb to other, with very short rhizomes between them, rhizomes producing a few roots. *Leaves* 2, at apex of new pseudobulb,8-14 x 2.2 -3.2-5cm, obovate-elliptic, oblong narrowly elliptic, veins plicate, subacute or obtuse; petiole 1-1.2cm. *Inflorescence* at apex of new pseudobulb, 6-14cm; rachis 9 or more flowered, ± flexuous; floral bracts 0.4-0.5 x 0.5-0.6 cm. narrowly ovate-oblong. *Flowers* greenish white or white and slightly tinged with reddish; pedicel and ovary 6-7mm. *Dorsal sepal* 0.6-0.9 x0. 4-0.5cm, oblong or elliptic, concave, dorsally carinate, 5-veined; lateral sepals ovate, oblique, slightly wider than dorsal sepal. *Petals* 0.5-0.7 x ca0.4cm, oblong-lanceolate or suboblanceolate, 5-veined. *Lip* broadly oblong in outline, contracted at apex into epichile and hypochile; hypochile cymbiform, slightly wider than epichile, qith 5 longitudinal lamellae near base; epichile transversely elliptic, 3-4mm wide, margin crisped. *Column* 2.5-3mm, ca. 1 mm wide, stout, apex winged; rostellum broadly ovate, ca 1.8mm. *Capsule* ca 1.2cm, ellipsoid to obovoid-ellipsoid.

Colour Plate 25

Flowering: April - May

Ecology: Epiphytic and found growing on tree trunk in an undisturbed, 1500-2900m

Distribution: India (Arunachal, Assam, Meghalaya, Nagaland, Sikkim, West Bengal), Bhutan, Nepal, Myanmar, Thailand, Cambodia, Vietnam, Sumatra, Java

Specimens examined: Longmatra, Nitoi village (Kiphire District) HYJ 107 (NUH), Pangsha village, anangba, Melangkiur (Tuensang District) HYJ288 (NUH), Aghunato, Satoi, Asukhomi, Naghuto village (Zunheboto District) HYJ330 (NUH)

2. Pholidota convallariae (E.C.Parish & Rchb.f.) Hook.f. Ic. Pl. 19t. 1880. 1889; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 589. fig 359. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 247. fig. 76. 2000. *Coelogyne convallariae* E.C.Parish & Rchb.f.Flora 55: 277. 1872. *Pholidota fragrans* Ridl.. Fed. Malay States Mus. 8(4): 106 1917.

Rhizome creeping and covered with scaly sheaths. *Pseudobulbs* 2.5-5 x ca. 1.5cm narrowly ovoid, apex 2-leaved. *Leaves* 2, arising from apex of pseudobulb, 15-18 x 2-2.5 cm narrowly elliptic, obtuse or shortly acuminate; petiole 1-2cm. *Inflorescence* 12-14cm arising with young pseudobulb and young leaves from base of last pseudobulb; rachis 10-14 or more flowered; floral bracts , 1-1.5cm. caducous, linear. *Flowers* fragrant, white or creamy white, with a pale green center, 0.5-0.6cm across; pedicel and ovary ca. 5 mm. *Dorsal sepal* 0.4-0.5 x ca 0.3cm suboblong or elliptic, obtuse; lateral sepals obliquely ovate and slightly wider than dorsal sepal. *Petals* 0.4-0.45 x ca. 0.3cm, ovate-elliptic, obtuse; lip shallowly saccate, ca. 4 mm, apex emarginate, base with 3 longitudinal lamellae ca. 1 mm. *Column* ca. 1.7 mm, stout, apex with a broad wing ca. 1.4 mm high; rostellum nearly transversely oblong, ca. 1.5 mm wide.

Colour Plate 26

Flowering: May - June

Ecology: Epiphytic and found growing on branch of tree, 1800-2500m

Distribution: India (Arunachal, Manipur, Meghalaya, Nagaland, Sikkim), Bhutan, Nepal, Myanmar, Thailand, Cambodia, Vietnam, Sumatra, Java.

Specimens examined: Nitoi village (Kiphire District) HYJ342 (NUH), Anangba village (Tuensang District) HYJ329 (NUH), Naghuto village (Zunheboto District) HYJ351 (NUH).

3. Pholidota pygmaea H.J. Chowdhery & G.D. Pal in Nordic J. Bot. 15: 411 1995; Chowlu *et al*. J. Orchid Soc. India 27 (1–2): 89-92.2013.

Pseudobulbs 3-3.4 x 2.5-2.7cm, clustered, smooth, sheathed at base, green in colour. *Leaves* solitary, 17-23.0 x 4.3-5.4cm, broadly elliptic, lanceolate, acute at apex, coriaceous, petiole 5–8 mm long. *Inflorescence* 30–36 cm long, curved, peduncle 11-15cm long, terete, rachis 16-22cm long, densely many-flowered; floral bracts 6.0-8.0 x 4.5-5.5 mm, ovate–round; pedicel ovary ca 5 mm long, pale green; flower 4-6mm across, creamy. *Sepals* unequal, creamy; dorsal sepal 4-6 x 3.4-5mm, ovate, acute, the lateral ones 6.5-8 x 3.0-3.4mm, oblong, acute with winged keel; petals 3.5-4 x 1.4-2mm, linear, obtuse, creamy; lip 5-7 x 4-4.5mm, trilobed, orbicular; apical lobe strongly decurved; column 3-3.4 x 2.5-3mm, creamy.

Colour Plate 26

Flowering: August - September

Ecology: Epiphytic and found growing on branch of tree 1200m.

Distribution: Endemic to NE India (Arunachal Pradesh, Manipur, Nagaland).

Specimen Examined: Chare village (Tuensang district) HYJ035 (NUH).

PINALIA Lindl.

Orchid. Scelet. 14, 21, 23. 1826

The Genus *Pinalia* was part of the genus *Eria* prior to 2005, but eventually it has become an accepted name of its own. It belongs to the subtribe. Eriinae Bentham (Tribe Podochileae Pfitzer) and comprises about 160 species (Cribb & Ng in Pridgeon *et al*. 2005) worldwide.

9 species are found in Nagaland and 6 species is reported by the author.

Key to species

1. Stems or pseudobulbs consisting of 1 distinct internode ……..….. *P. excavata*
- Stems or pseudobulbs consisting of several internode ……..…..…. 2
2. Plants reed like ……..……..…. *P. paniculata*
- Plants pseudobulbous ……...…… 3
3. Leaves terete ……....……. *P. pannea*
- Leaves flat ……..…… 4
4. Pseudobulbs long cylindric; sepals and petals pure white ……. *P. graminifolia*
- Pseudobulbs flask like and stacked; sepals and petals greenish or yellow 5
5. Sepals and petals whitish green; leaf apex obtuse, emarginated …. *P. acervata*

- Sepals and petals yellow with red veins; leaf apex acute …….. *P. amica*

1. Pinalia acervata (Lindl.) Kze., Rev. Gen. 2: 679. 1891. *Eria acervata* Lindl. in J. Hort. Soc. 6. 57. 1851; Paxt, Fl. Gard. 1 : 170. 1852; Hook.f., Fl. Brit. India 5. 796. 1890; King & Pantl. in Ann. Roy. Bot. Gard. Calcutta 8. 123. t. 170. 1898; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 350. fig. 207. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 168. Fig. 53. 2000. *Eria poilanei* Gagnep. Bull. Mus. Nat. Hist. (Paris) 2: Ser. 2, 3: 310, 1930, syn. Nov.- Gagnepain 355. 1934.

Plant 10-13 cm. *Rhizome* stout 0.3-0.4 cm thick with fibrous sheaths. *Roots* ca 1.5 mm thick. *Pseudobulbs* usually 2 or 3, sometimes 6-8, 2-4-0.5 - 1.4 cm, closely and regularly arranged into a row, fusiform, bottle-shaped, sometimes compressed, apex 2–4 - leaved. *Leaves* 6-10 x 0.9-2.0cm, oblong - lanceolate, sessile, narrow towards base, apex obtuse and slightly unequally 2-lobed. *Inflorescence* 1-3, axillary racemes and 4-7 flowered, 3-6 cm; rachis glabrous; floral bracts ovate or ovate-lanceolate, 0.5-1.0cm, margin sparsely denticulate, apex long acuminate. *Flowers* ca 0.6 x 0.2cm, cream white, sepals tinged green at apex, lip yellow; pedicel and ovary ca. 1cm. *Dorsal sepal* narrowly ovate, 5-veined, acuminate; lateral sepals ca 0.8 x 0.4-0.5cm, falcate - lanceolate, acuminate. *Petals* ca 0.5 x 0.2 cm, lanceolate, obtuse. *Lip* ca 0.6 x 0.5cm, broadly cuneate in outline, base attached to column foot at a right angle, 3-lobed; lateral lobes falcate-oblong, ca 0.2cm wide; mid-lobe orbicular, ca 0.3 x 0.3cm; disc with 3 keeled lamellae from base to middle of mid-lobe. *Column* ca 0.3cm; foot ca0.4 cm. *Pollinia* obovoid.

Colour Plate 26

Flowering: July - August

Habitat and Ecology: Epiphytic or lithophytic and found growing on tree branches in shaded area with diffused sunlight as well as on crack of rock, 400- 1500m.

Distribution: India (Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim Northern & Southern India), Bhutan, Myanmar, Thailand, Malaysia.

Specimens examined: Lumami village (Zunheboto district) HYJ048 (NUH), Chare (Tuensang district) HYJ305 (NUH), Longmatra (Kiphire district) HYJ339 (NUH).

2. Pinalia amica (Rchb.f.) Kuntze, Revis. Gen. Pl. 2: 679. 1891. *Eria amica* Rchb. f., Xenia Orchid. 2: 162, t. 168. 1870; Hook. f., Fl. Brit. India 5: 800. 1890; King & Pantl. in Ann .Roy. Bot. Gard. Calc. 8: 120. t. 169. 1898; Hynniewta, Kataki &

Wadhwa, Orch. Nagaland (BSI), 170. 2000. *Eria andersonii* Hook. f., Fl. Brit. Ind. 5(2): 795. 1890. *Eria confusa* (Hook. f.) Kuntze, *loc. cit*. 1891.

Pseudobulbs 3.5-8 x 0.8-1.9 cm, fusiform or cylindric, clustered. *Leaves* 1 to 3 from apex of pseudobulb, 8-18 x 0.8-2.0 cm, linear, oblong, or ovate-elliptic, base attenuate to short petiole or subsessile, apex acute. *Inflorescence* 1-2, 3-7.5 cm, usually arising from middle or upper part of pseudobulb, suberect, sparsely 4-8-flowered; rachis with dense hairs; floral bracts 0.7-1 x ca 0.2-0.4 cm, elliptic or elliptic-lanceolate, glabrous. *Flowers* translucent-yellow with red veins, lip pink with bright yellow apex, lateral lobes and keels brownish-red; pedicel and ovary ca 1.5 cm with dense hairs. *Dorsal sepal* 0.7-1.0 x ca 0.3 cm, oblong-lanceolate, obtuse; lateral sepals sub-similar, obliquely ovate-triangular, acuminate; mentum ca 3 mm. *Petals* 0.8-0.9 x ca 3 mm, obovate-lanceolate, acuminate. *Lip* 0.7-0.8 x ca 0.5 cm, subobovate-elliptic in outline, 3-lobed; lateral lobes ca 0.3 x 0.15 mm, incurved, ovate-elliptic, obtuse; mid-lobe ca 0.4 x 0.4 cm, reniform, fleshy except for middle part, apex emarginate; disk with 3 lamellae; central lamella extending to mid-lobe and thickened there, lateral 2 to near base of mid-lobe and thickened in apical half. *Column* ca 4 mm, foot ca 3 mm. *Capsule* ca 3 x 0.3 cm, obovoid-cylindric.

Colour Plate 26

Flowering: March - April

Habitat and Ecology: Epiphytic and growing on branch of tree in a disturbed forest.

Distribution: India (Arunachal, Assam, Meghalaya, Nagaland, Sikkim) Bhutan, China, Cambodia, Laos, Myanmar, Nepal, Thailand, Vietnam.

Specimen examined: Nokhu village (Tuensang District) HYJ355 (NUH).

3. Pinalia excavata (Lindl.) Kuntze, revis. Gen. Pl. 2. 679. 1891. *Eria excavata* Lindl., gen. sp. orchid. Pl.: 67. 1830; Hook. f., Fl. Brit. India 5: 795. 1890; King & Pantl. in Ann. Roy. Bot. Gard. Calcutta 8: 124, t. 171. 1898; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 363. fig. 217. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 176. fig. 57 2000. *Eria flava var. rubida* Lindl. in J. Proc. Linn. Soc., Bot. 3. 49. 1859. *Eria sphaerochila* lindl., op. cit. 54. 1859.

Plant 15-20cm. *Pseudobulbs* 1-3.3 x 0.2-0.5 cm, with one distinct internode, cylindric, tapering at end, compressed. *Leaves* 4-6, 8-13 x 1-1.4cm, oblong-lanceolate to elliptic lanceolate, acute, overlapping at base, many veined, petiolate; petiole grooved ca 12 cm long. *Inflorescence* 1, laxly 6-10 flowered, terminal, erect to

slightly decurved, racemose; peduncle sheathless, pubescent, 2-4cm long; rachis ca 2cm, reddish, pubescent; floral bracts 0.6-0.8 x ca 0.2 cm long, lanceolate, long-acuminate, glabrous. *Flowers* 0.8-1cm across, pale creamish; lip with yellow red markings; pedicel and ovary 0.6-0.9cm, long reddish-pubescent. *Sepals* 0.5-0.7 x 0.4-0.5cm long, 3-veined, pubesecent externally, sub-similiar; dorsal sepal elliptic-lanceolate, acute ; lateral sepals ovate-lanceolate, subacute, falcate. *Petals* 0.6-0.7 x 0.-0.4cm long, slightly smaller than sepals, obtuse, lanceolate, 3-veined. *Lip* 0.5-0.6 x 0.4-0.6cm, 3-lobed, sessile; lateral lobes erect, rounded; mid-lobe decurved, transeversely oblong cordate, apex acute, occasionally emarginated; disc with variable calluses, usually 2-callose basally. *Column* ca 0.3 cm long deeply excavate. *Pollinia* sub-clavate.

Colour Plate 26

Flowering: June - July

Habitat and Ecology: Epiphytic as well as lithophytic and found growing on tree trunks and lithophytic on rocks in forests predominant, 1800-2200m.

Distribution: India (Arunachal, Manipur, Meghalaya, Nagaland, Sikkim), Myanmar. Nepal.

Specimens examined: Seyochung (Kiphire district) HYJ326 (NUH), Chiang mai village (Tuensang district) HYJ314 (NUH), Nalto village (Zunheboto district) HYJ340 (NUH).

4. Pinalia graminifolia (Lindl.) Kuntze, Revis. Gen. Pl. 2. 679. 1891. *Eria graminifolia* Lindl. in J. Proc. Linn. Soc., Bot 3. 54. 1859; Hook. f., Fl. Brit. India 5: 794. 1890; King & Pantl. in. Ann. Roy. Bot. Gard. Calc. 8. 120. t. 164. 1898; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 367. fig. 219. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 176. fig. 58. 2000.

Plant 18-22cm. *Pseudobulbs* 9-14 x 0.4-0.8cm, sheathed when young, narrowly cylindrical; sheaths 2-8 x 0.6-1.0cm, tubular, membraneous and fibrous. *Leaves* 2-6, 9-15 x 1-2.4cm, linear-lanceolate, acuminate, narrow towards base, petiolate shortly, membraneous, many-veined, clustered at apex of pseudobulb; petiole 0.4-0.5cm, grooved. *Infloresecences* 2 or 3 arising from pseudobulb apex among young leaves, 8-10 flowered, erect, racemose; peduncle 2-3cm, short, glandular-pubescent; rachis 0.6-1cm long, glandular-pubescent; floral bracts 0.5-0.6 x 0.1-0.2cm,ovate-lanceolate, acuminate, apical margins fimbriate. *Flowers* ca 1 cm

across; sepals and petals white, lip lateral lobes red, disc ridges yellow-white; pedicel and ovary 0.7-0.8cm long, glandular-pubesecent. *Sepals* 0.7-0.9 x 0.3-0.4cm, subsimiliar, elliptic-lanceolate, acute to acuminate, 3 to 5 veined; lateral sepals weakly falcate. *Petals* 0.8-0.9 x 0.2-0.3cm, oblong, subacute, weakly falcate, 3-veined. *Lip* 0.4-0.5 x 0.4-0.4 cm, 3-lobed; lateral lobes oblong, erect, obtuse, incurved; mid-lobe emarginated, transversely oblong; Disc with 3 parallel ridges at base, central ridge extending into a large, oblong callus on mid-lobe. *Column* ca 0.3-0.4 cm long, white, purple flushed in front; foot short, puberulous. *Pollinia* linear-clavate.

Colour Plate 26

Flowering: June - July

Habitat and Ecology: Epiphytic or lithophytic and found growing on tree trunk in forest predominant with rhododendron as well as lithophytic on rocks, 2700m.

Distribution: India (Arunachal, Assam, Meghalaya, Nagaland, Sikkim), Myanmar. Nepal.

Specimens examined: Thanamir village – Saramati range (Kiphire district) HYJ060 (NUH), Satoi (Zunheboto district) HYJ341 (NUH).

5. Pinalia paniculata (Lindl.) Kuntze, Revis. Gen. Pl. 2. 679. 1891. *Eria paniculata* Lindl. in Wall., Pl. Asiat. Rar. 1. 32, t. 36. 1830; Hook. f., Fl. Brit. India 5 : 789. 1890; king & Pantl. in . Ann. Roy. Bot. Gard. Calc. 8. 126. t. 174. 1898; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 373. fig. 223. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 179. fig. 59. 2000. *Dendrobium floribundum* D. Don, Prodr. Fl. Nepal.34. 1825.

Plant reed-like 30-37 cm. *Stems* caespitose, woody, pendent, covered in sheaths; sheaths tubular, 2-4 cm long. *Leaves* 8-10 sometimes many, 10-23 x 0.7-0.8 cm thick, along stem, linear to linear-oblong, acuminate, fleshy, sub-sessile, to shortly petiolate, jointed, sheathing at base. *Inflorescences* 2-4, terminal, fasciculate to paniculate, densely many flowered; peduncle 4-6cm long, sheathed, wooly-pubescent; sheaths long-lanceolate; rachis 8-19cm long, wooly pubescent; floral bracts 0.5-0.7 x 0.2-0.3 cm, acuminate, lanceolate, falcate, glabrous. *Flowers* 0.3-0.5cm across, acrid scented; sepals pale yellowish green, petals, lip and column pale greenish with brownish-purple blotches, lip callus white; pedicel and ovary wooly-pubescent, 0.4-0.6cm long. *Sepals* 0.4-0.6 x 0.3-0.4 cm; dorsal sepal ovate; lateral sepals triangular,

weakly falcate, spreading, puberulent externally. *Petals* 0.3-0.4 x ca 0.2cm, elliptic obovate, margins weakly erose. *Lip* 3-lobed, 0.4-0.5 x 0.3-0.4cm; lateral lobes oblong, weakly falcate, subacute, porrect; mid-lobe broadly sub-orbicular, decurved, margins erose; disc 2 callose; basal callus round, and with a large, cylindric callus from base to apex. *Column* 0.3 cm long, stout; foot narrow.

Colour Plate 27

Flowering: March - April

Habitat and Ecology: Terrestrial or epiphytic and found growing on tree trunk in shaded forest and terrestrial humus rich soil, 1200-2300m.

Distribution: India (Arunachal, Meghalaya, Nagaland, Sikkim), Myanmar. Nepal, Thailand, Cambodia.

Specimens examined: Sikimi village & Saramati range (Kiphiri district) HYJ028 (NUH), Aizuto (Zunheboto district) HYJ033 (NUH).

6. Pinalia pannea (Lindl.) Kuntze, *loc. cit.* 1891. *Eria pannea* Lindl. in Bot. Reg. 28: misc.64, no. 79. 1842; Hook. f. Fl. Brit. India 5. 804. 1890; King & Pantl. in. Ann Roy. Bot. Gard. Calc. 8. 127, t. 176. 1898; Panigrahi & Naik, Bull. Bot. Surv. India, 3 (3 & 4): 361 – 388. 1961; Pradhan, Indian Orch. 2: 357. 1979; Hegde, Orchids of Arunachal Pradesh, 54. 1984; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 373. Fig. 224; Kataki, Orch. Meghalaya, 85. Pl. 24 (3a & 3b). 1986; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 181. 2000; Chowlu & Das, Pleione 2 (1): 118 – 122. 2008. *Eria teretifolia* Griff., Notul. 3 : 298. 1851.

Plant 13-23cm. *Rhizome* slender, partly covered with white-hairy sheaths, internodes 3-5cm. *Leaves* 2-6, 4-20 x 0.2-0.5 cm, fleshy, laterally flattened, terete, linear. *Inflorescence* arising from between leaves, 1-5 flowered; peduncle 1-3 cm long, densely wooly; rachis 2-3cm long, weakly zig-zag, wooly; floral bracts 0.4-0.5 x 0.3-0.4 cm, lanceolate-ovate, acute, wooly externally. *Flowers* 1-2cm wide, yellow to pale green, fragrant, lip brown purplish, yellow within; pedicel and ovary 4-5 mm long, pubescent. *Sepals* 0.6-0.9 x 0.3-0.5 cm, elliptic-lanceolate to ovate-triangular, acute, densely white-wooly externally; lateral sepals weakly falcate; mentum curved, obtuse. *Petals* 0.3-0.4 x 0.2-0.3 cm, lanceolate-elliptic. *Lip* 0.6-0.8cm fleshy, ovate-oblong, obtuse, with a patch of white mealy hairiness near apex, margins weakly undulate; basal callus oblong –granular. *Column* 0.1-0.2 cm long, pubescent externally; foot curved. *Pollinia* clavate, in two groups.

Colour Plate 27

Flowering: May - July

Habitat and Ecology: Epiphytic or lithophytic and found growing on tree trunk in open forest, 600- 800m.

Distribution: India (Arunachal, Meghalaya, Nagaland, Sikkim), Bhutan, Borneo, Myanmar, Malaya, Thailand.

Specimens examined: Lumami & Sumi Shettsu village (Zunheboto district) HYJ044 (NUH), Peshu village – Thonoknyu (Tuensang District) HYJ098 (NUH).

PLEIONE D. Don

Prodr. Fl. Nepal. 36. 1825

The genus was described by David don in 1825. The genus is named after '*Pleione*', the mother of Pleiades (the daughter of atlas) in Greek mythology who were transformed into a cluster of stars by Zeus.

About 8 species are recorded from India, 3 in Nagaland and 3 reported by the author.

Key to species

1. Pseudobulbs elongated, ovoid, olive green; leaf solitary on pseudobulb ….. …… *P. humilis*
- Pseudobulbs more or less turbinate, umbonate, greenish, pale mottled brownish purple; leaves 2 on pseudobulb ……..… 2
2. Sheaths at base of leaves with nodular inflations; lip broadly elliptic, anterior half with entire or obscurely dentate margins ……..... *P. maculata*
- Sheaths at base of leaves without nodular inflations; lip ovate-orbicular, anterior half with deeply and irregularly dentate margins ……..... *P. praecox*

1. Pleione humilis (J.E.Smith) D. Don, Prodr. Fl. Nepal.: 37. 1825; Hook. f., Fl. Brit. India 5: 840. 1890; King & Pantl. in Ann .Roy. Bot. Gard. Calc. 8 : 139. t. 194. 1898; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 610. fig. 372 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 255. 2000. *Epidendrum humile* J.E. Sm., Ext. Bot. 2: 75. t. 98. 1806. *Coelogyne humilis* (J.E.Smith) Lindl. Coll. Bot. sub t. 37. 1821.

Pseudobulbs 2-6 x 0.8-2.3cm, flask shaped, tapering to apex, olive green. *Leaf* 1, 15-25 x 2.7-3.6cm, acute, oblanceolate to elliptic, produced after the flowers. *Inflorescence* 1 or 2 flowered; peduncle enclosed by scarious sheaths; floral bract 2-2.9 x 0.7-1.1cm, obovate, subacute to obtuse. *Flowers* pendant to spreading; sepals

and petals white, lip white spotted with crimson and yellow; pedicel and ovary 2-3cm long. *Dorsal sepal* 3.2-4.4 x 0.6-0.8cm, linear oblanceolate, subacute; lateral sepals 3.8-5.2 x 0.6-0.9 cm, obliquely oblanceolat. *Petals* 3-3.8 x 0.5-0.7cm, obliquely oblanceolate, obtuse. *Lip* 3.3-4.3 x 2.5-3.2cm, oblong-elliptic, emarginated, saccate at base, obscurely 3-lobed in front; lateral lobeserect – incurved; callus 5-7 bearded lamellae. *Column* broadly winged, irregularly dentate at apex.

Colour Plate 27

Flowering: March - April

Habitat and Ecology: Epiphytic or lithophytic and found growing on logged decaying wood, 2600m.

Distribution: India (Arunachal Pradesh, Nagaland, Sikkim, West Bengal) Nepal, Myanmar.

Specimens examined: Thanamir village-Saramati (Kiphire district) HYJ312 (NUH).

2. Pleione maculata (Lindl.) Lindl. & Paxton, Paxt. Fl. Gard. 2: 5, t.39. 1851; Seidenf. & Smitnd. Orch. Thailand, 2(1):133. t. 100. 1959; Hook. f., Fl. Brit. India 5: 841. 1890; King & Pantl. in Ann .Roy. Bot. Gard. Calc. 8 : 140. t. 195. 1898; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 615. fig. 374 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 256. 2000. *Coelogyne maculata* Lindl. Gen. Sp. Orch. Pl. 43. 1830. *Pleione diphylla* Lindl. in Paxton's Fl. Gard. 2: 66. 1851.

Pseudobulb 1-3 x 1- 2 cm, green, turbinate to pyriform, pale mottled brownish purple, usually with a short, indistinct neck, often enclosed in persistent, smooth sheaths. *Leaves* 2, 10-20 x 1.5-3.5 cm, elliptic-lanceolate to oblanceolate, papery, apex acute, sheaths at base of leaves with nodular inflations. *Inflorescence* appearing after leaves have fallen, erect; peduncle 5-6 cm, completely enclosed in several membranous sheaths; floral bract 1.5-3 cm cucullate, broadly obovate or suborbicular when flattened, covering ovary, apex obtuse. *Flower* white sometimes tinged purplish red, solitary, fragrant, suberect or spreading horizontally, lip with a yellow center and purple blotches on apical margin. *Dorsal sepal* 3-3.7 x 0.7-0.9 cm, oblong-lanceolate, apex obtuse; lateral sepals 3-3.8 x ca 1.0 cm, broadly lanceolate, falcate, slightly oblique, apex acute. *Petals* 3-4 x 0.7-0.8 cm, oblanceolate, usually falcate, apex acute. *Lip* 2.7-3.4 x 2.0-2.4 cm, ovate-oblong to broadly elliptic, conspicuously 3-lobed at or below middle; lateral lobes small; mid-lobe ca 1 cm, margin erose, apex emarginate; disk with 5-7 papillate-toothed lamellae; central 2 or 3 lamellae arising at base of lip

and extending almost to apex of lip. *Column* ca 1.5 cm, ± arcuate, apex irregularly erose-toothed.

Colour Plate 27

Flowering: November - December

Habitat and Ecology: Epiphytic, sometimes lithophytic and found growing on tree trunk in a very old growth forest. 1500m.

Distribution: India (Arunachal, Meghalaya, Nagaland, Sikkim, West Bengal) Bhutan, China, Myanmar, Nepal, Thailand.

Specimens examined: Waoshou village (Tuensang district) HYJ321 (NUH).

3. Pleione praecox (J.E.Smith) D. Don, Prodr. Fl. Nepal.: 37. 1825; Hook. f., Fl. Brit. India 5 : 840. 1890; King & Pantl. in Ann .Roy. Bot. Gard. Calc. 8 : 141. t. 196. 1898; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 615. fig. 375 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 257. 2000. *Epidendrum praecox* J.E. Smith, Exot. Bot. 2 : 73, t. 97. 1806. *Coelogyne praecox* (J.E.Smith) Lindl., Coll. Bot.: sub t. 37. 1821.

Pseudobulbs 1.5-3.3 x 1.5-2cm, contracted, turbinate, green mottled with reddish brown to purplish. *Leaves* 1 or 2, 15-24 x 3-6cm, elliptic lanceolate to elliptic, acuminate, sheathed, at base; petiole 4-6cm; sheath red purple spotted. *Inflorescence* 1, produced after leaf have fallen; peduncle enclosed by ca 3 warty sheaths; floral bract ca 2.5 x 1.6cm, elliptic, acute. *Flowers* showy; sepals and petals white to pinkish purple, lip white and pink with yellow lamellae; pedicel and ovary ca 1.5cm long. *Sepals* similar, 4-7 x 0.7-1cm, narrowly oblong-lanceolate, acute. *Petals* 4-6 x 0.3-0.5cm, weakly falcate, linear lanceolate, acute. *Lip* 3-5 x 2.5-3cm, ovate-orbicular; mid-lobe emarginated, margins irregularly dentate-lacerate; callus of 3-5 pappilose lines to middle of mid-lobe. *Column* 3.5-4.5cm long, slender, incurved and dentate at apex. *Fruit* long-ellipsoid.

Colour Plate 27

Flowering: September - November.

Habitat and Ecology: Epiphytic or lithophytic and found growing on main tree trunk in a very old growth forest, 2000-2900.

Distribution: India (Arunachal, Meghalaya, Nagaland, Sikkim, West Bengal) Nepal, Myanmar.

Specimens examined: Thanamir village (Kiphire district) HYJ338 (NUH), Helipong and Melangkiur village (Tuensang district) HYJ068 (NUH), Satoi, Aghunato and Asukhomi Village (Zunheboto district) HYJ325 (NUH).

POLYSTACHYA Hook.

Exot. Fl. 2:t. 103. 1824 (*nom.cons.*)

The genus was described by Sir William Hooker in 1824. The generic name is derived from the Greek word "*poly*" (many) and "*stachys*" (ear of grain or spike)
1 species in India and reported as a new generic record for Nagaland by the author

1. Polystachya concreta (Jacq.) Garay & Sweet, Orcquideologia 9(3): 206. 1974; Seidenfaden in Opera Bot. 95: 14. 1988. *Epidendrum concretum* Jacquin, Enum. Syst. Pl. 30. 1760. *Onychium flavescens* Blume, Bijdr. 325. 1825. *Polystachya flavescens* (Blume) J.J. Smith, Fl. Buitenz.6: 285. Fig. 218. 1905; Pradhan, Indian Orch. Guide to Iden. Cult. 371.1979.

Plants variable in size, up to 13cm tall. *Stem* elongated, pseudobulbs slightly compressed, ovoid, clothed with leaf bases. *Leaves* 3-5, narrowly oblong or narrowly ovate-lanceolate, 7-17 x 1.2-3.5cm, bilobed at apex, base narrowed into a petiole, papery. Racemes terminal, 4-10 cm, often branched; rachis ± winged, 3-10 flowered. *Flowers* small, fleshy, greenish yellow; floral bracts narrowly lanceolate, 2-5mm; pedicel and ovary 7-11 mm. *Dorsal sepal* sub-ovate, acute, 3.4-4 x 1.5-2 mm; lateral sepals of similar size but broader, base forming a prominent mentum; petals linear-oblanceolate, 2.5-3 x 0.5-1mm. *Lip* 3.5-4mm, 3-lobed; lateral lobes incurved, ovate-oblong, small; mid-lobe orbicular, margin undulate and erose, apex emarginate, with a thickened central part; column 1-1.4mm long. *Capsules* ellipsoid, 1.2-1.5 cm x 4-6mm.

Colour Plate 27

Flowering: July

Habitat and Ecology: Epiphytic on *Syzygium* sp. 850m.

Distribution: India (Peninsula & Andaman & Nicobars, Arunachal Pradesh, Manipur and Nagaland), Myanmar, Thailand, Vietnam, Laos, southeastern China, Sri Lanka, Sumatra, Java, Malaysia.

Specimen cited: Lumami village (Zunheboto district) H.Y. Jakha 87 (NUH).

RENANTHERA Lour.

Fl. Cochinch. 516, 521. 1790.

The genus was described by Juan Loureiro in 1790. The generic name is derived from the Greek words ‘renes’ (kidney) and ‘anthera (anther) referring to the its kidney shaped anthers.

1 species reported from India, 1species from Nagaland and 1species reported by the author.

1. Renanthera imschootiana Rolfe in Kew Bull. 1891: 200 (1891); H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 626. fig. 382 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 258. 2000.

Stems upto 1 m, with contiguous and distichous leaves. *Leaves* 6-10 x 1.2 x 2.4 cm, leaf blade oblong, leathery, somewhat oblong-lanceolate, apex unequally bilobed and rounded. *Inflorescence* 50 x 80cm, axillary, usually branched, many flowered; peduncle and rachis slender; floral bracts ca 2 mm broadly ovate, apex obtuse. *Flowers* ca 4.5 cm across, brownish red; floral bracts 1-2 mm long, purplish green, ovate, acute. Dorsal sepal 1.5-1.7 x 0.4-0.5cm, subspatulate-oblanceolate, brownish red, obtuse, slightly keeled; lateral sepals 2-2.3 x 1-1.2cm, bright red with slightly brownish yellow, obliquely elliptic-ovate, margin undulate, apex obtuse; lip red with whitish markings; spur ca 2mm, obtuse, yellow with red tip; pedicel and ovary 2-2.3cm, reddish. *Petals* 1.2-1.3 x 0.2-0.3cm, brownish yellow, red spotted, linear spatulate. *Lip* 0.4-0.5cm long, 3-lobed; side lobes ca 3 mm erect, triangular, deltoid, exceeding column, base with 2 membranous lamellae, apex acute; mid-lobe ca 3 mm, ovate, acute, strongly recurved, base with 3 fleshy calli. *Column* 4-5mm long, terete, brownish red. *Pollinia* reniform.

Colour Plate 28

Flowering: April - May

Habitat and Ecology: Epiphytic and found growing on tree trunk in an undisturbed thick forest along a valley, 1700-2600m

Distribution: India (Arunachal, Nagaland, Sikkim) Nepal, Myanmar.

Specimens examined: Satoi village (Zunheboto district) HYJ034, Longmatra village (Kiphire district), Mimi village (Tuensang district).

RHYNCHOSTYLIS Bl.

Bijdr. 6:t. 49; 8: 285, 434. 1825

The genus was described by Carl Ludwig Blume in 1825. The generic name is derived from the Greek words '*rhynchos*' (a beak) and '*stylos*' (pillar). About 4 species distributed in India, Sri Lanka, Myanmar, S.E. Asia, Malaysia, Indonesia, Philippines.

1 species is recorded from India, 1 from Nagaland and 1 sp. reported by the author.

1. Rhynchostylis retusa (Linn.) Bl. Bijdr. 286. t. 49. 1825; Hook. f., Fl. Brit. India 6 : 32. 1890; King & Pantl. in Ann. Roy. Bot. Gard, Calc. 8: 213. 1898; Pradhan, Indian Orch. 2: 552. 1979; Kataki, Orch. Meghalaya 164. Pl. 61(1a, 1b, 1c) & N (iii). 1986; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 626. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 259. 2000. *Epidendrum retusum* Linn., Sp. Pl. 2: 953. 1753. *Aerides spicatum* D. Don, Prodr. Fl. Nepal.: 31. 1825.

Plant pendent. *Stems* stout, covered by leaf sheaths, sheaths overlapping, 1.5 - 2cm long. *Leaves* 14-38 x 1.5-3.4cm, distichous, spreading to arching, lorate, deeply chanelled, coriaceous, sessile, apex obliquely 2-lobed to retuse. *Inflorescence* emerging from leaf sheath, cylindric, pendulous, densely many flowered; peduncle 5-8cm long, 3-sheathed; rachis 26 – 34 cm long, glabrous; floral bracts 4-5 x 1.5-2mm, membranous, ovate, acute. *Flowers* 1.7-2.3cm across, unscented; sepals and petals white and spotted with pink or pale purple, lip purplish pink, apex white, spur white; pedicel and ovary 8-10 mm. *Dorsal sepal* 0.7-0.9 x 0.4-0.6cm broadly elliptic, obtuse; lateral sepals 0.8-1.1 x 0.5-0.7cm, obliquely ovate, obtuse. *Petals* 0.7-0.9 x 0.4-0.5cm, oblong ovate, rounded. *Lip* 1-1.2 x 0.7-0.8 cm, saccate spurred, at base, adnate to the column foot; epichile oblong-spatulate, apex rounded, apiculate slightly retuse; spur 6-7mm long, compressed, cylindric, obtuse to sub-truncste. *Column* ca 3 mm with foot ca 2 mm. *Capsule* ca 2.5 x 1.3 cm, ellipsoid.

Colour Plate 28

Flowering: April - May

Habitat and Ecology: Epiphytic and found growing on tree trunk in an open disturbed forest, 650-1600m.

Distribution: India (Arunachal, Assam, Manipur, Meghalaya, Nagaland, Sikkim, West Bengal) Bhutan, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Nepal, Philippines, Sri Lanka, Thailand, Vietnam.

Specimens examined: Longmatra village (Kiphire district) HYJ331 (NUH), Chare village (Tuensang district) HYJ306 (NUH), Mukhami, Lumami, Mukalimi, Mishilimi Village (Zunheboto district) HYJ289 (NUH).

SCHOENORCHIS Bl.

Bijdr. 6:t. 3. F. 23; 8: 361. 1825.

The genus was described by Carl Ludwig Blume in 1825. The generic name is derived from the Greek word '*schoenos*' (a reed, cord) referring to reed like stems of this genus.

6 species recorded from India, 1 sp. in ngaland and 1 sp. reported by the author.

1. Schoenorchis gemmata (Lindl.) J.J. Sm. in Nat. Tijd. Ned. Ind. 72: 100. 1912; Hook. f., Fl. Brit. India 6 : 56. 1890; Pradhan, Indian Orch. 526. 1979; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 638. fig. 380. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 60. fig. 81. 2000. *Saccolabium gemmatum* Lindl., in Bot. reg. 24. Misc. 50. No. 88. 1838. *Cleisostoma gemmatum* (Lindl.) King & Pantl. in Ann. Roy. Bot. Gard. Calc. 8:243. t. 313. 1898.

Stems 9-30cm long, terete, leafy, covered by leafy sheaths, usually pendulous; sheaths 0.8-1.5cm long, tubular, striate. *Leaves* 6-10 x 0.3-0.5cm, distichous, fleshy, curved, chanelled, apex unequally 2-3 lobed, base sheathing. *Inflorescence* sub erect to pendent, paniculate, laxly many; peduncle 2.5-4cm long, glabrous, sheathed; sheaths distant, lanceolate, adherent; rachis 3-5cm long, glabrous; floral bracts ovate-triangular, ca 1 mm. *Flowers* 3-4mm long; sepals white or bright purple with white apices, petals bright purple, lip white with purple on spur and lateral lobes, column and anther cap yellowish brown; pedicel and ovary ca 2 mm, purplish red. *Dorsal sepal* 1.5-2 x 0.8-1.2mm, ovate, 1-veined, obtuse; lateral sepals slightly obliquely ovate, 2-2.4 x 1.1-1.4 mm, dorsally slightly carinate, apex obtuse. *Petals* 0.9-1.4x ca 1mm, obovate - cuneate, 1-veined, apex truncate and emarginated. *Lip* 1.5-2 x 1-1.5mm, obscurely 3-lobed; lateral lobes, erect, rounded; mid-lobe obovate, obtuse to rounded, fleshy, surface rugose; spur straight and parallel to ovary, swollen at apex. *Column* fleshy, 2 horned at apex. *Fruit/ Capsule* subovoid.

Colour Plate 28

Flowering: March - April

Habitat and Ecology: Epiphytic and found growing on tree trunk in an open disturbed forest, 650-1600m.

Distribution: India (Arunachal, Manipur, Meghalaya, Nagaland, Sikkim, West Bengal), Bhutan, Cambodia, China, Myanmar, Nepal, Thailand, Vietnam.

Specimens examined: Noklak (Tuensang district) HYJ027 (NUH), Mukhami, Lumami, Mukalimi, Aizuto village (Zunheboto district) HYJ311 (NUH).

SMITINANDIA Holtt.

Gard. Bull. Singapore 25: 105.1969

The genus was described by R.E.Holttum in 1969. The genus is named after Tem Smitinand, an Orchidologist from Thailand and former director of the royal Thailand Department of Forestry. 1 sp. in India, 1 sp. in Nagaland and documented by the author.

1. Smitinandia micrantha (Lindl.) Holttum in Gard. Bull. Singapore 25: 106. 1969; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 642. fig. 391. 1998. *Saccolabium micranthum* Lindl., Gen. Sp. Orchid. Pl. 220. 1833. *Cleisostoma micranthum* (Lindl.) King & Pantl., in Ann. Roy. Bot. Gard. 8:234, t. 312. 1898.

Stems pendent to almost erect, terete, slightly flattened, 4-6cm, ca 7 mm in diam., internodes 1-1.3cm. Leaves 8-10 to more, 9-11 x 1.5-2.1cm, narrowly oblong, fleshy, base subrounded, apex obtuse and unequally bilobed. *Racemes* 1-2, opposite leaves, 8-10cm, densely many flowered; floral bracts ca 1.2mm, ovate-triangular, acute. *Flowers* 3-4mm in diam., opening widely, whitish pink to purple, anther cap white with yellowish brown midvein; pedicel and ovary ca 4mm. *Dorsal sepal* ca 3.5 x 1.5mm, subobovate, 3-veined, obtuse; lateral sepals ca 2.5 x 2mm, slightly oblique, ovate-triangular, 3-veined, acute. *Petals* ca 2 x 1 mm,narrowly oblong, 1-veined, margin ± scabrous, apex obtuse. *Lip* 3-lobed; lateral lobes erect, subquadrate, ca 1 mm; mid-lobe obovate-spatulate, ca 2 x 1.5 mm, base with a fleshy transverse appendage ± covering spur entrance, with 2 central ridges fused at apex, apex subacute; spur ca 2 x 1.5mm, oblong-conic, slightly laterally compressed, obtuse. *Column* ca 1mm; rostellum very short; anther cap beaked.

Colour Plate 28

Flowering: May - June

Habitat and Ecology: Epiphytic and found growing on main tree trunk in a disturbed forest 2400m.

Distribution: India (Arunachal, Assam, Manipur, Meghalaya, Nagaland, Sikkim, West Bengal), Bhutan, Nepal, Myanmar, Thailand, Laos, Cambodia, Vietnam and Malaysia.

Specimens examined: Izheto village (Zunheboto district) HYJ324 (NUH).

SPATHOGLOTTIS Bl.

Bijdr. 6: t. 2, f. 76; 8:400. 1825

The genus was described by Carl Ludwig Blume in 1825. The generic name is derived from the greek words "*spathe*" (spatula/spade) and *"glotta"* (tongue) referring to the broad mid-lobeof the lip. 3 species are found in India and 3 in Nagaland and 1 reported by the Author.

1. Spathoglottis pubescens Lindl., Gen. Sp. Orchid. Pl. 120. 1831; Hook. f., Fl. Brit. India 5 : 814. 1890; Seidenf. & Smitnd. Orch. Thailand, 3: 343. T. 262 B. 1961; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 643-646. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 262. 2000. *Epipactis graminifolia* Roxb., Fl. Ind. 3: 456. 1832. *Spathoglottis parviflora* Lindl. in Bot. Reg. t. 19. 1845. *Spathoglottis pubescens* var. *parviflora* (Lindl.) Hook. f. Fl. Brit India 5(2) : 814. 1890.

Pseudobulbs compressed dorsiventrally, globose, usually 1–2.5 cm in diam., usually covered with leathery scalelike sheaths. *Leaves* 1-3, 20-40 x 1-4.5 cm, linear-lanceolate, base acute. *Inflorescence* upto 50 cm, densely pubescent, lower part covered with several amplexicaul tubular sheaths; rachis 5-14 cm; floral bracts 0.6-0.8 cm, lanceolate to ovate-lanceolate, pubescent, apex acute. *Flowers* 3 upto 12 flowered sparsely, yellow, lip base spotted violet; pedicel and ovary ca 2.4 cm, densely pubescent. *Dorsal sepal* 1.4-1.7 x 0.5-0.8 cm, ovate-elliptic, outer surface pubescent, usually 5-7 veined, apex acute; lateral sepals similiar. *Petals*1.5-1.9 x 0.8-1.0 cm, 5 or 6 veined, broadly oblong, apex obtuse. *Lip* 1.5-1.6 x ca 1.2 cm, saccate at base, 2 small obtuse auricles at base of claw, 3-lobed; disk with 3 keels; lateral lobes oblong, deeply incised, apex rounded or truncate; mid-lobe obovate-cuneate, ca 1.2 cm, base with a distinct claw, apex subtruncate and emarginate; disk with a central ridge running from middle of claw to midway along mid-lobe; keels arising from base of lip, usually pubescent, outer 2 terminating at base of claw, central one divided at apex

in 2 fleshy, rounded-truncate extensions and terminating at base of mid-lobe. *Column* ca 1cm.

Colour Plate 28

Flowering: August - September

Habitat and Ecology: Terrestrial and found growing among grasses. 1600m.

Distribution India (Arunachla, Meghalya, Manipur, Meghalaya, Nagaland), Cambodia, China, Laos, Myanmar, Thailand, Vietnam.

Specimens examined: Kizare village (Kiphire district) HYJ354 (NUH), Helipong village (Tuensang district).

TAINIA Bl.

Bijdr. 6:t.5, f.48; 7:354. 1825

The genus was described by Carl Ludwig Blume in 1825. The generic name is derived from the Greek word '*tainia'* (band or ribbon/a fillet) referring to its unusually long petiole or to the elevated keels on the lip.

About 9 species are recorded from India, 3 in Nagaland and 2 sp. reported by the author.

Key to species

1. Lip 2- or 3-keeled …….. *T. latifolia*
- Lip 5-keeled ……..… *T. minor*

1. Tainia latifolia (Lindl.) Rchb. f. in Bonplandia 5:54. 1857; Hook.f., Fl. Brit. India 5:820. 1890; King & Pantl. in Ann. Roy. Gard. Calc 8:103, t. 142. 1898; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 657. fig. 399. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 268- 269. 2000. *Ania latifolia* Lindl., Gen. Sp. Orchid. Pl. 130. 1831. *Mitopetalum latifolium* (Lindl.) Bl., Mus. Bot. 2 : 185. 1856. *Tainia cordata* Hook. f., loc. cit 6(1):193. 1890. *Tainia khasiana* Hook.f., loc. cit. 1890.

Pseudobulbs 3-5 x 3-5cm, cylindric-ovoid, swollen towards base, covered with membranous sheaths. *Leaves* 14-38 x 4.2-11 cm, leaf blade elliptic or elliptic-lanceolate, papery,many veined, acuminate; petiole 4-5.5cm long. *Inflorescence* arising from base of pseudobulb, 16-28 laxly many flowered; peduncle 30-63 cm long; rachis ca 28 cm, deep brown; floral bracts 0.4-1.2 cm, narrowly lanceolate, triangular. *Flowers* opening simultaneously; sepals and petals dark chocolate brown,

greenish yellow towards apex, brown veins, lip light yellow, column yellow, anther cap with 2 purplish red appendages; pedicel and ovary ca 1.4 cm, ovary dilated. *Dorsal sepal* 1.2-1.9 x 0.2-0.4cm, elliptic to obovate, acute to obtuse; lateral sepals 1.3-2.0 x 0.3-0.5cm, elliptic to obliquely triangular, obtuse to sub acuminate. *Petals* 1.4-2.0 x 0.2-0.4cm, similar to lateral sepals, obliquely elliptic-obovate, subacuminate to obtuse. *Lip* 0.8-1.2 x 0.4 x 0.8cm, elliptic to ovate, normally 3-lobed; lateral lobes erect, ovate-triangular, acute; mid-lobe suborbicular or obovate, apex emarginate; callus 2 or 3 keeled. *Column* ca 9 mm arcuate, distal margin entire to slightly denticulate; foot ca 2 mm.

Colour Plate 28

Flowering: February - March

Habitat and Ecology: Terrestrial and found growing on loose soil with other grasses in an open disturbed forest, 700m.

Distribution: India (Arunachal, Assam, Manipur, Meghalaya, Nagaland, Sikkim, West Bengal) Bangladesh, Bhutan, China (Yunnan), Thailand, Laos, Vietnam.

Specimens examined: Sumi Shettsu Village (Zunheboto district) HYJ031 (NUH).

2. Tainia minor Hook. f. Fl. Brit. India, 5: 821. 1890; King & Pantl. in Ann. Roy. Bot. Gard. Calcutta, 8: 102, t. 141. 1898; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 661. fig. 400. 1998; Mishra, Orch. India, 317, 2007.

Pseudobulbs 2.8-6.3 x 0.6-1cm, cylindric-ovoid, covered by numerous tubular sheaths. *Leaves* 12-24 x 2.4-5.8cm, elliptic, acuminate, many – veined, apex acute; petiole 4-7cm long. *Inflorescence* terminal; peduncle sheathed; floral bracts narrowly ovate - lanceolate. *Flowers* 7-14, sub-erect, opening simultaneously; sepals and petals yellow to dull brownish green with deep purple lines and spots, lip yellow; pedicel and ovary 0.4-2cm long. *Dorsal sepal* narrowly oblong, 1.3-1.7 x 0.2-0.4cm; lateral sepals 1.2-1.8 x 0.2-0.3cm long, elliptic, falcate-oblong, obtuse to subacute. *Petals* 1.1 - 1.6 x 0.2 - 0.4 cm, obliquely elliptic to obovate, weakly falcate-oblong, obtuse. *Lip* 0.8-1.3 x 0.5-0.8cm, elliptic, 3-lobed; lateral lobes triangular, obtuse; midlobe orbicular, apex rounded and emarginated; callus 5-keeled, glabrous, thickened. *Column* 0.6-0.8 cm long, winged.

Colour Plate 29

Flowering: April - May

Habitat and Ecology: Terrestrial and found growing as an undergrowth along with organic litter in a sub-tropical forest, 1900m.

Distribution: India (Arunachal, Assam, Manipur, Meghalaya, Nagaland, Sikkim, West Bengal), Myanmar and China.

Specimen examined: Helipong village forest area, (Tuensang district) HYJ350 (NUH).

THRIXSPERMUM Lour.

Fl. Cochinch. 2: 516, 519. 1790.

The genus was described by Juan Loureiro in 1970. The generic name is derived from Greek words "*thrix*" (hair) and "*spermum*" (seed) referring to the hair like seeds. About 100 species are distributed widely from the Himalayas to Philippines and the tropical Islands of s.W. Pacific. 9 species are found in India and 1 species has been added to the flora of the country by the author from the state.

1. Thrixspermum laurisilvaticum (Fukuy.) Garay. Bot. Mus. Leafl. 23: 207 1972. *Sarcochilus laurisilvaticus* Fukuy. Bot. Mag. (Tokyo) 52: 246 1938. *Thrixspermum xanthanthum* Tuyama J. Jap. Bot. 16: 523 1940.

Stems ascending, less than 2.5cm. *Leaves* virtually basal, elliptic to linear-oblong, sometimes falcate, 2 – 6.5 x 0.6 – 1.2 cm, acute. *Inflorescence* ascending and pendulous, 3 – 4.5 cm, laxly 2-4-flowered; peduncle and rachis usually flexuous and slender; floral bracts ovate, 2-3 mm. *Flowers* opening simultaneously, lasting several days, well spaced, creamy yellow to yellowish, with pinkish to red spots on lip, lip mid-lobe reddish; pedicel and ovary 5.5-8 mm. *Dorsal sepal* elliptic, 0.6 – 0.8 x 0.4 – 0.5 cm, obtuse; lateral sepals 0.6 – 0.75 x 0.4 – 0.5 mm, obliquely ovate, obtuse or acute. *Petals* 0.6 – 0.7 x ca 0.25 mm, suboblong-spatulate, obtuse. *Lip* saccate at base, margin 3-lobed; lateral lobes erect, oblong, falcate, 6-7 mm; mid-lobe fleshy, small, mucronate; disk without a callus and with a tuft of purple hairs. *Column* ca. 3 mm, foot ca. 4 mm.

Colour Plate 29

Flowering: May - June

Ecology: Epiphytic and found growing on old growth tree trunk in a forest with, 1800m.

Distribution: India (Nagaland), China, Japan, Vietnam.

Specimens examined: Khashito village (Zunheboto district) HYJ356 (NUH).

THUNIA Rchb. f.

Bot. Zeit. (berlin) 10:764. 1852

The genus was described by Heinrich Gustav reichenbach in 1852. The generic name is in honour of Count Von Thun Hohenstein of Bohemia.

About 2 species is recorded from India, 1 Sp. in India and 1 sp. reported by the author.

1. Thunia alba (Lindl.) Reichb. f. in Bot. Zeit. 10 :764. 1852; Seidenf. & Smitnd. Orch. Thailand, 2(2) : 185. 1960; Hook. f., Fl. Brit. India 5 : 818. 1890; King & Pantl. in Ann. Roy. Bot. Gard, Calc. 8: 110. t. 153. 1898; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 666. fig. 404. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 270. 2000. *Phaius albus* Lindl. in Wall., Pl. Asiat. Rar. 2: 85, t. 198. 1831.

Stem 30-90cm long, stout, erect; basal sheaths 1.5-2.4cm, tubular, ovate, acute. *Leaves* ca 10 to many, 10-24 x 2.5 x 3.5cm; leaf blade narrowly elliptic or narrowly elliptic-lanceolate, papery or herbaceous, glaucous beneath, apex acuminate. *Inflorescence* pendent; peduncle 2-6cm long, short, sheathed; sheath 1, lanceolate, acute, tubular; rachis short, 2-4cm becoming scarious; floral bracts 3-4.5 x 0.8-1.4cm, large, oblong, boat shaped, papery. *Flowers* large, white, lip yellow and white with orange or chestnut spots and stripes; pedicel and ovary 1-1.5cm long. *Sepals* 4-6 x 1.2-1.4cm, narrowly oblong-ovate, subequal, free, apex acuminate. *Petals* 4.5-5 x 0.8-1.0cm almost similar to sepals in size, slightly narrower, oblong, acute. *Lip* 4-5 x 2.5-3cm, broadly ovate-oblong or broadly oblong-pandurate, irregularly fimbriate or erose, simple, spurred at base, apical margin crisped; disk with 5 - 9 shortly dentate-fimbriate ridges; spur cylindric, 1.4-1.5 x 0.2-0.3cm. *Column* 1.3-1.5cm long, expanded and winged at apex. *Fruit/Capsule* narrowly ellipsoid.

Colour Plate 29

Flowering: May - June

Ecology: Epiphytic or lithophytic/terrestrial and found growing on old growth tree trunk in a forest with shade as well as on rocks. 1400-2100m.

Distribution: India (Arunachal, Assam, Manipur, Meghalaya, Nagaland, Sikkim, West Bengal) Bhutan, China, Myanmar, Nepal, Thailand, Malaysia.

Specimens examined: Lizu Naghuto village (Zunheboto district) HYJ322 (NUH), Sikimi/Sikur village (Kiphire district), Mangakhi (Tuensang district).

UNCIFERA Lindl.

Jour. Linn. Soc. 3: 39. 1858.

The genus was described by John lindley in 1858. The generic name is derived from the Greek words '*uncus*' (a hook or barb) and '*fero*' (to bear) referring to the presence of the barbs. About 3 species recorded from India, 2 spp. From Nagaland and 1 sp. reported by the author.

1. Uncifera obtusifolia Lindl. in J. Linn. Soc. 3: 40. 1859; Pradhan, Indian Orchids. 2 :529. 1979; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 579. fig. 412. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 272. 2000. *Saccolabium obtusifolium* (Lindl.) Hook. f., Fl. Brit. India 6 : 65. 1890; King & Pantl. in Ann .Roy. Bot. Gard. Calc. 8 : 222. Pl. 295. 1898.

Plant 22-30cm, pendent. Stem 5-7mm diam., covered by leaf sheaths; sheaths 1.4 – 1.6 cm long, veined. *Leaves* 12-18 x 1.8-3.1cm, oblong,-elliptic, flat, apex inequally 2-lobed, lobules rounded, base narrowed, jointed. *Inflorescence* leaf-opposed, densely many flowered; peduncle 5-7cm, sheathed, glabrous; sheaths 5-8 x 4-7mm, broadly ovate, acute, distant; rachis 8-9cm long, glabrous; floral bracts 3.5-5 x 2-3mm, oblong-lanceolate, subacute. *Flowers* pale yellow, apices of sepals, petals and lip brighter yellow; pedicel and ovary 4 – 6 mm long. *Dorsal sepal* 3.5-5 x 2-3mm, obovate, obtuse, concave, 3 –veined; lateral sepals subsimiliar to dorsal sepal. *Petals* 3.5-5 x 2-3mm, broadly obovate, obtuse, 3-veined to apex. *Lip* 3-lobed, 3-4mm long, spurred; lateral lobes small, triangular; mid-lobe thickened, laterally compressed, 3-lobulate; spur 6-8 x 4-4.5mm (at base). funnel shaped, strongly curved forward, base broad, *Column* 2-3mm long; anther cap long beaked.

Colour Plate 29

Flowering: August - Sept

Habitat and Ecology: Epiphytic and found growing on branch of tree trunk in an open forest, 1400m.

Distribution: India (Arunachal, Assam, Manipur, Meghalaya, Nagaland, Sikkim,), Bhutan, Thailand.

Specimens examined: Hekiye village (Zunheboto district) HYJ322 (NUH).

VANDA W. Jones ex R. Br.

Bot. Reg.6.t. 506. 1820

The generic name is derived from the Sanskrit word referring to *Vanda tessallata* and to the common parasite '*Banda*' (Fam : Loranthaceae) meaning "tied to the host'.

About 40 species, widely distributed from India to S. E. Asia, Indo-China, New Guinea, Australia, Philippines to Taiwan and neighbouring Inlands. About 12 species in India, 8 spp. In Nagaland and 6 reported by the author.

Key to species

1. Flowers upto 2.1 cm across; stipe narrow …… 2
- Floweres upto 5 cm across or more ……...3
2. Flowers pinkish, orange to red ……..…… *V. ampullaceae*
- Flowers whitish to yellowish with purple markings on lip …….. *V. testacea*
3. Peduncle of inflorescence shorter than pedicel and ovary ……...…….... 4
- Peduncle of inflorescence exceeding the pedicel oand ovary ……. 5
4. Sepals and petals white ……...…… *V. pumila*
- Sepals and petals green to greenish white ……... *V. alpina*
5. Inflorescence shorter than the leaves; flowers distinctly tessellated, yellowish brown inside and violet externally, lip violet; disc smooth ……..….. *V. bicolor*
- Inflorescence longer than the leaves; flowers obscurely tessellated, blue colored throughout; lip deep blue; disc 2-ridged ……...…. *V. coerulea*

1. Vanda alpina (Lindl.) Lindl., Fol. Orch. Vanda 10. 1853; Hook. f., Fl. Brit. India 6 : 53. 1890; King & Pantl. in Ann. Roy. Bot. Gard, Calc. 8: 217. t. 289. 1898; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 683. fig. 413. 1998. *Luisia alpina* Lindl. in Bot. Reg. 24: misc. 56, no.101. 1838. *Trudelia alpina* (Lindl.) Garay in Orchid Digest 50(2): 76. 1986. *Stauropsis alpina* (Lindl.) T. Tang & F. T. Wang in Acta Phytotax. Sin. 1: 93. 1951.

Plant 15-20cm. *Roots* basal, 1-2mm thick. *Stems* 7-18cm tall, terete, covered by overlapping leaf sheaths; sheaths 0.6-1-.7cm long, veined. *Leaves* broadly linear to oblong, arched, slightly fleshy or thickly leathery, apex unequally 2-lobed, leaf blade 5-16 x 0.7-1.4cm. *Inflorescence* 2 or 3, 1 – 3 flowered; peduncle 1-2cm long, sheathed, glabrous, shorter than pedicel and ovary; sheaths ovate, subacute, 3-4mm long; rachis 0.5-1cm; floral bracts ovate - triangular, 2-3 x 1.5-2 mm, apex obtuse -

acute. *Flowers* pendent, thickly textured, not widely opening, 2.5-4 cm across, faintly scented; pedicel and ovary 1.2-1.5cm, yellowish green, slender, winged; sepals and petals green to yellow-green, not tessellated. *Sepal* 1-1.2 x 0.3-0.5cm, oblong - ovate, base cuneate, apex obtuse; lateral sepals 1.1-1.3 x 0.4-0.6cm, ovate-lanceolate, base cuneate, apex sub-acute. *Petals* 1-1.2 x 0.3-0.4cm, obliquely oblong-lanceolate, apex obtuse-acute. *Lip* 0.8-1 x 0.6-0.7cm, pale yellowish, apical lamina striped violet, fleshy, base concave, spurless, 3 - lobed; lateral lobes suberect, reddish purple, semi – circular, apex rounded; mid-lobe , broadly lanceolate, subacute to obtuse, apex recurved, margins weakly undulate. *Column* ca 3 mm long, broad, white.

Colour Plate 29

Flowering: July - August

Habitat and Ecology: Epiphytic and found growing on branch of tree in an open forest by the side of a river as well as on the main tree trunks, 1000-2100m.

Distribution: India (Arunachal, Meghalaya, Nagaland, Sikkim) Bhutan, China, Myanmar, Nepal, Thailand, Malaysia.

Specimens examined: New Longmatra village (Kiphire district) HYJ332 (NUH), Mangakhi (Tuensang district) HYJ353 (NUH), Tsaphimi village (Zunheboto district) HYJ322 (NUH).

2. Vanda ampullacea (Roxb.) L.M.Gardiner, Phytotaxa 61: 48. 2012, *comb. nov*. *Aerides ampullacea* Roxburgh, Fl. Ind., ed. 1832, 3: 476. 1832. *Saccolabium ampullaceum* (Roxb.) Lindl., Sert. Orchid. 4: t. 17. 1838; Hook. f., Fl. Brit. India 6 : 64. 1890; King & Pantl. in Ann .Roy. Bot. Gard. Calc. 8 : 220. t. 293. 1898. *Ascocentrum ampullaceum* (Roxb.) Schltr, Repert. Spec. Nov. Regni Veg. Beih. 1: 975. 1913; Seidenf. & Smitnd. Orch. Thailand, 4(1):598. t. 449. 1963; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 74. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 48. 2000. *Gastrochilus ampullaceus* (Roxb.) Kuntze, Revis. Gen. Pl. 2: 661. 1891. *Ascocentrum ampullaceum* var. *aurantiacum* Pradhan, Indian Orch.: Guide Identif. Cult. 2: 561. 1979.

Stems 1-4 cm, erect, stout. Root ca 0.4 cm Diam. *Leaves* 3-4 to 5, 5-18 x 1-1.5 cm, nearly basal, abaxially tinged reddish with age, adaxially yellowish green with purplish red spots, narrowly oblong flat, conduplicate in basal half, thickly leathery, apex praemorse. *Inflorescences* 2-4, 5-6.5 cm, erect, shorter than leaves, many flowered; peduncle and rachis greenish with red streak; floral bracts ca 1 mm, ovate-

triangular, acute. *Flowers* red to bright orange, 1.5-2.1 cm across. opening widely, anther cap and pollinia purplish; pedicel and ovary ca 1.3cm, pale orange to red. *Sepals* 0.7-0.9 x 0.3-0.5 cm, similar, narrowly ovate, obtuse. *Petals* 0.7-0.9 x 0.3-0.6, broadly ovate. *Lip* ca 0.9 cm long, 3-lobed; lateral lobes erect, subtriangular, very small, obtuse; mid-lobe narrowly oblong, or ligulate, 0.5-0.6 x ca 0.15 cm, apex obtuse to acute, base with 2 calli at spur entrance; spur pale, cylindric, ca 0.8 x 0.25 cm, apical half usually curved and slightly dilated. *Column* and distinct foot 2-3 mm long, thick.

Colour Plate 29

Flowering: April - May

Habitat and Ecology: Epiphytic and found growing on branches of trees as well as tree trunk in an open disturbed forest with diffused sunlight. 900-1700m.

Distribution: India (Arunachal, Assam, Manipur, Meghalya, Nagaland, Sikkim, Andaman Islands) Bangladesh, Bhutan, China, Laos, Myanmar, Nepal, Thailand, Vietnam.

Specimens examined: Chare village (Tuensang district) HYJ335 (NUH), Satoi village, Asukhomi village, Khashito village (Zunheboto district) HYJ103 (NUH).

3. Vanda bicolor Griff., Notul. Pl. 3: 354. 1851; Icon. Pl. Asiat.: t. 330.1851;Hook. f., Fl. Brit. India 6:52. 1890; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 683. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 274. 2000.

Plant 30-70cm. *Roots* 3-7mm thick, arising from between leaf sheaths, terete. *Stems* 18-35cm tall, covered by leaf sheaths; sheaths 2-2.3cm long, overlapping, veined. *Leaves* 14-20 x 1.8-2.4cm, curved, oblong, somewhat twisted in the middle, apex obliquely 2-lobed, lobules tridentate. *Inflorescence* arising from beteen leaf sheaths, laxly 3-6 flowered; peduncle 10-12cm long, sheathed, glabrous; sheaths distant, 3-4mm long, exceeding the pedicel oand ovary; rachis 2-4 cm long, glabrous; floral bracts 2-3 x 2-2.3 mm, base broad. *Flowers* 4-5cm across; sepals and petals distinctly tessellated, yellowish brown inside and violet externally, lip violet and golden coloured, spur white, column white; pedicel and ovary ca 4.6 cm long, slender. *Dorsal sepal* 2-2.2 x 0.5-1cm, obvate-spathulate, apex rounded, margins wavy, tessellated behind; lateral sepals ca 2.4 x 1.4cm, sub-similar, spreading. *Petals* 1.8-2.1 x 0.2-1cm, narrowly obovate-spathulate, rounded, margins wavy, tessellated behind. *Lip* ca 1.3 x 0.9cm, spurred, 3-lobed; lateral lobes broadly rounded to ovate; mid-lobe

hastate triangular, apex 2-lobed; disc 2-callose; spur conical, obtuse, pubescent. *Column* ca 5 x 3 mm, terete; anther cap flat, triangular, 3 x 2 mm. *Fruit* long stalked.

Colour Plate 30

Flowering: February - April

Habitat and Ecology: Found growing on branches of trees as well as tree trunk in an open disturbed forest with enough sunlight.

Distribution: India (Arunachal, Assam, Manipur, Nagaland) Bhutan.

Specimens examined: Noklak and Pangsha village (Tuensang district) HYJ352 (NUH), Mukalimi, Natsumi, Ghokimi, Naghutomi, V.K., Izheto and Lumami village (Zunheboto district) HYJ323 (NUH).

4. Vanda coerulea Griff. ex Lindl. in. Bot. Reg. 33:t. 30. 1847; Hook. f., Fl. Brit. India 6 : 51. 1890; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 683. fig. 414. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 275. 2000.

Plant 40-100cm. *Roots* 0.4-1.2cm thick. *Stems* 30-65cm, sometimes upto a 90cm. *Leaves* 1-1.8 x 1.8-3.4cm, thickly leathery, apex unequally 2-lobed. *Inflorescence* 1 - 3, 20-39 cm, sparsely 6-16 flowered; peduncle 15-20cm; rachis weakly zigzag, 9-28cm, exceeding the pedicel oand ovary; floral bracts 0.7-1 x 0.5-0.8 cm, broadly ovate,apex obtuse-acute. *Flowers* ca 5 x 5 cm across or more, widely opening, thinly textured; pedicel and ovary whitish blue, 2-3cm; sepals and petals sky-blue, tessellated. *Sepals* 3.7-5 x 1.7-3.4cm, similar, broadly obovate, base contracted into short claw, apex almost rounded. *Petals* 3-4.5 x 1.8-2.8cm, elliptic-obovate, base contracted into a short claw, apex almost rounded. *Lip* sky - blue, shorter than sepals, fleshy, spurred; lateral lobes 3.3-3.9 x 1-2 mm, erect, narrowly falcate, adaxially white with yellow spots, apex subacuminate; mid-lobe 1.7-2.5 x 0.5-0.7mm, deep blue, ligulate, base with a pair of calli, apex subtruncate and emarginate; disk with 3 longitudinal ridges; spur 0.5-0.7 x ca 0.3 cm, tubular, slightly conic, apex obtuse. *Column* ca 6 mm; anther cap ca 2 mm wide,white.

Colour Plate 30

Flowering: September - November

Habitat and Ecology: Epiphytic and found growing on branches of trees and tree trunk both an open disturbed forest and undisturbed forest with enough sunlight, 600-2300m.

Distribution: India (Arunachal, Assam, Manipur, Meghalaya, Nagaland, Sikkim) Indonesia, Myanmar, Nepal, Sri Lanka, Thailand, Java.

Specimens examined: Mukalimi, Mishilimi, Lazami, Chishilimi, Asukhomi, Alaphumi and Lumami village (Zunheboto district) HYJ337 (NUH), Sikimi/Sikur & Longmatra (Kiphire district), Chare, Pangsha & Melangkiur village (Tuensang district).

5. Vanda pumila Hook. f., Fl. Brit. India 6(1): 53. 1890; King & Pantl. in Ann .Roy. Bot. Gard. Calc. 8 : 216. t. 288. 1898; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 688. fig. 416. 1998. *Trudelia pumila* (Hook. f) Senghas in Schltr., orchideen ed.3, 1(19-20):1211. 1988.

Plant 22-30cm tall. *Roots* piercing through leaf sheaths. *Stems* 5-22cm tall, stout, arcuately ascending, covered by leaf sheaths; sheaths 1.6-1.8cm long, veined, overlapping. *Leaves* 9-22 x 1.4-2cm, oblong, curved, apex unequally 3-dentate, leaf blade. *Inflorescence* erect, laxly 2-3 flowered; peduncle 1.5-2.8 cm long, glabrous; rachis 2.8-3.3cm, zig-zag, glabrous, shorter than pedicel and ovary; floral bracts 2-4 x 2-3mm, elliptic-ovate, obtuse. *Flowers* 4-5.4cm across, fragrant; sepals and petals creamish yellow, lip pale cream to yellow, streaked with brick red to almost brown, column creamish white; pedicel and ovary 2-4.5cm, ridged. *Dorsal sepal* 1.8-2 x 0.5-0.7cm, oblanceolate, obtuse to subacute; lateral sepals 1.8-2.1 x 0.4-0.5cm, sub-similiar. *Petals* 2-2.2 x 0.7-0.9cm, linear, acute. *Lip* 1.5-1.9 x 0.6-0.8cm, saccately spurred, 3-lobed; lateral lobes ca 2.3 x 2.3 mm, triangular; mid-lobe ca 6 x 5 mm, broadly ovate, concave, surface 4-6 ridged, apex acuminate, with 2 knob like lumps; spur almost conical. *Column* 4-5 mm long, stout; anther cap 3 mm wide. Fruit shortly stalked, cylindric, deeply ridged.

Colour Plate 30

Flowering: March - April

Habitat and Ecology: Epiphytic and found growing on tree trunk by the side of a perennial river bank on open disturbed forest with enough sunlight, 900m.

Distribution: India (Arunachal, Meghalaya, Nagaland, Sikkim, West Bengal) China, Myanmar, Thailand, Laos, Vietnam and Sumatra.

Specimen examined: Between Sikimi/Sikur & Longmatra village (Kiphire district) HYJ352 (NUH), Nokhu village (Tuensang district).

6. Vanda testacea (Lindl.) Rchb. f. in Gard. Chron. 2: 166. 1877; Hook. f., Fl. Brit. India 6 : 50. 1890; King & Pantl. in Ann .Roy. Bot. Gard. Calc. 8 : 215. t. 288. 1896; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 688. fig. 417. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 276. 2000. *Aerides testacea* Lindl., Gen. So. Orchid. Pl.: 238. 1833. *Vanda parviflora*. Lindl. in Bot. Reg. 30 Misc. 45. 1835.

Plant 25-40cm. *Root* 0.8-1.2cm in diam., *Stem* about 20-34 cm long, erect, covered by leaf sheaths; sheaths 1.1-1.5cm long, overlapping. *Leaves* oblong, coriceous, apex unequally 2-lobed, 3-dentate, lobules triangular to rounded, leaf blade 8-12 x 1.2-1.7cm. *Inflorescence* laxly 7 - 11 - flowered; peduncle 6-15cm stout, sheathed; rachis 3.5-4cm; floral bracts 2-2.5 x 2.5-3mm, broadly ovate, acute. *Flowers* 1.8-2cm across; sepals and petals creamish yellow, lip white, purple to reddish pink; pedicel and ovary 1.2-1.8cm, slender. *Dorsal sepal* 0.8-1 x 0.2-0.5cm, obovate - spathulate, obtusely rounded and incurved at apex, spreading; lateral sepals 0.8-1.1 x 0.3-0.6cm, obovate-spathulate, falcate, apex rounded, incurved and twisted. Petals 0.7-0.8 x 0.1-0.5cm, spathualte, concave, base very narrow and twisted, spreading. *Lip* 0.6-0.8 x 0.2-0.4cm, spurred, sessile, 3-lobed; lateral lobes erect, oblong, obtuse; mid-lobe ca 6 x 3 mm, recurved, sub-quadrate to oblong, apex dilated, emarginated, margins crenulate;disc wuth 2 fleshy ridges; spur ca 3mm, narrow, funnel shaped. *Column* ca 3 mm long, truncate. *Fruit* long stalked, 2-3 x 0.7cm long.

Colour Plate 30

Flowering: March - May

Habitat and Ecology: Epiphytic and found growing on branches of trees in an open disturbed forest with sufficient sunlight, 600-1800m.

Distribution: India (Arunachal, Assam, Nagaland, Sikkim) China, Myanmar, Thailand, Sri lanka.

Specimens examined: Mukhami, Philimi, Tsaphimi and Ghokimi village, Mukhami village-V.K. Area(Zunheboto district) HYJ106 (NUH), Sikimi/Sikur and Longmatra village (Kiphire district), , Chare village & Noklak (Tuensang district).

VANDOPSIS Pfitzer

Engler & Prantl, Nat. Pflanzenfam. 2(6): 210:1889

The genus was described by E. Pfitzer in 1889. The generic name is given after Vanda and the Greek word ‘ opsis’ (resembles), due to its resemblance with the genus ‘Vanda’ . about 8 species in S.E. asia, S. china, Phillipines and New Guinea.

1 species recorded from India, 1 sp.from Nagaland and 1 sp. recorded by the author

1. Vandopsis undulata (Lindl.) J. J. Smith in Engler & Prantl, Nat. Pflanzenfam. 2(6) : 210. 1889; King & Pantl. in Ann. Roy. Bot. Gard, Calc. 8: 205. t. 275. 1898; H.J. Chowdhery, Orch. Fl. Arunachal Pradesh, 692. fig. 418. 1998; Hynniewta, Kataki & Wadhwa, Orch. Nagaland (BSI), 276. 2000. *Vanda undulata* Lindl. in Jour. Linn. soc.3: 42. 1859. *Stauropsis undulatus* (Lindl.) Benth ex Hook. f., Fl. Brit. India 6 : 27. 1890.

Plant 30-60cm. *Roots* ca 2 mm thick, piercing through leaf sheaths. *Stems* covered by leaf sheaths; sheaths 2.5-3.8cm long, warty. *Leaves* 5-12 x 1-1.7cm, oblong,apex unequally 2-lobed, lobules rounded, narrowed slightly at base. *Inflorescence* leaf opposed, laxly 3-4 flowered; peduncle 1.2-2.5 x ca 0.2cm long, glabrous, sheathed; sheaths 5-7mm long, distant, broadlyovate; rachis 3-12cm long, glabrous; floral bracts 6-8 × 3-4.5mm, ovate-lanceolate. *Flowers* 3-3.5cm across; sepals and petals white, lip yellow to white at apex, greenish yellow with purple streaks at base, anther cap pinkish; pedicel and ovary 1.7-2.4cm, slender. *Dorsal sepal* 2-2.2 x 0.2-0.6 cm, oblong - spathulate, 5- veined, margins undulate; lateral sepals 1.7-2.2 x 0.3-0.7cm, similar, spreading, yellow tinged at apex. *Petals* 2-2.2 x 0.2-0.6cm, narrowly oblong-spathulate, 5-veined, margins undulate. *Lip* 1.2-1.4 x ca 0.7cm long, fleshy, adnate to the column, 3-lobed; lateral lobes erect, rounded, surrounding the column; mid-lobe ca 6 x 5 mm, spathulate, truncate, laterally compressed; disc with 2-ridges from base. *Column* 3-4 x 2-2.5mm, stout. *Pollinia ca* 1 mm across; stipe 0.4-0.5mm.

Colour Plate 30

Flowering: March - April

Habitat and Ecology: Epiphytic or terrestrial/lithophytic and found growing on moss covered tree branch as well as on rocks by the side of the road, 1800-2600m.

Distribution: India (Arunachal, Assam, Manipur, Meghalaya, Sikkim, Nagaland, West Bengal) Bhutan. Nepal.

Specimens examined: Helipong and Melangkiur village (Tuensang district) HYJ 309 (NUH), Hutanger- amahotor (Kiphire district), Tsutoho village (Zunheboto district).

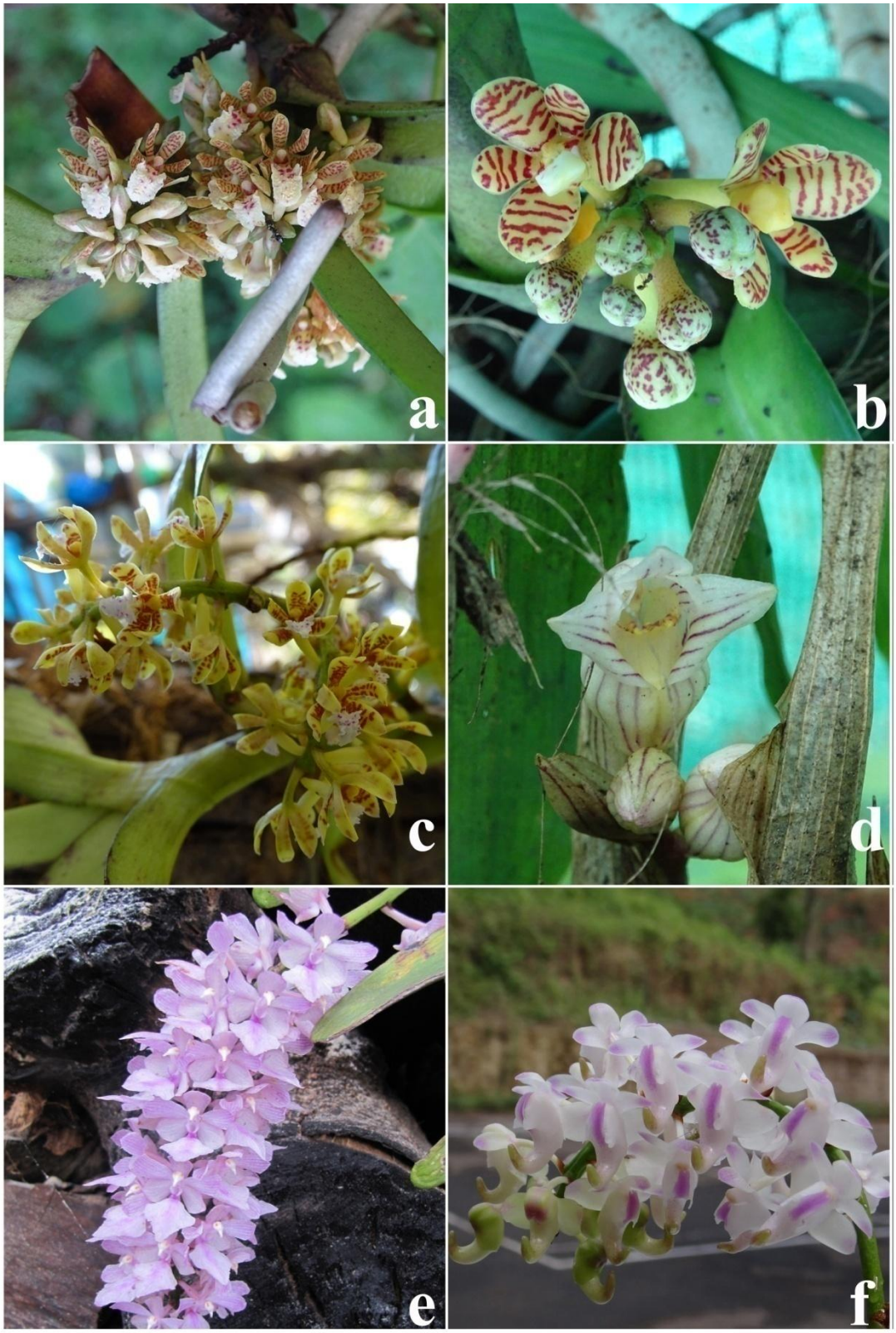


Plate 1. a) *Acampe praemorsa* (Roxb.) Blatt. & Mc Cann; **b)** *Acampe rigida* (Buch.-Ham. ex Sm.) **P.**F.Hunt ; **c)** *Acampe ochracea* (Lindl.) Hochr. ; **d)** *Acanthephippium striatum* Lindl. ; **e)** *Aerides multiflora* Roxb. ; **f)** *Aerides odorata* Lour.

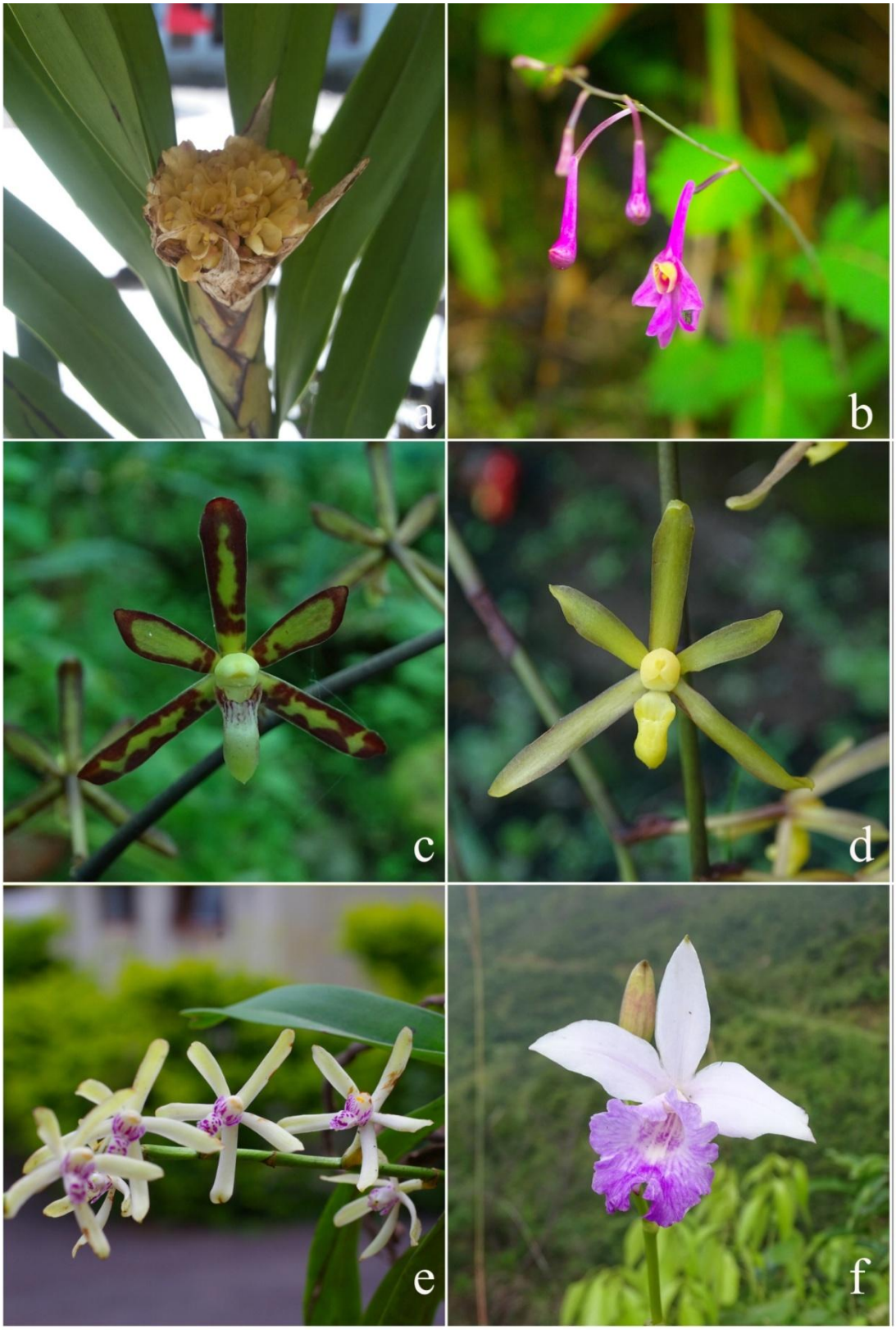


Plate 2. a) *Agrostophyllum. callosum* Rchb.f.; **b)** *Anthogonium gracile* Lindl.; **c)** *Arachnis labrosa* (Lindl. ex Paxt) Rchb. f.; **d)** *Arachnis labrosa* var. *zhaoi;* **e)** *Arachnis senapatiana* (Phukan & A.A. Mao) Kocyan & Schuit.; **f)** *Arundina graminifolia* (D. Don) Hochr.

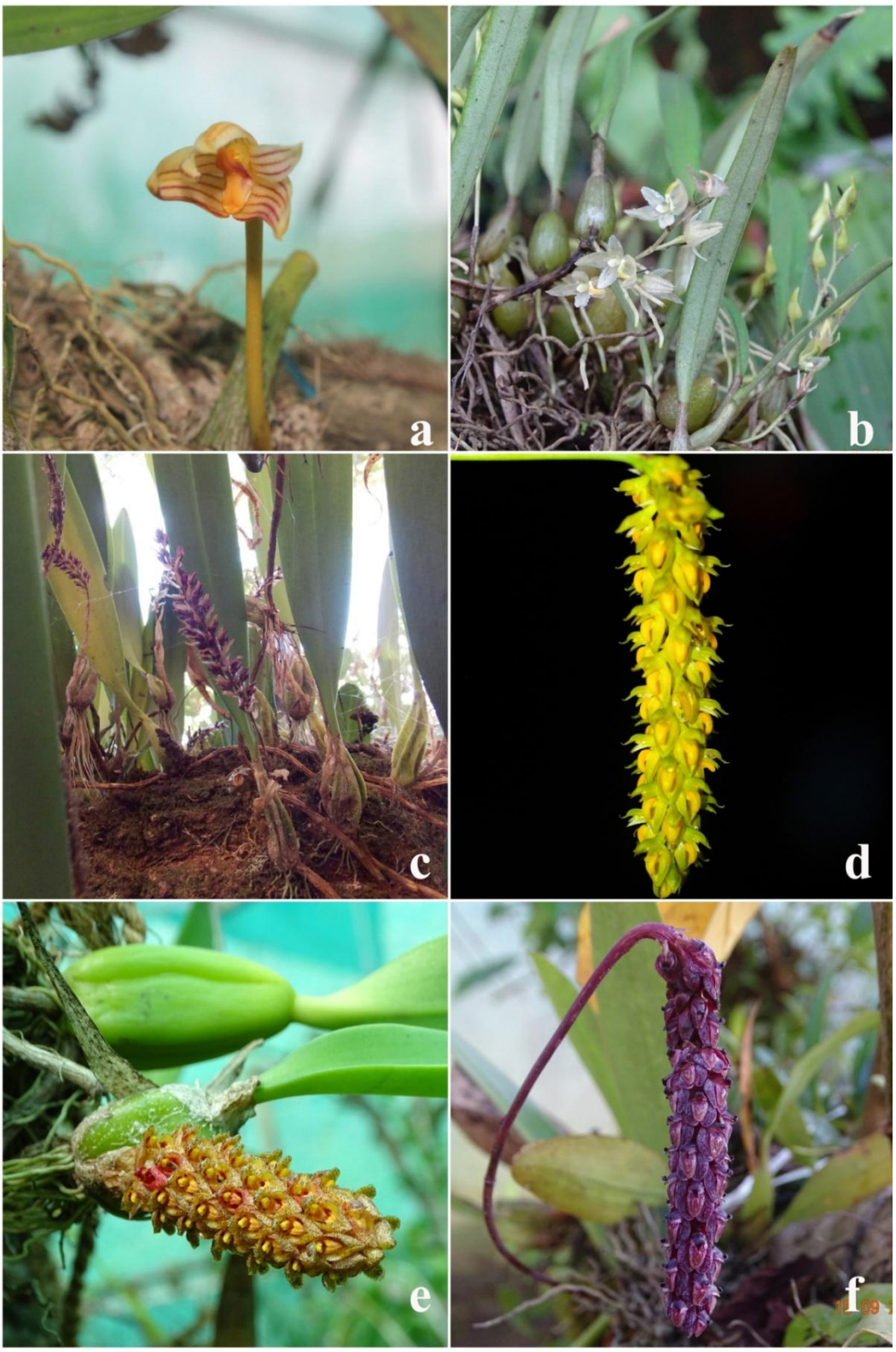


Plate 3. a) *Bulbophyllum affine* Lindl.; **b)** *Bulbophyllum candidum* Hook.f. ; **c)** *Bulbophyllum caryanum* (Hook.) Spreng; **d)** *Bulbophyllum cariniflorum* Rchb. f.; **e)** *Bulbophyllum crassipes* Hook. f. ; **f)** *Bulbophyllum cylindraceum* Lindl.

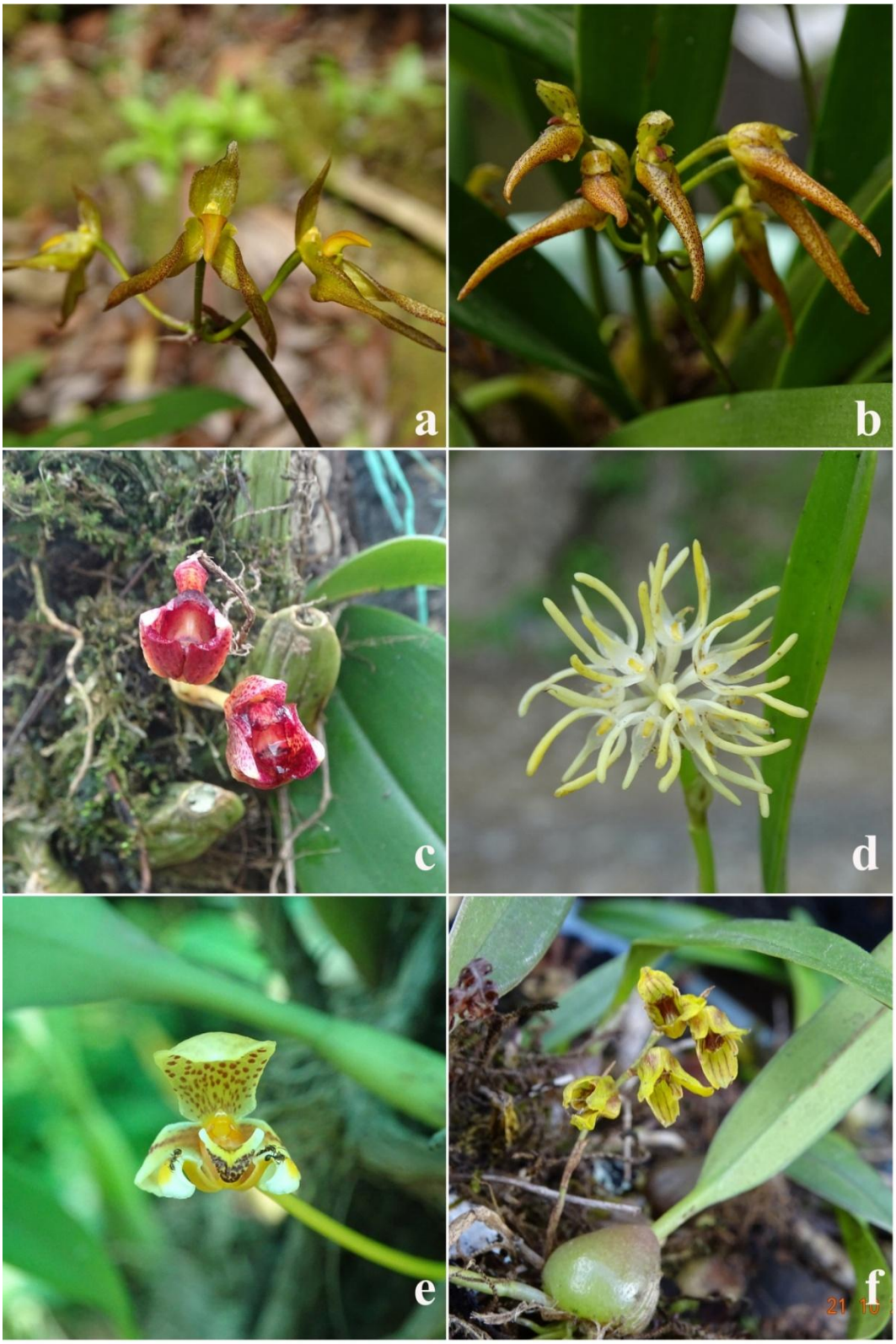


Plate 4. a) *Bulbophyllum elatum* (Hook.f.) J.J.Sm. ; **b)** *Bulbophyllum helenae* (Kuntze.) J. J. Sm. ; **c)** *Bulbophyllum leopardinum* (Wall.) Lindl.; **d)** *Bulbophyllum odorotissimum* (J.E. Smith) Lindl.; **e)** *Bulbophyllum pteroglossum* Schltr. ; **f)** *Bulbophyllum reptans* Lindl.

Plate 5. a) *Bulbophyllum retusiusculum* Rchb. ; **b)** *Bulbophyllum umbellatum* Lindl.; **c)** *Bulbophyllum sunipia* J.J.Verm., Schuit. & de Vogel ; **d)** *Bulbophyllum rotschildianum* (O'Brien) J.J. Sm.; **e)** *Bulbophyllum viridiflorum* (Hook.f.) Schltr.; **f)** *Bulleyia yunnanensis* Schltr.

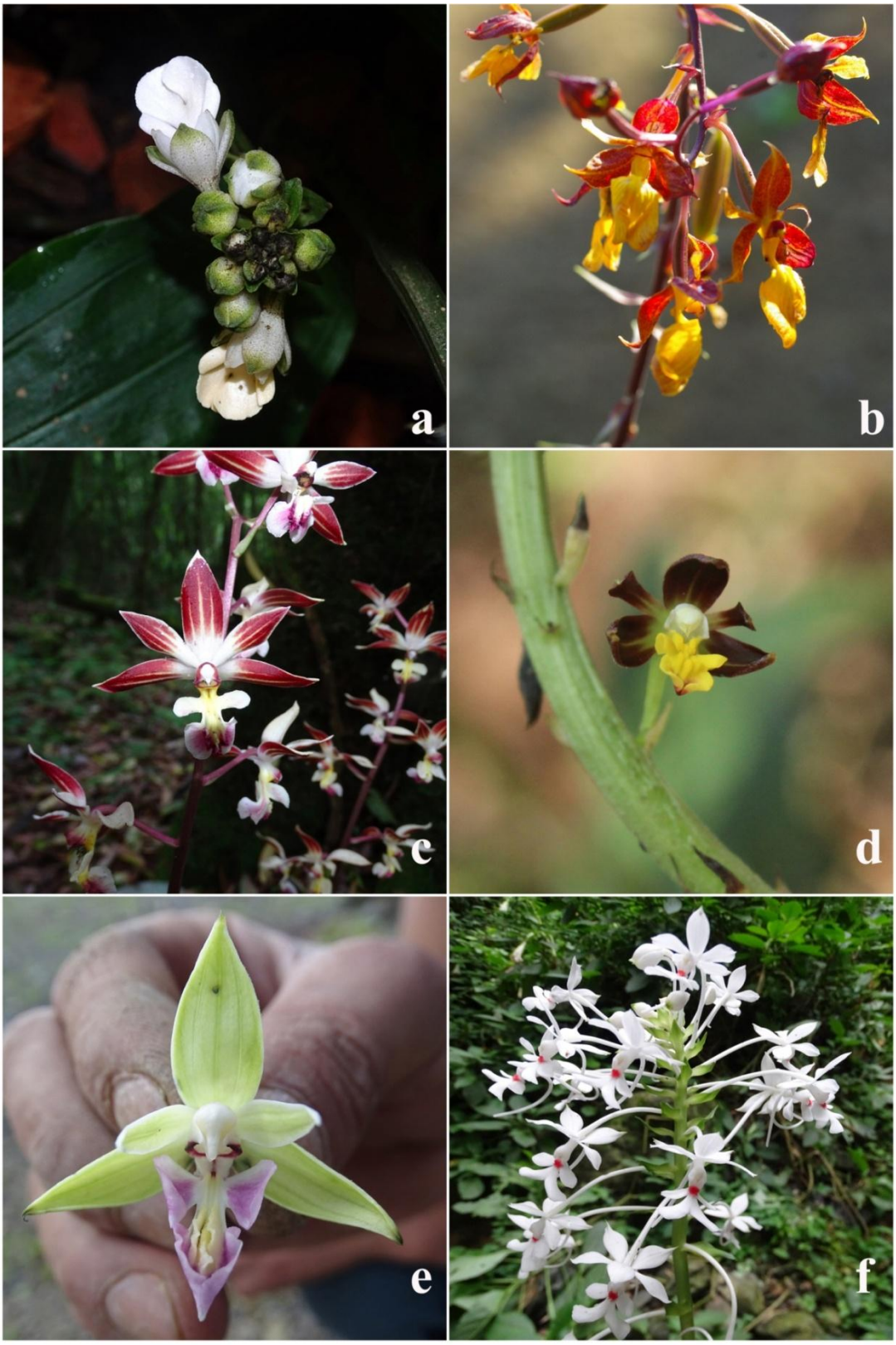


Plate 6. a) *Calanthe alismifolia* Lindl.; **b)** *Calanthe biloba* Lindl.; **c)** *Calanthe brevicornu* Lindl.; **d)** *Calanthe mannii* Hook.f.; **e)** *Calanthe puberula* Lindl.; **f)** *Calanthe triplicata* (Willem.) Ames.

Plate 7. a) *Chiloschista parishii* Seidenf.; **b)** *Cleisostoma paniculatum* (Ker Gawler) Garay.; **c)** *Cleisocentron pallens* (Cathcart ex Lindl.) N. Pearce & P.J. Cribb; **d)** *Cleisostoma williamsonii* (Reichb. f.) Garay; **e)** *Cleisostoma parishii* (Hook.f.) Garay; **f)** *Coelogyne barbata* Lindl. ex Griff.

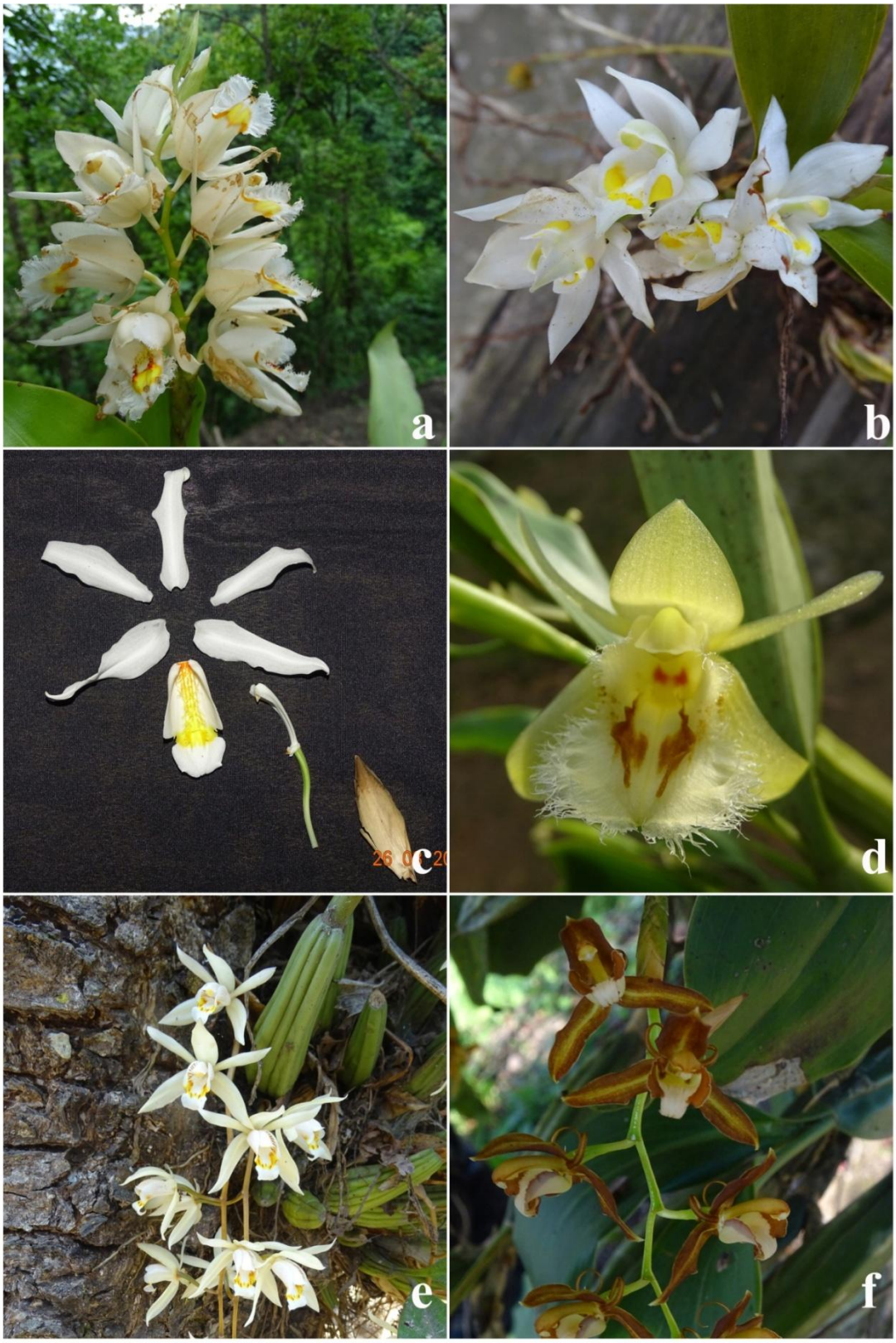


Plate 8. a) *Coelogyne calcicola* Kerr.; **b)** *Coelogyne corymbosa* Lindl. ; **c)** *Coelogyne cristata* Lindl. **d)** *Coelogyne fimbriata* Lindl.; **e)** *Coelogyne flaccida* Lindl.; **f)** *Coelogyne griffithii* Hook.f.

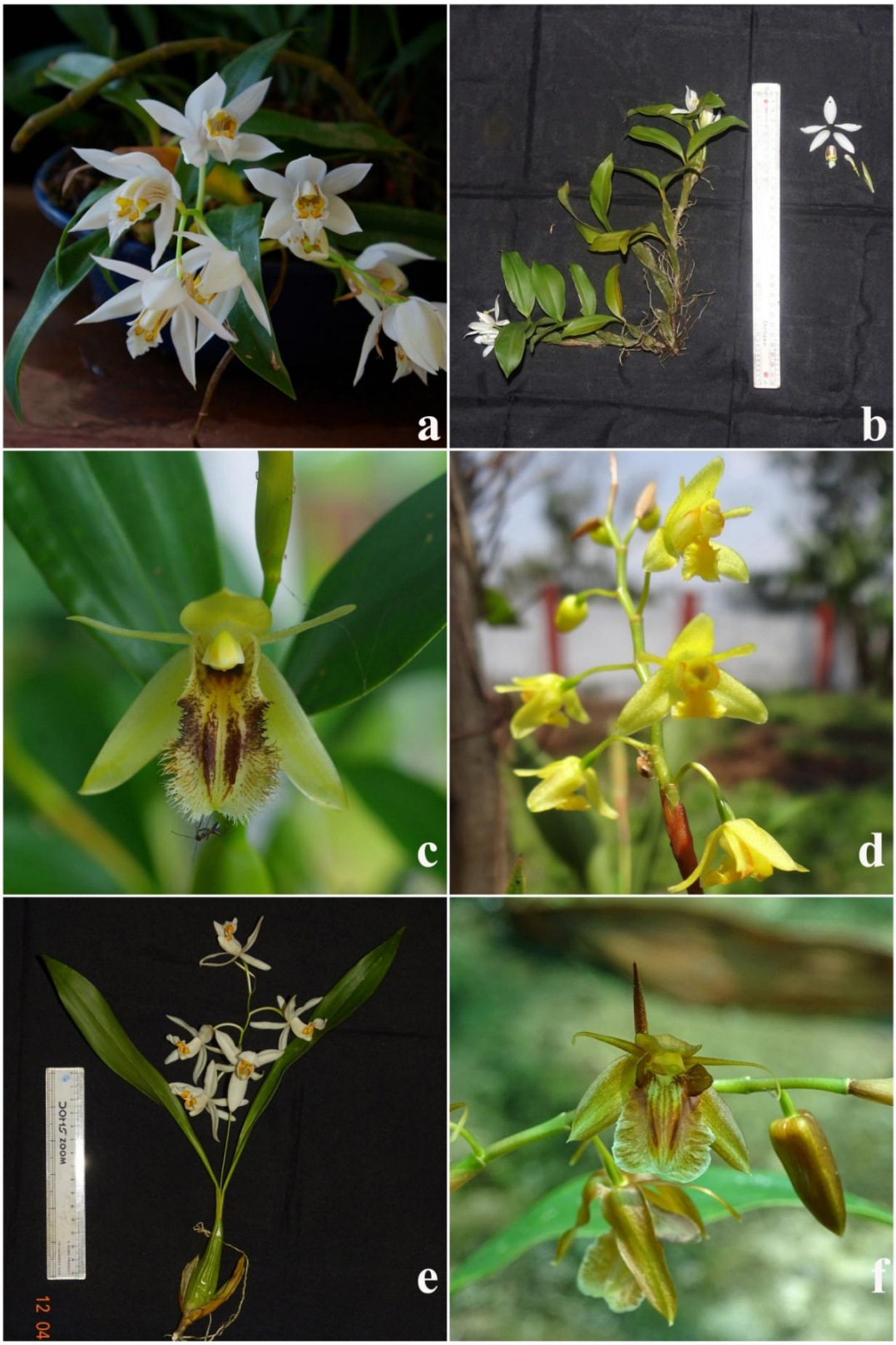


Plate 9. a) *Coelogyne nitida* (Wall. Ex D. Don) Lindl.; **b)** *Coelogyne occultata* Hook. f.; **c)** *Coelogyne ovalis* Lindl.; **d)** *Coelogyne prolifera* Lindl.; **e)** *Coelogyne punctulata* Lindl.; **f)** *Coelogyne schultesii* S.K.Gen & S.Das

Plate 10. a) *Coelogyne. suaveolens* Hook. f.; **b)** *Cremastra appendiculata* (D.Don) Makino; **c)** *Crepidium acuminatum* (D.Don) Szlach.; **d)** *Crepidium calophyllum* (Rchb.f.) Szlach.; **e)** *Crepidium khasianum* (Hook.f.) Szlach.; **f)** *Cryptochilus luteus* Lindl.

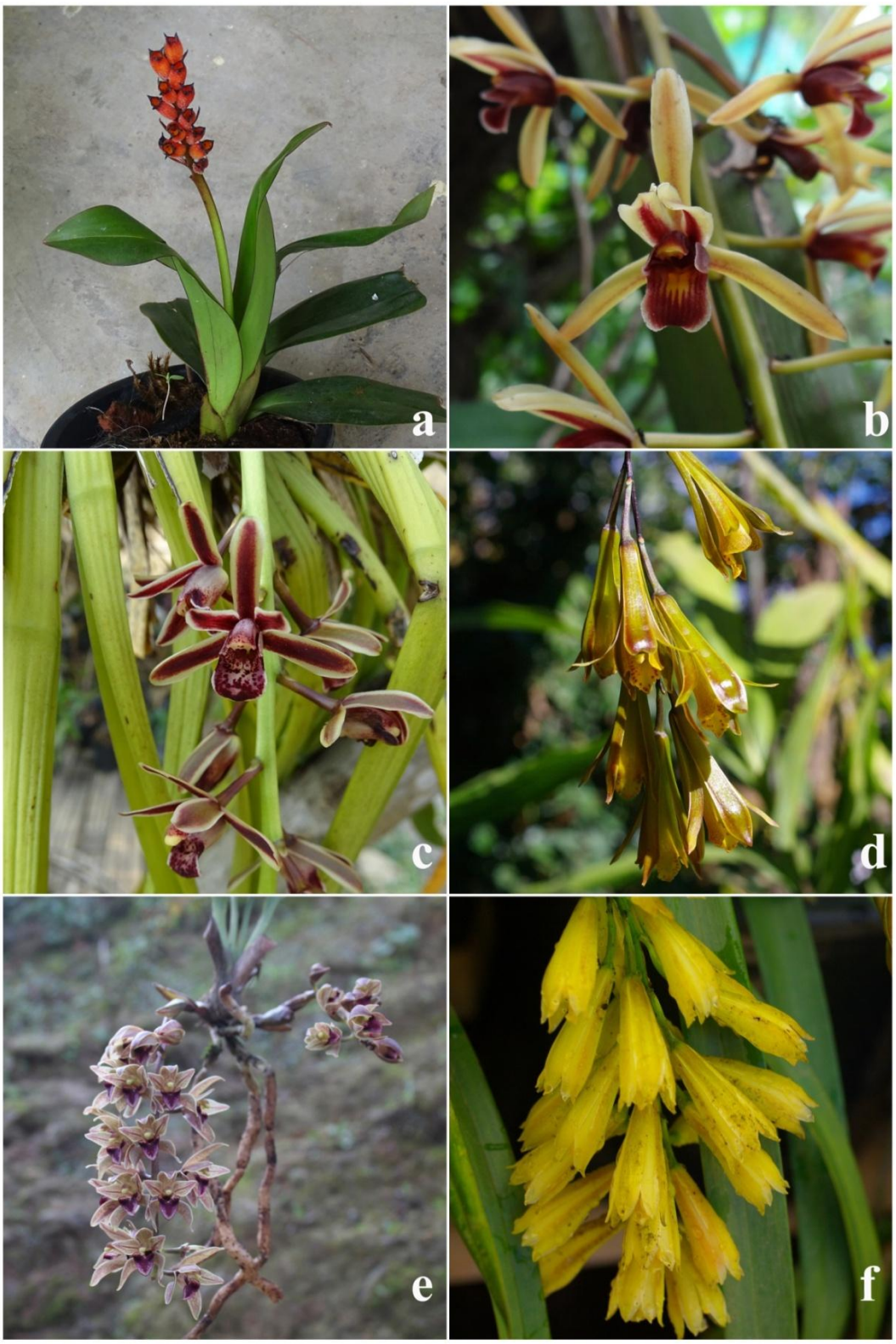


Plate 11. a) Cryptochilus sanguineus Wall.; **b)** *Cymbidium aloifolium* (Linn.) Sw.; **c)** *Cymbidium bicolor* Lindl.; **d)** *Cymbidium cochleare* Lindl.; **e)** *Cymbidium devonianum* Paxton.; **f)** *Cymbidium elegans* Lindl.

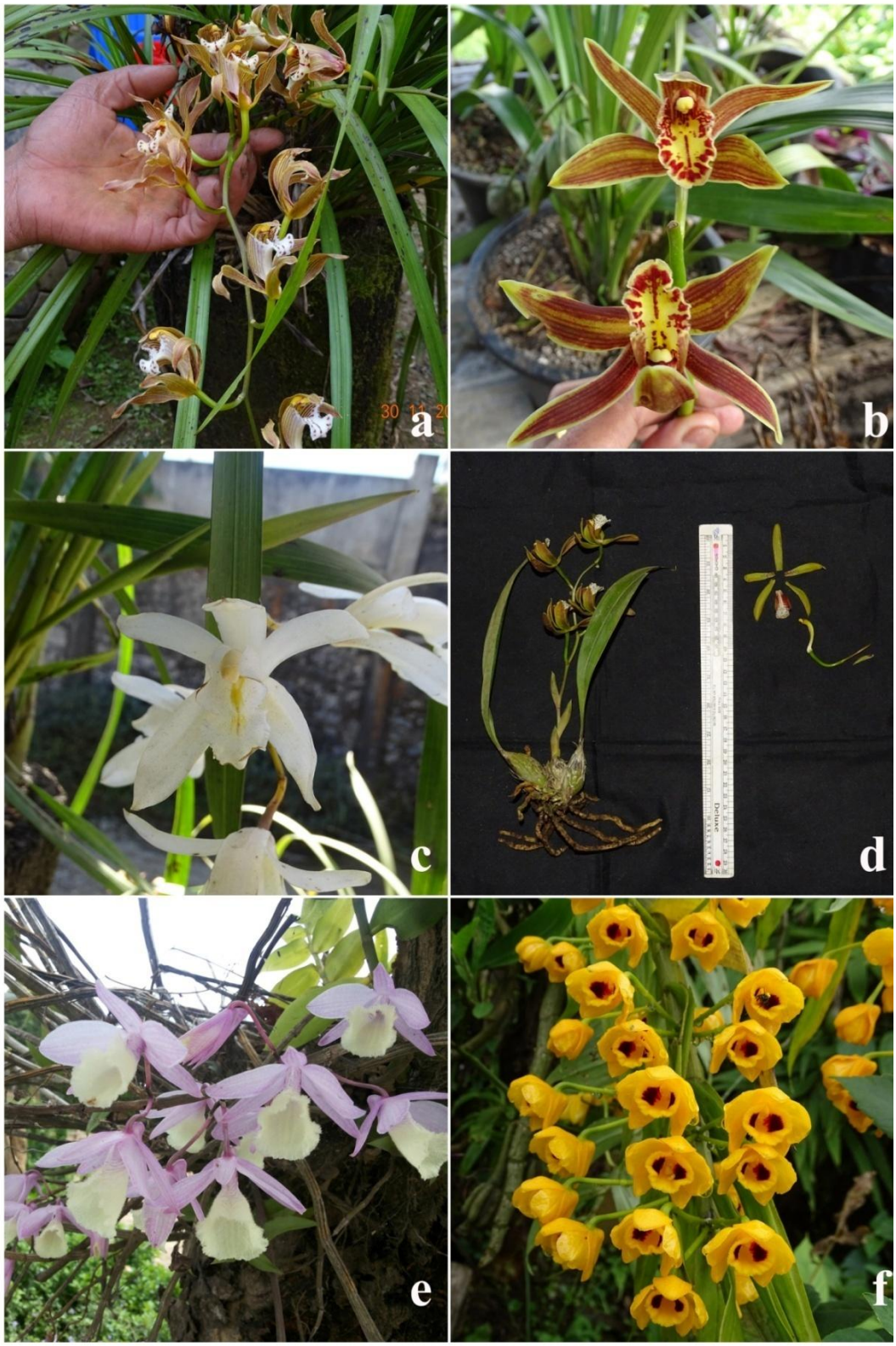


Plate 12. a) *Cymbidium erythraeum* Lindl.; **b)** *Cymbidium iridiodes* D. Don; **c)** *Cymbidium mastersii* Griff. ex Lindl.; **d)** *Cymbidium tigrinum* Par. Ex Hook; **e)** *Dendrobium aphyllum* (Roxb.) Fischer; **f)** *Dendrobium chrysanthum* Wall. ex Lindl.

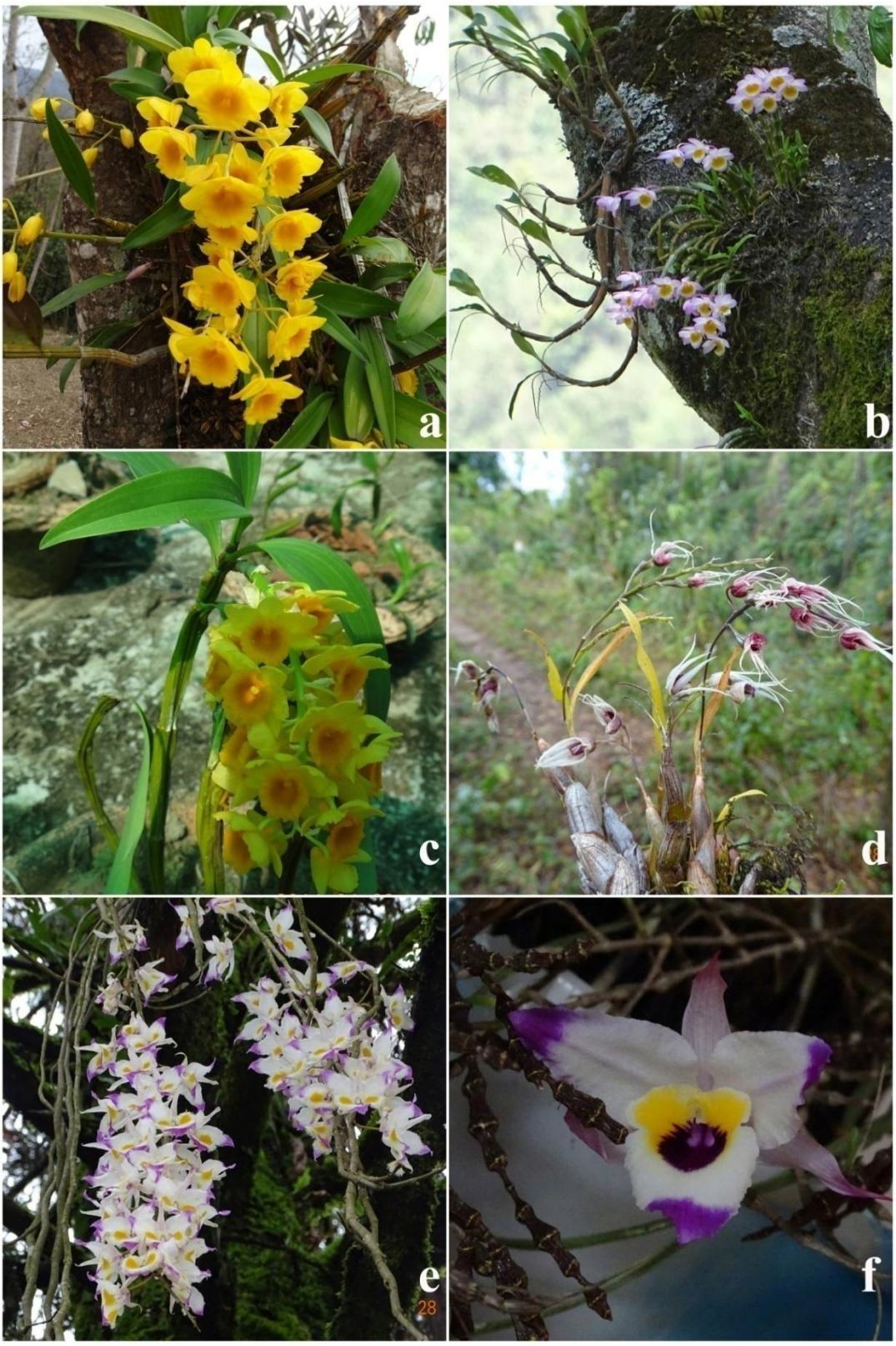


Plate 13. a) *Dendrobium chrysotoxum* Lindl.; **b)** *Dendrobium crepidatum* Lindl. & Paxt.; **c)** *Dendrobium densiflorum* (Lindl.) Wall.; **d)** *Dendrobium denudans* D. Don; **e)** *Dendrobium devonianum* Paxt.; **f)** *Dendrobium falconeri* Hook. f.

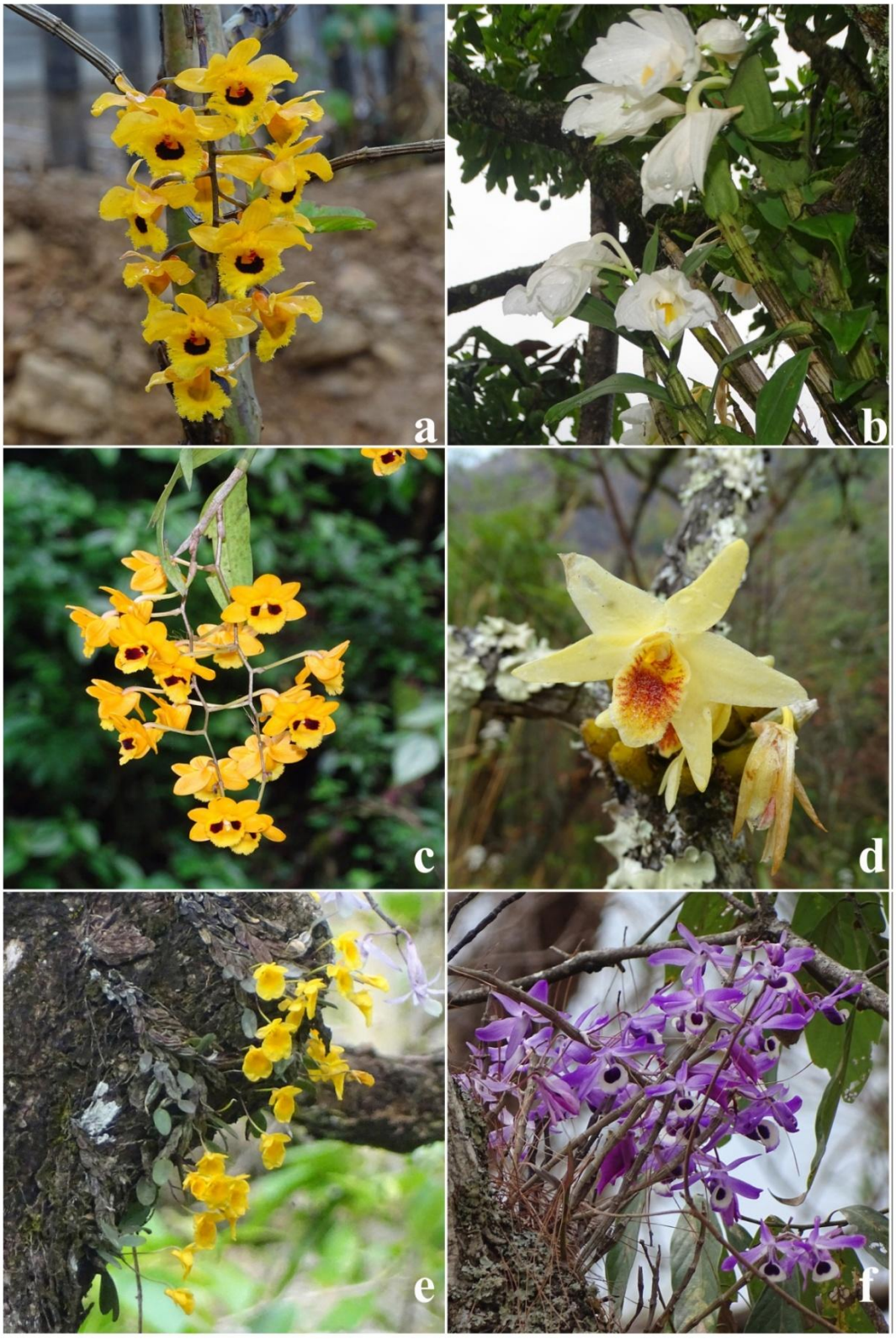


Plate 14. a) *Dendrobium fimbriatum* Hook. f. var. *oculatum* Hook.; **b)** *Dendrobium formosum* Roxb.ex Lindl.; **c)** *Dendrobium gibsonii* Lindl.; **d)** *Dendrobium heterocarpum* Wall. ex Lindl. **e)** *Dendrobium jenkinsii* Wall. ex Lindl.; **f)** *Dendrobium lituiflorum* Lindl.

Plate 15. a) *Dendrobium longicornu* Lindl.; **b)** *Dendrobium moschatum* Griff.; **c)** *Dendrobium nobile* Lindl.; **d)** *Dendrobium ochreatum* Wall. ex Lindl.; **e)** *Dendrobium parishii* Rchb.f.; **f)** *Dendrobium polyanthum* Wall. ex Lindl.

Plate 16. a) *Dendrobium porphyrochilum* Lindl. ; **b)** *Dendrobium sociale* J.J.Sm.; **c)** *Dendrobium spatella* Rchb.f.; **d)** *Dendrobium tamenlongse***; e)** *Dendrobium thyrsiflorum* Rchb. f.; **f)** *Dendrobium transparens* Wall. ex Lindl.

Plate 17. a) *Dendrobium wardianum* Warner.; **b)** *Dendrobium wattii* Rchb. f.; **c)** *Dendrobium williamsonii* Day & Rchb. f.; **d)** *Dienia ophrydis* (J.König) Seidenf.; **e)** *Epigeneium amplum* (Lindl.) Summer.; **f)** *Epigeneium fuscescens* (Griff.) Summer.

Plate 18. a) *Epigeneium rotundatum* (Lindl.) Summer.; **b)** *Epipogium roseum* (D.Don) Lindl.; **c)** *Eria coronaria* (Lindl.) Rchb. f.; **d)** *Eria spicata* (D.Don) Hand.-Mazz.; **e)** *Eria vittata* Lindl.; **f)** *Eriodes barbata* (Lindl.) Rolfe

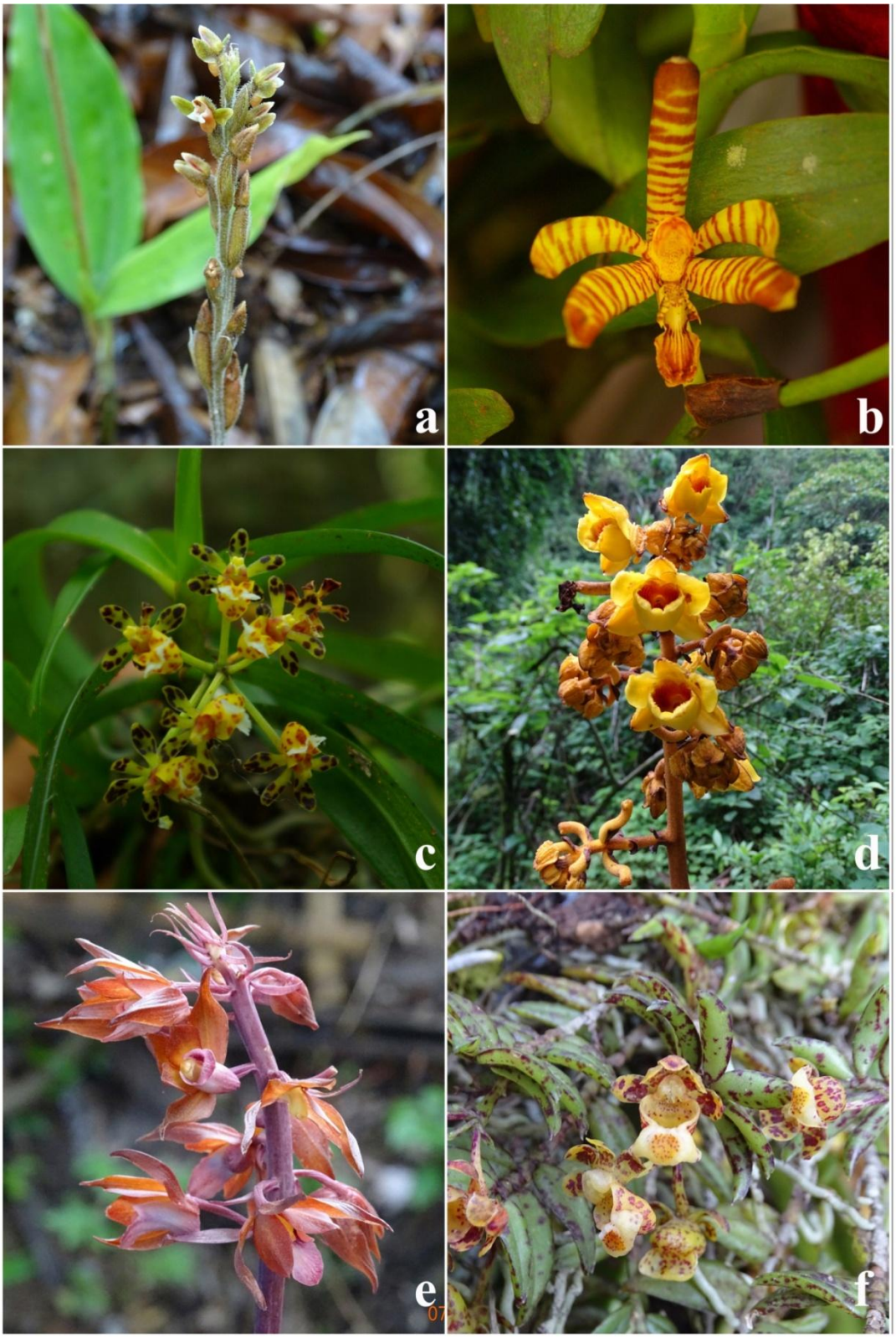


Plate 19. a) *Erythrodes blumei* (Lindl.) Schltr.; **b)** *Esmeralda Clarkei* Rchb. f.; **c)** *Gastrochilus calceolaris* (Buch.-Ham. ex Sm.) D. Don; **d)** *Galeola lindleyana* (Hook.f. & Thom.) Rchb.f.; **e)** *Eulophia zollengeri* (Rchb. f.) J.J. Smith; **f)** *Gastrochilus distichus* (Lindl.) Kuntze

Plate 20. a) *Gastrochilus inconspicua* (Wall. ex Hook. f.) Kuntze; **b)** *Gastrochilus pseudodistichus* (King & Pantl.) Schltr.; **c)** *Goodyera schlechtendaliana* Rchb.f.; **d)** *Goodyera viridiflora* (Blume.) **e)** *Habenaria arietina* Hook.f.; **f)** *Habenaria dentata* (Sw.)Schlechter

Plate 21. a) *Hygrochilus parishii* (Veitch. Reichb. f.) Pfitz; **b)** *Liparis bistriata* E.C. Parish & Rchb. f.; **c)** *Liparis bootanensis* Griff.; **d)** *Liparis distans* C.B. Clarke; **e)** *Liparis elliptica* Wight. ; **f)** *Liparis nervosa* (Thunb.) Lindl.

Plate 22. a) *Liparis resupinata* Ridl.; **b)** *Liparis viridiflora* (Blume) Lindl.; **c)** *Luisia trichorrhiza* (Hook.) Blume; **d)** *Oberonia acaulis* Griff.; **e)** *Oberonia mucronata* (D.Don) Ormerod & Seidenf.; **f)** *Oberonia obcordata* Lindl.

Plate 23. a) *Oberonia pachyrachis* Rchb.f. ex Hook.f.; **b)** *Otochilus albus* Lindl.; **c)** *Otochilus fuscus Lindl.;* **d)** *Otochilus lancilabius* Seidenf.; **e)** *Panisea tricallosa* Rolfe.; **f)** *Paphiopedilum hirsutissimum* (Lindl.) Stein.

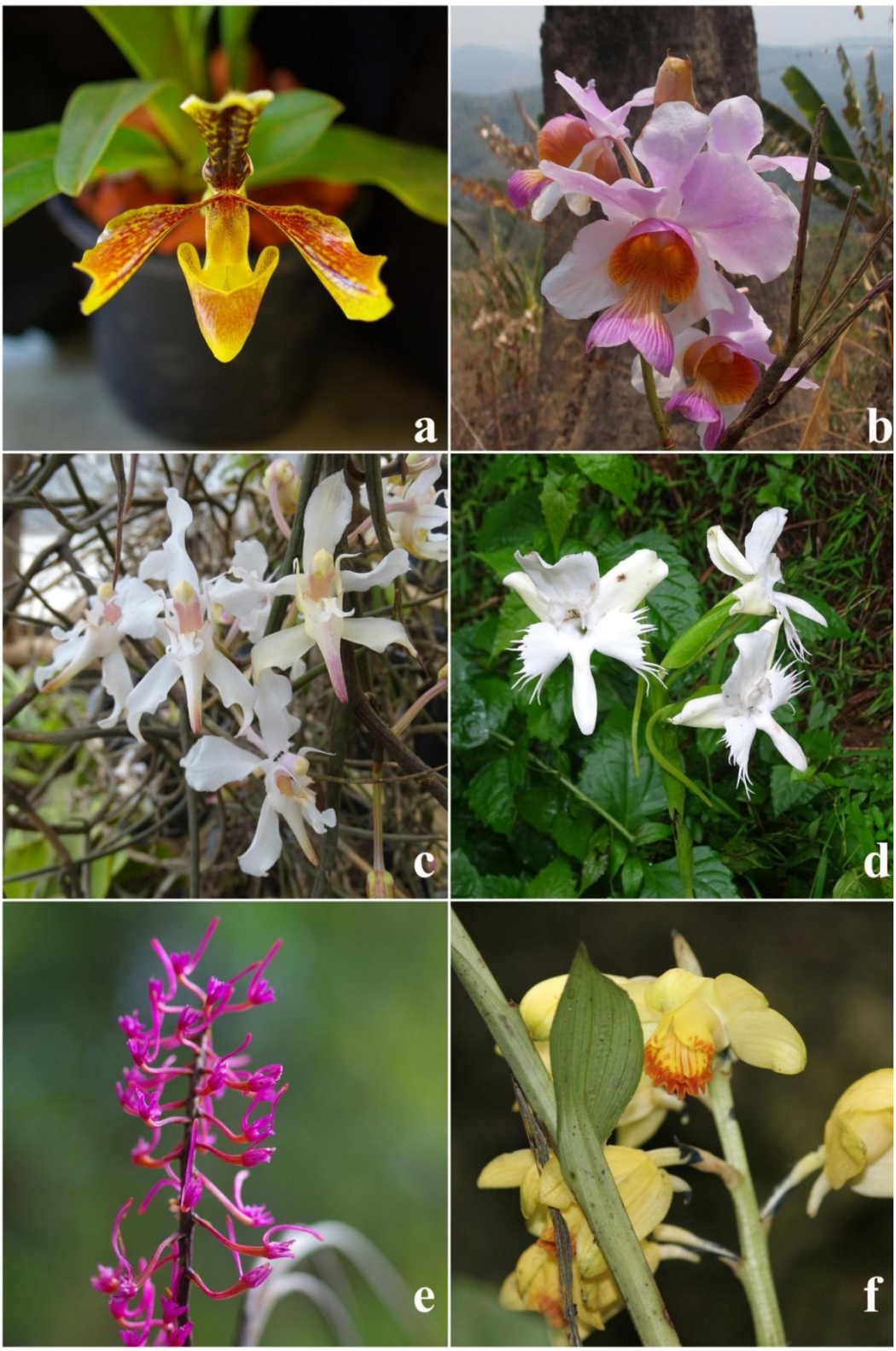


Plate 24. a) *Paphiopedilum villosum* var. *boxallii* (Reichenbach fil.) Pfitzer; **b)** *Papilionanthe teres* (Roxb.) Schltr.; **c)** *Papilionanth vandarum* (Rchb. f.) ; **d)** *Pecteilis susannae* (Linn.) Rafinesque; **e)** *Pendulorchis himalaica* (Deb, Sengupta & Malick) Z.J. Liu, Ke Wei Liu & X. J. Xiao.; **f)** *Phaius flavus* (Blume) Lindl.

Plate 25. a) *Phaius tankervilleae* (Banks ex L'Her.) Blume.; **b)** *Phalaenopsis braceana* (Hook. f.) Christenson; **c)** *Phalanaeopsis difformis* (Wall. ex Lindl.) Kocyan & Schuit.**; d)** *Phalaenopsis taenial*is (Lindl.) E.A. Christ. & Pradhan; **e)** *Phalaenopsis yingjiangensis* **(**Z.H.Tsi) Kocyan & Schuit.; **f)** *Pholidota articulata* Lindl.

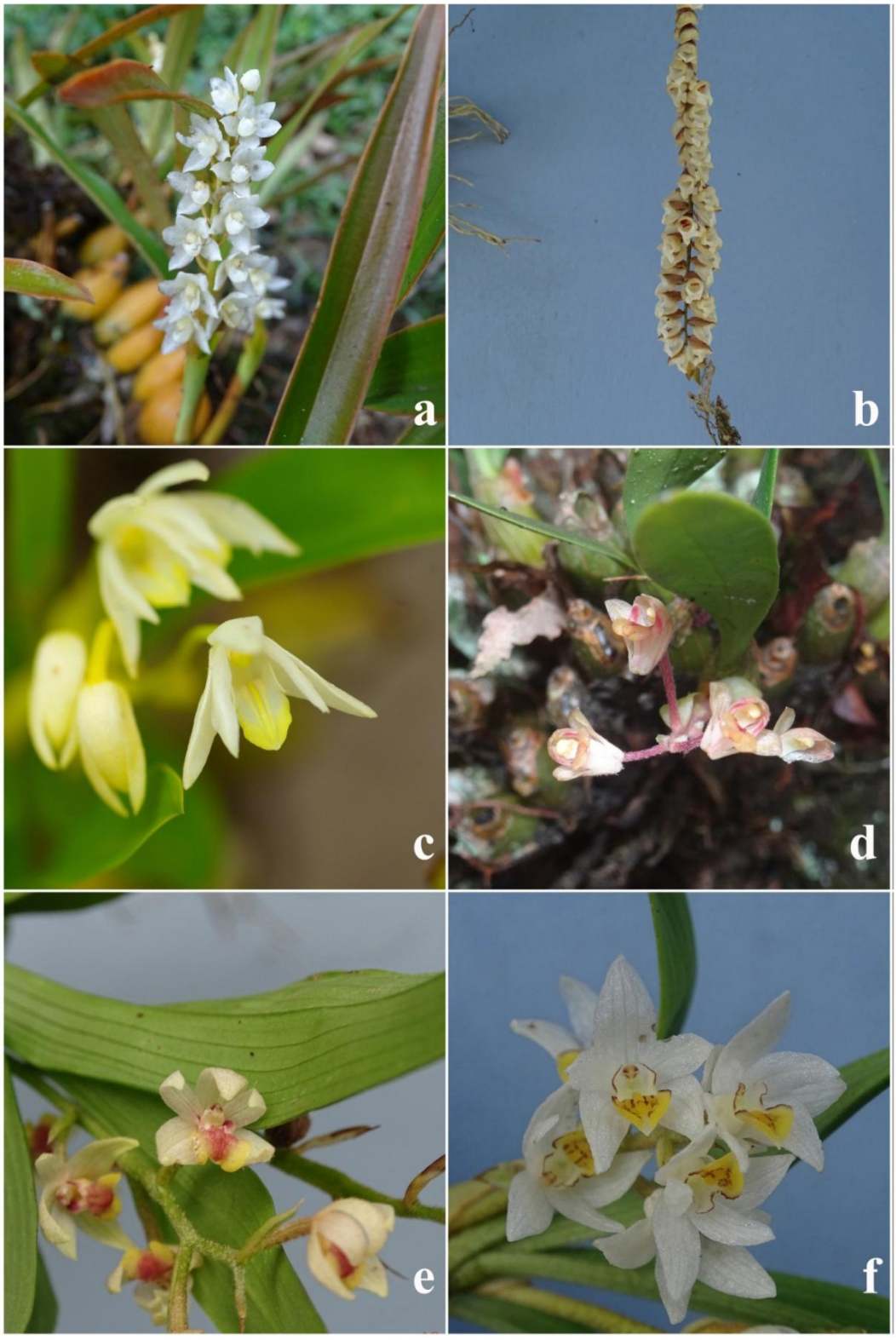


Plate 26. a) *Pholidota convallariae* (E.C. Parish & Rchb.f) Hook.f.; **b)** *Pholidota pygmaea* H.J. Chowdhery & G.D. Pal; **c)** *Pinalia acervata* (Lindl.) Kuntze.; **d)** *Pinalia amica* (Rchb.f.) Kuntze; **e)** *Pinalia excavata* (Lindl.) Kuntze; **f)** *Pinalia graminifolia* (Lindl.) Kuntze.

Plate 27. a) *Pinalia paniculata* (Lindl.) Kuntze; **b)** *Pinalia pannea* (Lindl.) Kuntze; **c)** *Pleione humilis* (Sm.) D. Don; **d)** *Pleione maculata* (Lindl.) Lindl.; **e)** *Pleione praecox* (Lindl.) D. Don**;** **f)** *Polystachya concreta* (Jacq.) Garay & Sweet

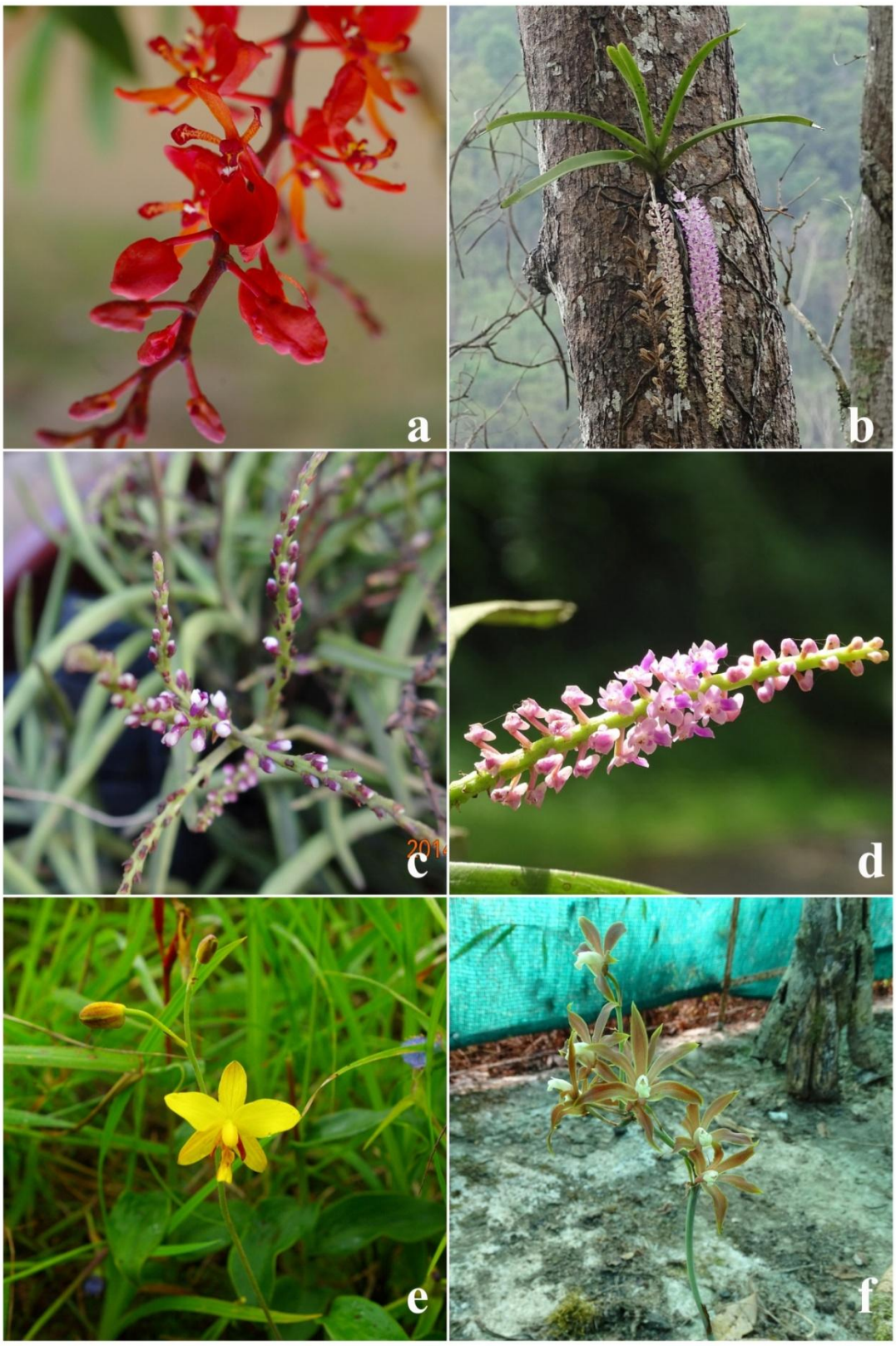


Plate 28. a) *Renanthera imschottiana* Rolfe.; **b)** *Rhynchostylis retusa* Blume.; **c)** *Schoenorchis gemmata* (Lindl.) J.J. Sm.; **d)** *Smitinandia micrantha* (Lindl.) Holttum; **e)** *Spathoglottis pubescens* Lindl. **f)** *Tainia latifolia* Benth. ex Hook.

Plate 29. a) *Tainia minor* Hook. f.; **b)** *Thrixspermum laurisilvaticum* (Fukuy.) Garay; **c)** *Thunia alba* (Lindl.) Rchb. f.; **d)** *Uncifera obtusifolia* Lindl.; **e)** *Vanda alpina* (Lindl.) Lindl.; **f)** *Vanda ampullaceaum* (Roxb.) L.M.Gardiner

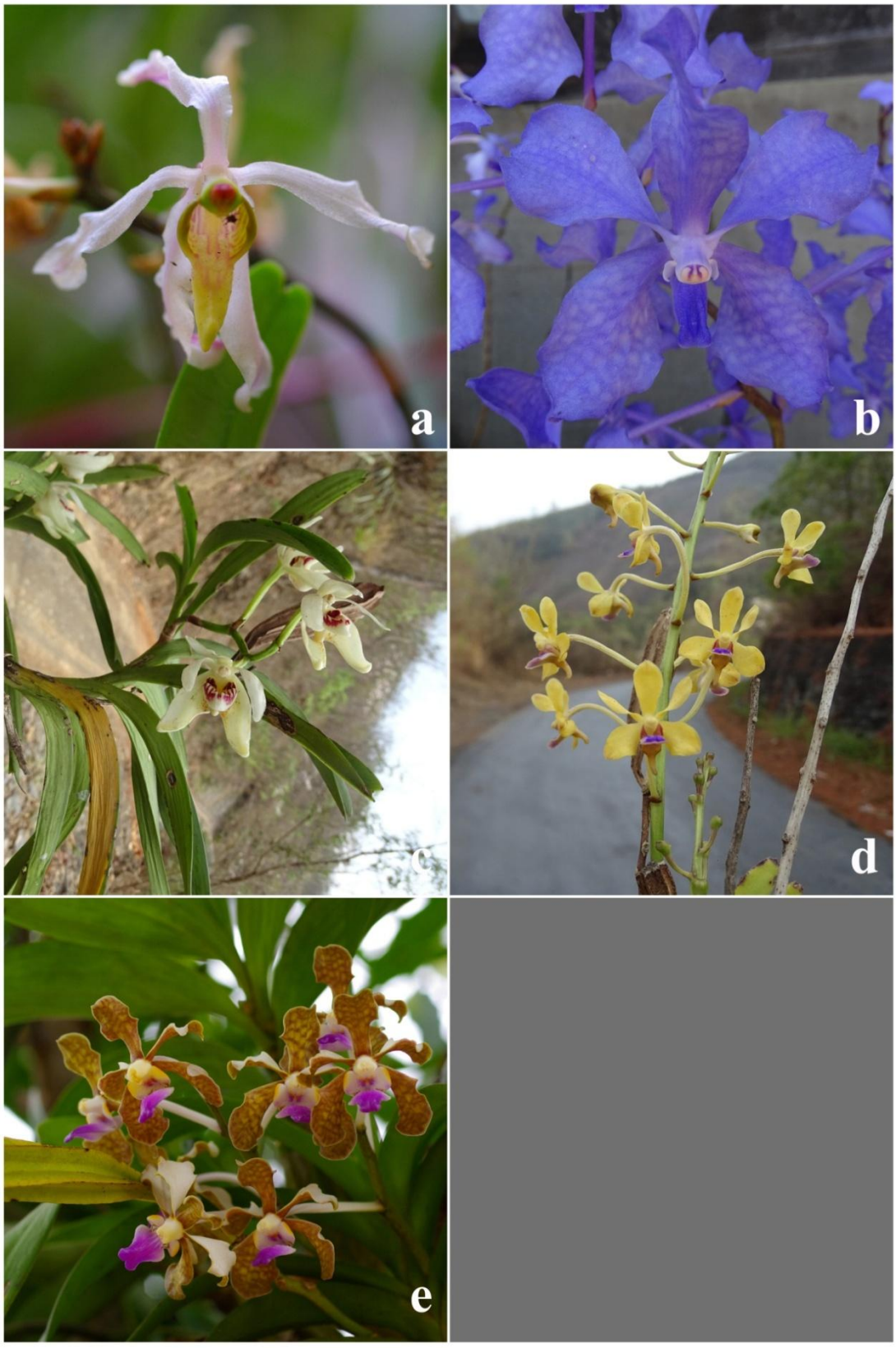


Plate 30. a) *Vanda bicolor* Griff.; **b)** *Vanda coerulea* Griff. ex Lindl.; **c)** *Vanda pumila* Hook. f.; **d)** *Vanda testaceae* (Lindl.) Reichb. f.; **e)** *Vandopsis undulata* (Lindl.) J.J.Sm.

2.3. Results

The present floristic study documents a total of 180 species under 58 genera **(Table 2.2)** from the three districts collected solely by the author. The Genus *Dendrobium*, *Bulbophyllum* and *Coelogyne* recording maximum species at 29, 17 and 15 species respectively and other genus are represented by lesser species **(Table 2.3).** Out of the 58 genera, 30 genera were strictly epiphytic, while 15 genera were terrestrial and 11 genera belonging to the mixed type i.e. either terrestrial or epiphytic. Species from the genus *Epipogium* and *Eulophia* were found to be saprophytic and was represented by 1 species each namely *Epipogium roseum* and *Eulophia zollengeri*. *Polystachya concreta*, *Esmeralda clarkei*, *Dendrobium tamenglongense*, *Arachnis senapatiana* *Phalaenopsis braceana*, *Cymbidium bicolor*, *Erythrodes blumei*, *Eriodes barbata*, *Crepidium calophyllum*, *Pendulorchis himalaica* are new records for the state whereas *Arachnis labrosa* var. zhaoi and *Thrixspermum laurisilvaticum* are new records for the country reported by the author. Reports of new species/new records by other authors viz., *Dendrobium tuensangense* N. Odyuo & C. Deori – New species to science discovered from Tuensang district in 2016, new records for the country namely *Panisea panchaseensis* Subedi also from Tuensang district have not been included in the list since the author has not come across the specimen.

Table 2.2: List of orchid species documented from the three districts viz., Kiphire, Tuensang and Zunheboto

Name of Genus	Name of Species		Flowering Season
	Sl. No.		
Acampe	1	*Acampe praemorsa* (Roxb.) Blatt. & Mc Cann	Dec - Jan
	2	*Acampe ochracea* (Lindl.) Hochr.	Jan- Feb
	3	*Acampe rigida* (Buch.-Ham. ex Sm.) P.F.Hunt	Aug- Oct
Acanthephippium	4	*Acanthephippium striatum* Lindl.	May - June
Aerides	5	*Aerides multiflora* Roxb.	April - May
	6	*Aerides odorata* Lour.	May - June
Agrostophyllum	7	*Agrostophyllum callosum* Rchb.f.	Jun – July
Anthogonium	8	*Anthogonium gracile* Lindl.	Aug – Sept
Arachnis	9	*Arachnis labrosa* (Lindl. ex Paxt) Rchb. f.	Aug – Sept
	10	*Arachnis labrosa* var Zhaoi	Aug - Sept
	11	*Arachnis senapatiana* (Phukan & A.A. Mao) Kocyan & Schuit.	May – June
Arundina	12	*Arundina graminifolia* (D. Don) Hochr.	Jun – Aug
Bulbophyllum	13	*Bulbophyllum affine* Lindl.	May - June
	14	*Bulbophyllum candidum* Hook.f.	Aug – Sept
	15	*Bulbophyllum caryanum*(Hook.) Spreng	June – July
	16	*Bulbophyllum cariniflorum* Rchb. f.	March - April
	17	*Bulbophyllum crassipes* Hook. f.	Sept - Nov
	18	*Bulbophyllum cylindraceum* Lindl.	Sept-Oct
	19	*Bulbophyllum elatum* (Hook.f.) J.J.Sm.	May-June
	20	*Bulbophyllum. helenae* (Kuntze.) J. J. Sm.	May – June
	21	*Bulbophyllum leopardinum* (Wall.) Lindl.	June - July
	22	*Bulbophyllum odorotissimum* (J.E. Smith) Lindl.	May - June
	23	*Bulbophyllum pteroglossum* Schltr.	Oct-Nov
	24	*Bulbophyllum reptans* Lindl.	Oct- Nov
	25	*Bulbophyllum retusiusculum* Rchb.	Aug - Sept
	26	*Bulbophyllum rotschildianum* (O'Brien) J.J. Sm.	Sept – Oct
	27	*Bulbophyllum sunipia* J.J.Verm., Schuit. & de Vogel	May - June
	28	*Bulbophyllum umbellatum* Lindl.,	April – June
	29	*Bulbophyllum viridiflorum* (Hook.f.) Schltr.	Oct – Nov
Bulleyia	30	*Bulleyia yunnanensis* Schltr.	June – July
Calanthe	31	*Calanthe alismifolia* Lindl.	June – July
	32	*Calanthe biloba* Lindl.	Nov – Dec
	33	*Calanthe brevicornu* Lindl.	May – June
	34	*Calanthe mannii* Hook.f.	April – May
	35	*Calanthe puberula* Lindl.	May – June

	36	*Calanthe triplicata* (Willem.) Ames.	July – Oct
Chiloschista	37	*Chiloschista parishii* Seidenf.	April – May
Cleisocentron	38	*Cleisocentron pallens* (Cathcart ex Lindl.) N. Pearce & P.J. Cribb	Sept – Oct
Cleisostoma	39	*Cleisostoma paniculatum* (Ker Gawler) Garay.	July – Aug
	40	*Cleisostoma parishii* (Hook.f.) Garay	Sept
	41	*Cleisostoma williamsonii* (Reichb. f.) Garay	June – July
Coelogyne	42	*Coelogyne barbata* Lindl. ex Griff.	Oct – Dec
	43	*Coelogyne calcicola* Kerr.	May – June
	44	*Coelogyne corymbosa* Lindl.	March – April
	45	*Coelogyne cristata* Lindl.	March – May
	46	*Coelogyne fimbriata* Lindl.	Oct – Dec
	47	*Coelogyne flaccida* Lindl.	March
	48	*Coelogyne griffithii* Hook.f.	March – May
	49	*Coelogyne nitida* (Wall. Ex D. Don) Lindl.	
	50	*Coelogyne occultata* Hook. f.	June – July
	51	*Coelogyne ovalis* Lindl.	Sept – Oct
	52	*Coelogyne prolifera* Lindl.	May – June
	53	*Coelogyne punctulata* Lindl.	March – April
	54	*Coelogyne schultesii* S.K.Gen & S.Das	March
	55	*Coelogyne stricta* (D. Don) Schltr.	April-May
	56	*Coelogyne. suaveolens* Hook. f.	May – June
Cremastra	57	*Cremastra appendiculata* (D.Don) Makino	May – June
Crepidium	58	*Crepidium acuminatum* (D.Don) Szlach.	June – July
	59	*Crepidium calophyllum* (Rchb.f.) Szlach.	June – July
	60	*Crepidium khasianum* (Hook.f.) Szlach.	June – July
Cryptochilus	61	*Cryptochilus luteus* Lindl.	May – June
	62	*Cryptochilus sanguineus* Wall.	June – July
Cymbidium	63	*Cymbidium aloifolium* (Linn.) Sw.	April – May
	64	*Cymbidium bicolor* Lindl.	March – April
	65	*Cymbidium cochleare* Lindl.	Nov – Dec
	66	*Cymbidium devonianum* Paxton.	April – May
	67	*Cymbidium elegans* Lindl.	Nov – Dec
	68	*Cymbidium erythraeum* Lindl.	Nov – Dec
	69	*Cymbidium iridiodes* D. Don	Oct – Jan
	70	*Cymbidium mastersii* Griff. ex Lindl.	Oct – Nov
	71	*Cymbidium tigrinum* Par. Ex Hook	April – May
Dendrobium	72	*Dendrobium aphyllum* (Roxb.) Fischer	April – May
	73	*Dendrobium chrysanthum* Wall. ex lindl.	Sept – Oct
	74	*Dendrobium chrysotoxum* Lindl.	April - May
	75	*Dendrobium crepidatum* Lindl. & Paxt	April – May
	76	*Dendrobium densiflorum* (Lindl.) Wall.	April – May
	77	*Dendrobium denudans* D. Don	Nov - Dec
	78	*Dendrobium devonianum* Paxt.	May – June
	79	*Dendrobium falconeri* Hook. f.	April – May
	80	*Dendrobium fimbriatum* Hook. f. var oculatum Hook.	April - May
	81	*Dendrobium formosum* Roxb. ex Lindl.	June-July

	82	*Dendrobium gibsonii* Lindl.	June – July
	83	*Dendrobium heterocarpum* Wall. ex Lindl.	March – April
	84	*Dendrobium jenkinsii* Wall. ex Lindl.	March – April
	85	*Dendrobium lituiflorum* Lindl.	March – April
	86	*Dendrobium longicornu* Lindl.	Oct – Nov
	87	*Dendrobium moschatum* Griff.	June – July
	88	*Dendrobium nobile* Lindl.	April- May
	89	*Dendrobium ochreatum* Wall. ex Lindl.	April – May
	90	*Dendrobium parishii* Rchb.f.	April – May
	91	*Dendrobium polyanthum* Wall. ex Lindl.	March – April
	92	*Dendrobium porphyrochilum* Lindl.	May – June
	93	*Dendrobium sociale* J.J.Sm.	March – April
	94	*Dendrobium spatella* Rchb.f.	June – august
	95	*Dendrobium tamenlongse*	July – Aug
	96	*Dendrobium thyrsiflorum* Rchb. f.	Sept – Oct
	97	*Dendrobium transparens* Wall. ex Lindl.	April – May
	98	*Dendrobium wardianum* Warner.	May – June
	99	*Dendrobium wattii* Rchb. f.	Dec- Jan
	100	*Dendrobium williamsonii* Day & Rchb. f.	April – May
Dienia	101	*Dienia ophrydis* (J.König) Seidenf.	July – Aug
Epigeneium	102	*Epigeneium amplum* (Lindl.) Summer.	Oct – Nov
	103	*Epigeneium fuscescens* (Griff.) Summer.	Sept – Oct
	104	*Epigeneium rotundatum* (Lindl.) Summer.	March – April
Epipogium	105	*Epipogium roseum* (D.Don) Lindl.	May – June
Eria	106	*Eria coronaria* (Lindl.) Rchb. f.	May – June
	107	*Eria spicata* (D.Don) Hand.-Mazz.	July – Aug
	108	*Eria vittata* Lindl.	Feb – March
Eriodes	109	*Eriodes barbata* (Lindl.) Rolfe	Oct – Nov
Erythrodes	110	*Erythrodes blumei* (Lindl.) Schltr.	March – April
Esmeralda	111	*Esmeralda Clarkei* Rchb. f.	Dec – Feb
Eulophia	112	*Eulophia zollengeri* (Rchb. f.) J.J. Smith	May – June
Galeola	113	*Galeola lindleyana* (Hook.f. & Thomson) Rchb.f.	May - June
Gastrochilus	114	*Gastrochilus calceolaris* (Buch.-Ham. ex Sm.) D. Don	March - April
	115	*Gastrochilus distichus* (Lindl.) Kuntze	May – Aug
	116	*Gastrochilus inconspicuus* (Wall. ex Hook. f.) Kuntze	June - July
	117	*Gastrochilus pseudodistichus* (King & Pantl.) Schltr.	Aug – Oct
Goodyera	118	*Goodyera schlechtendaliana* Rchb.f.	Aug - Sept
	119	*Goodyera viridiflora* (Blume.) Lindl.ex Dietrich.	September
Habenaria	120	*Habenaria arietina* Hook.f.	Aug - Sept
	121	*Habenaria dentata* (Sw.)Schlechter	Sept – Oct
Hygrochilus	122	*Hygrochilus parishii* (Veitch. Reichb. f.) Pfitz	May – June
Liparis	123	*Liparis bistriata* E.C. Parish & Rchb. f	June - July
	124	*Liparis bootanensis* Griff.	Aug - Sept
	125	*Liparis distans* C.B. Clarke	Oct – Nov
	126	*Liparis elliptica* Wight.	Nov-Dec

	127	*Liparis nervosa* (Thunb.) Lindl.	June - July
	128	*Liparis resupinata* Ridl.	Oct – Nov
	129	*Liparis viridiflora* (Bl.) Lindl.	Oct – Nov
Luisia	130	*Luisia trichorrhiza* (Hook.) Blume	April - May
Oberonia	131	*Oberonia acaulis* Griff.	October
	132	*Oberonia mucronata* (D.Don) Ormerod & Seidenf.	June – July
	133	*Oberonia obcordata* Lindl.	August - Sept
	134	*Oberonia pachyrachis* Rchb.f. ex Hook.f.	Aug – Sept
Otochilus	135	*Otochilus albus* Lindl.	May – July
	136	*Otochilus fuscus* Lindl.	Nov – Dec
	137	*Otochilus lancilabius* Seidenf.	March - April
Panisea	138	*Panisea tricallosa* Rolfe.	Nov – Dec
Paphiopedilum	139	*Paphiopedilum hirsutissimum* (Lindl.) Stein.	April – May
	140	*Paphiopedilum villosum* var. *boxallii* (Reichenbach fil.) Pfitzer	Jan – March
Papilionanthe	141	*Papilionanthe teres* (Roxb.) Schltr.	Feb – March
	142	*Papilionanth vandarum* (Rchb. f.)	Feb – March
Pecteilis	143	*Pecteilis susannae* (Linn.) Rafinesque	Aug-Sept
Pendulorchis	144	*Pendulorchis himalaica* (Deb, Sengupta & Malick) Z.J. Liu, Ke Wei Liu & X. J. Xiao.	Nov – Dec
Phaius	145	*Phaius flavus* (Blume) Lindl.	March – April
	146	*Phaius tankervilleae* (Banks ex L'Her.) Blume	April – June
Phalaenopsis	147	*Phalaenopsis braceana* (Hook. f.) Christenson	April – May
	148	*Phalanaeopsis difformis* (Wall. ex Lindl.) Kocyan & Schuit.	June – July
	149	*Phalaenopsis taenialis* (Lindl.) E.A. Christ. & Pradhan	May – June
	150	*Phalaenopsis yingjiangensis* (Z.H.Tsi) Kocyan & Schuit.	July – Aug
	151	*Pholidota articulata* Lindl.	June
	152	*Pholidota convallariae* (E.C. Parish & Rchb.f) Hook.f.	May – June
Pholidota	153	*Pholidota pygmaea* H.J. Chowdhery & G.D. Pal	Nov – Dec
Pinalia	154	*Pinalia acervata* (Lindl.) Kuntze	July – Aug
	155	*Pinalia amica* (Rchb.f.) Kuntze	March – April
	156	*Pinalia excavata* (Lindl.) Kuntze	June – July
	157	*Pinalia graminifolia* (Lindl.) Kuntze	June – July
	158	*Pinalia paniculata* (Lindl.) Kuntze	March – April
	159	*Pinalia pannea* (Lindl.) Kuntze	May – July
Pleione	160	*Pleione humilis* (Sm.) D. Don	March – April
	161	*Pleione maculata* (Lindl.) Lindl.	Nov – Dec
	162	*Pleione praecox* (Lindl.) D. Don	Sept – Nov
Polystachya	163	*Polystachya concreta* (Jacq.) Garay & Sweet	June – July
Renanthera	164	*Renanthera imschottiana* Rolfe.	May – June
Rhynchostylis	165	*Rhynchostylis retusa* Bl.	May – June

Schoenorchis	166	*Schoenorchis gemmata* (Lindl.) J.J. Sm.	May – June
Smitinandia	167	*Smitinandia micrantha* (Lindl.) Holttum	June – july
Spathoglottis	168	*Spathoglottis pubescens* Lindl.	June – July
Tainia	169	*Tainia latifolia* Benth. ex Hook.	March – April
	170	*Tainia minor* Hook. f.	April - May
Thrixspermum	171	*Thrixspermum laurisilvaticum* (Fukuy.) Garay	May – June
Thunia	172	*Thunia alba* (Lindl.) Rchb. f.	June – Aug
Uncifera	173	*Uncifera obtusifolia* Lindl.	Aug – Sept
Vanda	174	*Vanda alpina* (Lindl.) Lindl.	June – Aug
	175	*Vanda ampullaceaum* (Roxb.) L.M.Gardiner	March - April
	176	*Vanda bicolor* Griff.	Jan – Feb
	177	*Vanda coerulea* Griff. ex Lindl.	Sept – Oct
	178	*Vanda pumila* Hook. f.	March - April
	179	*Vanda testaceae* (Lindl.) Reichb. f.	May – June
Vandopsis	180	*Vandopsis undulata* (Lindl.) J.J.Sm.	March - April

Total = 180 species belonging to 58 Genera

Table 2.3: Orchid genera represented by number of species and its habitat

Sl. No.	Name of the Orchid Genera	Number of species	Type/Habitat
1.	Acampe Lindl.	3	Epiphytic
2.	Acanthephippium Blume.	1	Terrestrial
3.	Aerides Lour.	2	Epiphytic
4.	Agrostophyllum Blume.	1	Epiphytic
5.	Anthogonium Wall. ex Lindl	1	Terrestrial
6.	Arachnis Blume.	3	Epiphytic
7.	Arundina Blume.	1	Terrestrial
8.	Bulbophyllum Thou	17	Epiphytic
9.	Bulleyia Schltr.	1	Epiphytic/Lithophytic
10.	Calanthe R. Br.	6	Terrestrial
11.	Chiloschista Lindl.	1	Epiphytic
12.	Cleisocentron Bruhl.	1	Epiphytic
13.	Cleisostoma Blume.	3	Epiphytic
14.	Coelogyne Lindl.	15	Epiphytic/ Lithophytic
15.	Cremastra Lindl.	1	Terrestrial
16.	Crepidium Blume.	3	Terrestrial

17.	Cryptochilus Wall.	2	Epiphytic/ Lithophytic
18.	Cymbidium Swartz	9	Epiphytic/ Lithophytic
19.	Dendrobium Swartz	29	Epiphytic
20.	Dienia Lindl.	1	Terrestrial
21.	Epigenium Gagnep.	3	Epiphytic/ Lithophytic
22.	Epipogium J.G. Gmelin ex Borkhausen	1	Saprophyte
23.	Eria Lindl.	3	Epiphytic/ Lithophytic
24.	Eriodes Rolfe	1	Epiphytic/ Lithophytic
25.	Erythrodes Blume.	1	Terrestrial
26.	Esmeralda Rchb. f.	1	Epiphytic
27.	Eulophia R. Br. e*x* Lindl.	1	Saprophyte
28.	Galeola Lour.	1	Terrestrial
29.	Gastrochilus D. Don	4	Epiphytic
30.	Goodyera R. Br.	2	Terrestrial
31.	Habenaria Willd.	2	Terrestrial
32.	Hygrochilus Pfitzer	1	Epiphytic
33.	Liparis Rich.	7	Epiphytic/ Lithophytic
34.	Luisia Gaud.	1	Epiphytic
35.	Oberonia Lindl.	4	Epiphytic
36.	Otochilus Lindl.	3	Epiphytic
37.	Panisea Lindl.	1	Epiphytic
38.	Paphiopedilum Pfitzer	2	Epiphytic/ Lithophytic
39.	Papilionanthe Schltr.	2	Epiphytic
40.	Pecteilis Rafin.	1	Terrestrial
41.	Pendulorchis Z.J. Liu, Ke Wei Liu & G.Q. Zhang	1	Epiphytic
42.	Phaius Lour.	2	Terrestrial
43.	Phalaenopsis Blume	4	Epiphytic
44.	Pholidota Lindl. ex Hook.	3	Epiphytic
45.	Pinalia Lindl.	6	Epiphytic
46.	Pleione D. Don	3	Epiphytic/ Lithophytic

47.	Polystachya Hook.	1	Epiphytic
48.	Renanthera Lour.	1	Epiphytic
49.	Rhynchostylis Blume	1	Epiphytic
50.	Schoenorchis Blume	1	Epiphytic
51.	Smitinandia Holtt.	1	Epiphytic
52.	Spathoglottis Blume	1	Terrestrial
53.	Taenia Blume	2	Terrestrial
54.	Thrixspermum Lour.	1	Epiphytic
55.	Thunia Rchb. f.	1	Epiphytic
56.	Uncifera Lindl.	1	Epiphytic
57.	Vanda W. Jones ex R. Br.	6	Epiphytic
58.	Vandopsis Pfitzer	1	Epiphytic/ Lithophytic

Epiphytic = 30, Terrestrial = 15, Mixed (Terrestrial/Epiphytic) = 11, Saprophyte = 2

2.4 Discussion

The three districts are predominatly mountainous, altitudinal variations of the three districts are broad, ranging from approximately 300 m in the lower regions of the Zunheboto side of Doyang river to 3840 m (12,602ft.) Mt. Saramati, in Pungro sub-division of Kiphire district and as such diverse species of orchids are predominant across these altitudinal ranges. From the field studies and recorded species from the three districts, species from the same genus tend to have an affinity both towards low or high altitudinal ranges and not strictly to a given altitudinal range for some genus such as *Bulbophyllum*, *Coelogyne*, *Cymbidium*, *Dendrobium*, *Eria*, *Goodyera*, *Papilionanthe*, *Pinalia*, *Thrixspermum*, *Vanda* which survives in wide altitudinal range, on the other hand species from the genus *Epigenium*, *Phalaenopsis*, *Panisea*, *Pleione*,*Renanthera*, *Vandopsis*, were found to occur only at higher altitudes of above 2000 m.

The Forest types predominant to the state according to Champion and Seth, 1968 are Northern Tropical Wet Evergreen Forests (1B), Northern Tropical Semi Evergreen Forests (2B), Northern Sub-tropical Broad Leaved Wet Hill Forests (8B/C1), Northern Sub-tropical Pine Forests (9/C2), Northern Montane Wet-temperate Forests (11B), and Alpine Forest (15) on the other hand, the vegetation and forest of Nagaland as per Naithani (2011), has been classified broadly into 1) Tropical

vegetation consisting of Moist evergreen forest and Moist deciduous forest 2) Sub-tropical vegetation consisting of Evergreen forests, Semi-evergreen forests and Degraded Bamboo forests3) Temperate vegetation consisting of Broad–leaved evergreen forest, Pine forests and Rhododendron forests 4) Sub Alpine/Alpine vegetation. There is Homogeneity in vegetation of the three districts and comprise predominantly of Sub-tropical and Temperate vegetation with Tropical vegetation in patches in the lower regions of river Dikhu and Zunheboto side of Doyang river, Sub Alpine/ Alpine vegetation in Saramati range of Kiphire District. Based on the classification of vegetation types the predominant orchid species that occupy are:

1. Tropical vegetation

Among the studied three districts, only a small patch on the Zunheboto side of Doyang river could be classified under these class but is a home to a wide variety of orchid species both epiphytic and terrestrial. Epiphytic species viz. *Acampe papillosa*, *Aerides odorata*, *Bulbophyllum caryanum*, *Cleisostoma paniculatum*, *C. williamsonii*, *Coelogyne fimbriata*, *C. ovalis*, *Cymbidium aloifolium*, *C. iridiodes*, *Dendrobium aphyllum*, *D. chrysotoxum*, *Luisia trichorrhiza*, *Papilionanthe teres*, *Pinalia amica*, *Polystachya concreta*, *Vanda testaceae* and terrestrial orchids viz. *Calanthe triplicata*, *Crepidium acuminatum*, *C. calophyllum*, *Dienia ophrydis*, *Phaius tankervilleae*, *Tainia latifolia* are predominant.

2. Sub-Tropical vegetation

Generally restricted to a limit of 1850 m but reaches upto 2000 m, three types of forest are found in this vegetation type viz. Evergreen forests, Semi-evergreen forests and Degraded Bamboo forests. The studied three districts are dominant of this forest vegetation type and majority of the orchid species diversity were found to occur in this vegetation type . Epiphytic orchids viz. *Acampe ochracea*, *A. rigida*, *Aerides multiflora*, *A. odorata*, *Agrostophyllum callosum*, *Arachnis labrosa*, *A. labrosa* var Zhaoi, *Bulbophyllum affine*, *B. caryanum*, *B. cariniflorum*, *B. crassipes*, *B. cylindraceum*, *B. leopardinum*, *B. pteroglossum*, *B. rotschildianum*, *Cleisocentron pallens*, *Cleisostoma parishii*, *C. williamsonii*, *Coelogyne cristata*, *C. fimbriata*, *C. ovalis*, *C. prolifera*, *C. schultesii*, *C. Suaveolens*, *Cryptochilus luteus*, *C. sanguineus*, *Cymbidium aloifolium*, *C. bicolor*, *C. iridiodes*, *D. aphyllum*, *D. chrysanthum*, *D. chrysotoxum*, *D. densiflorum*, *D. formosum*, *D. jenkinsii*, *D. moschatum*, *D. ochreatum*, *D. spatella*, *D. transparens*, *Epigeneium amplum*, *Eria spicata*, *Gastrochilus calceolaris*, *G. inconspicua*, *Liparis bootanensis*, *L. distans*, *L.*

viridiflora, *Luisia trichorrhiza*, *Oberonia pachyrachis*, *Papilionanth vandarum*, *Phalanaeopsis difformis*, *Pholidota articulate*, *Pinalia acervata*, *P. paniculata*, *P. pannea*, *Pleione maculata*, *Polystachya concreta*, *Vanda ampullaceaum*, *V. bicolor*, *V. coerulea*, *V. testaceae* and terrestrial orchids such as *Acanthephippium striatum*, *Anthogonium gracile*, *Arundina graminifolia*, *Calanthe biloba*, *C. mannii*, *Calanthe puberula*, *C. triplicata*, *Crepidium acuminatum*, *C.* calophyllum, *C. khasianum*, *Dienia ophrydis*, *Eriodes barbata*, *Erythrodes blumei* , *Goodyera viridiflora*, *Habenaria arietina*, *Habenaria dentate*, *Pecteilis susannae* , *Phaius tankervilleae* , *Tainia latifolia*.

3. Temperate vegetation

Altitudinal ranges of these vegetation types is from 2000-3000 m. Three types of forest are classified under these vegetation types viz., Broad-leaved evergreen forest, Pine forests and Rhododendron forests and is well represented in Kiphire district (Pungro, Khongsa, Longmatra, Seyochung, Sitimi and Amahotor areas comprising various villages) Zunheboto district (Aghunato, Satoi, Suruhuto, Zunheboto areas comprising various villages), Tuensang district (Longkhim, Sotokur, Chare, Chingmei, Noklak, Shamator areas comprising various villages), During field studies, it was observed that majority of the more rare species were found in these vegetation type. Epiphytic orchid species viz., *Acampe rigida*, *A. multiflora*, *Agrostophyllum callosum*, *Arachnis senapatiana*, *Bulbophyllum affine*, *B. candidum*, *B. crassipes*, *B. cylindraceum*, *B. elatum*, *B.. Helenae*, *B. odorotissimum*, *B. reptans*, *B. retusiusculum*, *B. sunipia*, *B. umbellatum*, *B. viridiflorum*, *Bulleyia yunnanensis*, *Coelogyne barbata*, *C. calcicola*, *C. corymbosa*, *C. cristata*, *C. griffithii*, *C. nitida*, *C. occultata*, *C. stricta*, *Cryptochilus luteus*, *C. sanguineus*, *Cymbidium cochleare*, *C. devonianum*, *C. elegans*, *C. erythraeum*, *C. mastersii*, *C. tigrinum*, *Dendrobium aphyllum*, *D. chrysanthum*, *D. crepidatum* , *D. densiflorum*, *D. denudans*, *D. devonianum*, *D. ochreatum*, *D. falconeri*, *D. fimbriatum*, *D. heterocarpum*, *D. lituiflorum*, *D. longicornu*, *D. nobile*, *D. sociale*, *D. wardianum*, *D. wattii*, *D. williamsonii*, *Epigeneium fuscescens*, *E. rotundatum* , *Eria coronaria*, *E. spicata*, *Esmeralda Clarkei*, *Gastrochilus calceolaris*, *G. distichus*, *G. pseudodistichus*, *Hygrochilus parishii*, *Liparis bistriata*, *L. resupinata*, *Oberonia acaulis*, *O. mucronata*, *O. obcordata*, *O. pachyrachis*, *Otochilus albus*, *O. fuscus*, *O. lancilabius*, *Panisea tricallosa*, *Paphiopedilum hirsutissimum*, *P. villosum* var. *boxallii*, *Papilionanthe vandarum*, *Pendulorchis himalaica*, *Phalaenopsis braceana* , *P.*

taenialis, P. yingjiangensis, Pholidota articulata, P. convallariae, Pinalia excavata, P. graminifolia, P. paniculata , P. pannea, Pleione humilis, P. praecox, Renanthera imschottiana, Schoenorchis gemmata, Thrixspermum laurisilvaticum, Thunia alba, Vanda alpina, V. pumila, Vandopsis undulata and terrestrial orchids such as *Calanthe alismifolia, C. puberula, Cremastra appendiculata, Epipogium roseum, Eulophia zollengeri, Galeola lindleyana, Goodyera schlechtendaliana, Phaius flavus.*

4. Sub Alpine/Alpine vegetation

These types of forest occur only in high altitudinal area in Saramati range of Kiphire district and are predominated with Rhododendron species (Particulary *Rhododendron macabeanum* and *Rhododendron arboreum*). Species of *Epigenium, Pleione* and *Goodyera* are some rare species of the region.

Major Threats and Conservation Status

Based on the interpretation of satellite (ISFR, 2015) the forest cover in the state of Nagaland is 12, 489 sq km, which is 75.33% of the State's geographical area out of which the state has 1,279 km under very dense forest, 4,587 sq km under moderately dense forest and 6, 623 sq km under open forest in terms of forest canopy density classes (FSI, 2015. However, the state has reported a recorded forest area of 8, 623 sq km (52.01%) of its geographical area. The Reserved and unclassed forest are 2.71% and 97.29% respectively of the recorded forest area. District wise forest cover shows Kiphire with a geographical area of 1, 130 sq km has total forest area of 835 sq km (73.89 % of Geographical area) out of which 152 sq km of very dense forest, 285 sq km of moderately dense forest and 398 sq km of open forest. Tuensang with a geographical area of 2, 536 sq km has total forest area of 1, 673 sq km (65.97% of Geographical area) out of which 441 sq km of very dense forest, 554 sq km of moderately dense forest and 678 sq km of open forest. Zunheboto with a geographical area of 1, 255 sq km has total forest area of 934 sq km (74.42% of Geographical area) out of which 84 sq km of very dense forest, 369 sq km of moderately dense forest and 481 sq km of open forest (ISFR, 2017). A net decrease of 450 sq km in forest area has therein been reported as per 2017 assessment from year 2015-2017 (ISFR, 2017), unplanned developmental activities and shifting cultivation being the main reasons for the decrease

The state has witnessed a large scale exploitation of orchid species in the past owing to their horticultural value, moreover the practice of Logging **(Figure 2.5),**

Jhumming for shifting cultivation **(Figure 2.6)** and unplanned developmental activities has added to the

decrease in plant biodiversity of the region and orchids being vulnerable to changes in microclimate has been affected the most consequently driving a good number of orchid species to the verge of extinction. The authors on field floristic studies and documentation have in the process unearthed some interesting findings. Based on the Redlist of threatened vascular plant species in India (Rao *et al.*, 2003), compiled from the 1997 IUCN red list of threathened plants and published by Botanical Survey of India, 105 species under 46 genera from family orchidaceae are represented out of which 14 species reported by the author from the three districts are represented viz., *Esmeralda clarkei* (*Arachnis clarkei*), *Bulbophyllum rotschialdianum*, *Bulleyia yunnanensis*, *Calanthe alismaefolia*, *Coelogyne barbata*, *Coelogyne cristata*, *coelogyne flaccida*, *Coelogyne nitida*, *Coelogyne prolifera*, *Galeola lindleyana*, *Paphiopedilum hirsutissimum*, *Renanthera imschottiana*, *Vanda coerulea*, *Pholidota imbricata (Pholidota calceata*).

The author has subsequentely documented wild flowering of most of this taxa**.** Interestingly, some of this species viz., *Coelogyne barbata*, *Coelogyne cristata* and *Vanda coerulea* adorn the house of a good number of hobbyists aplenty, hence a more detailled compilation of threathened plants particularly on orchids could thus unearth interesting species. Wild flowering population of *Paphiopedilum villosum* var boxallii from Pangsha village bordering Myanmar in Tuensang district report of *Arachnis labrosa* var. zhaoi and *Thrixspermum laurisilvaticum* as new records for India are some of the findings. It should be noted that all orchid species are included under Annex B of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and subsequently all *Paphiopedilum* species (Lady's slippers) are listed under Appendix I of CITES, hence a collaborative effort from the governmental agency and researchers alike could thus go a long way in conservation of the remaining orchid species.

Fig.2.5. Excerpt from field studies: a) Logging at Helipong range forest, Tuensang district **; b)** Collection of orchids from a logged tree; **c)** At base camp Wangsoi village; **d)** Field guide helping in collection of wild *Paphiopedilum villosum* var. boxallii - Indo-Myanmar border Tuensang; **e)** Returning from field work, Tsutoho village, Zunheboto; **f)** Field collection for later sorting; **g)** Indo-Myanmar Border stone bordering DAN ITC, Tuensang district; **h)** Indo -Myanmar boundary stone atop Saramati range, Kiphire district; **i)** Sample collection of wild *Paphiopedilum hirsutissimum.*

Fig.2.6. Panoromic view of Jhumming cultivation; a) Fresh Slash and burn (Jhum) for cultivation at Noklak area, Tuensang; **b)** Large forest areas converted for Jhum cultivation, Longmatra, Kiphire district; **c)** Cultivation after Jhumming, V.K area, Zunheboto

2.5 Summary and Conclusion

India is home to three biodiversity hotspots viz., Indo-Burma, Himalayas, Western Ghats & Srilanka out of the 36 biodiversity hotspots which makes it one of the richest country in terms of flora and fauna and North-East India is a part of Himalayas as well as Indo-Burma biodiversity hotspot, as a result of which this region is fascinating for researchers. North-East India has the richest reservoir of plant diversity in India. subsequently, Indian orchids are mostly confined to North-Eastern region and Western Ghats constituting about 1378 species and about 890 species are found in North-East India. Nagaland, one of the states of North-East India contributes significantly with about 396 species of 92 genera to family Orchidaceae which occupies a prominent place in the rich flora, many more being added lately. Unfortunately, in recent years excessive human intervention has led to the rapid decline of floral diversity and orchids being intolerant to slight changes in microclimates have subsequently experienced massive decline in population. Hence, the need for conservation both *in-situ* and *ex-situ* is necessitated for further sustainable utilization of this rich resource. The present Documentation work has thus unearthed 180 species belonging to 58 genera from the three study area districts several of which are new records for the state as well as the country bringing the total diversity of orchid taxa to about 426 species belonging to 101 genera for the state.

Chapter - 3

Micropropagation

3.1. Introduction

Orchid seeds are microscopic and non-endospermous with undifferentiated embryos. Due to this they require a special fungal association (mycorrhiza) to germinate, and their germination in nature thus depends upon a suitable association with a mycorrhizal fungus to provide an essential physico-chemical stimulus for initiating germination. Seed germination of orchids in nature is very poor ~0.2-0.3% (Sungkumlong and Deb, 2008) because of their poorly organized as well as the lack of an appropriate metabolic machinery to utilize their own lipidaceous food reserves. Moreover, the rate of vegetative propagation (i.e. keikis, back-bulbs, division of shoots etc.) is very slow in many orchid species. When Knudson (1922) for the first time demonstrated the possibility of bypassing the fungal requirements during germination of *Cattleya* seeds *in vitro* with the supply of appropriate organic carbon in the medium, and subsequently Tsuchiya (1954) discussed the possibility of germinating orchid seeds from immature pods, these two techniques led to the development of 'green pod culture' that enabled to rescue hybrid embryos from desired mating. The asymbiotic germination potential of fertilized ovules (seeds) has since then been positively tested in several commercially viable and or threatened species and has been accepted as an important tool for propagating orchids. *In vitro* cloning of *Phalaenopsis* using uni-nodal floral stock cuttings was first developed by Rotor (1949) and Thomale (1957) successfully cultured the shoot tips of *Orchis maculata*, moreover the possibility of using aerial roots for micropropagation was first suggested by Beechey (1970). Plant tissue culture techniques have since opened new possibilities in conservation and many orchid species have thus been propagated successfully through this techniques, particularly the threatened orchid species and re-introduced into the wild.

However, *Paphiopedilum* species and their hybrids are the only commercially grown orchids that are not cloned since explants from mature plants of *Paphiopedilum* species are recalcitrant to shoot induction and plant regeneration. The traits of *in vitro Paphiopedilum* hybrid protocorms or seedlings are variable and unpredictable, which is unacceptable in commercial production, moreover the phenotype of plants must be uniform to be commercially viable on a large scale and at present, there are few protocols for the tissue culture of *Paphiopedilum* from explants of mature plants. Moreover, aseptic explants from mature plants are difficult to survive without contamination as surface sterilization steps for *in vitro* culture of *Paphiopedilum* are inefficient due to presence of endogenous bacteria (Chugh *et al*., 2009). *Paphiopedilum* available commercially are almost entirely from *in vitro* germinated seeds of hybrid species. Factors such as seed maturity, basal medium, organic amendments, light, temperature, carbon source, choice of PGRs, and culture method have a strong impact on the outcome of *in vitro* propagation; hence an understanding of the physiogy and ecology of seeds and whole plant ecology of *Paphiopedilum* is necessitated. In India 9 species of the genera are recorded out of which 8 species are restricted to Eastern Himalaya and North-East India with only *Paphiopedilum druryi* (Bedd.) Pfitzer being endemic to Western Ghats. Consequently, All *Paphiopedilum* species (Lady's slippers) are listed under Appendix I of CITES and *Paphiopedilum* species are protected by Wildlife Protection Act of India under Schedule VI and hence illegal collection and propagation is banned. The present investigation protocols is thus carried out for establishment of more defined protocols in culture initiation from immature seeds/embryos of various developmental stages, foliar explants, regeneration of plantlets and mass multiplication of *Paphiopedilum insigne* and *Paphiopedilum villosum* var. *boxallii*.

3.2 Materials and Methods

3.2.1 Plant material collection and sterilization

Paphiopedilum insigne plants were collected from hobbyists (in Mokokchung and Zunheboto districts) whereas *P. villosum* var. *boxallii* plants were collected in the wild from Pangsha village of Tuensang District, Nagaland, India and raised at Orchidarium of Botany Department, Nagaland University. Hand pollination for both the species was done in the orchid house of the Department. Green pods of various developmental age starting from 120 days after pollination (DAP) to 300 DAP were

harvested at 30 days interval and the immature embryos/seeds from these pods were used for the present study. Harvested pods were then scrubbed with brush using diluted 'Labolene' (laboratory detergent, 1:100, v/v), surface of pods were then scrapped with laboratory blade to remove fibers from the pod surface and again washed with Labolene and rinsed under running tap water. Subsequently, they were surface sterilized with aqueous solution of mercuric chloride (0.3%, w/v) for 5 min and rinsed 5 times with sterilized distilled water. Later the pods were dipped in ethanol and flamed for about 3-4 sec in the laminar flow cabinet before scoping out the seeds/immature embryos.

Foliar and root explants were obtained from *in vitro* stained from the cultured seeds. A part of the leaves were cut into segments (~5 mm) and tiny incisions were made on the surface of leaf with a needle before inoculation. Intact leaves as well as leaf segments were cultured on nutrient medium for culture initiation. The foliar explants were cultured horizontally as well as vertically to study the effect of alignment on performance in various media. Similarly the root explants (~3 mm) cultured on nutrient medium conjunct differently.

3.2.2 Nutrient media

For asymbiotic *in vitro* germination of immature embryos/seeds of both the species, different nutrient media viz., Gamborg or (B5) (Gamborg *et al.*, 1968), Knudson 'C' (Knudson, 1946), Mitra *et al.* (Mitra *et al.*, 1976), Murashige and Skoog (MS) (Murashige and Skoog, 1962) and SH (Schenk and Hildebrandt, 1972) were used in conjunct with different supplements. For asymbiotic seed germination agar gelled (0.8%, w/v) nutrient media were fortified with different organic carbon sources such as dextrose, glucose and sucrose (0-4%, w/v), plant growth regulators (PGRs) i.e., α-napthalene acetic acid (NAA), benzyl adenine (BA) (0-10 μM) either singly or in combination, tender coconut water (CW) (0-25%, v/v) and activated charcoal (AC) (0-0.5%, w/v).

For foliar explants and roots from *in vitro* source of both *P. insigne* and *P. villosum* var. *boxallii* three media i.e., Knudson 'C', Mitra *et al.* and Murashige and Skoog (MS) fortified with organic carbon sources (dextrose, glucose and sucrose, 1-4%) and different levels of PGRs like IAA, NAA, BA, and KN (0-10 μM) singly or in combination to study morphogenetic response. The *p*H of the media was adjusted at 5.6 using 0.1 N NaOH and 0.1 N HCL. About 12 ml medium was dispensed in borosilicate test tube (size: 25 mm x 150 mm) and ~30 ml medium on 400 ml culture

jam bottles (diameter 70 mm). Both test tube and jam bottles were clogged with plastic caps. The medium was then sterilized by autoclaving at 121°C for 20 min at a pressure of 1.05 Kg cm^{-2}.

3.2.3 Tissue culture

3.2.3.A Initiation of Culture

***Asymbiotic seed germination*:** The surface sterilized pods were cut open longitudinally using sterilized blade and about 100 seeds were transferred to each test tube containing different culture media fortified differently as mentioned above. For each treatment 10 test tubes were maintained and the experiments were repeated thrice. Cultures vials were incubated at 25±2°C under normal laboratory light (40 µmol m^{-2} s^{-2}), diffused light (20 µmol m^{-2} s^{-1}) provided by white fluorescent lamps with 12/12 h photoperiod as well as in dark room (no light). The cultured seeds/immature embryos were monitored at regular interval for germination and germination frequencies by observing under a light microscope. For the purpose, a part of the cultured seeds were scoped out randomly and stained on microscopic slide with Acetocarmine (2%, w/v) prepared following (Darlington and La Cour, 1976) and observed under microscope. The first stage of germination is seen as nodular swelling of embryos followed by rapture of the testa and enlargement of embryo and then subsequently formation of top-shaped protocorm-like bodies (PLBs). When the embryo emerged from the testa and the size of the embryo doubled germination is considered to have occurred. Mean values were obtained from the three replicates of each treatment. The germinated embryos formed PLBs on the same initiation medium followed by released the first set of leaves. Cultures were sub-cultured on optimum germination condition for another 2 passages at 4-5 wk interval for subsequent differentiation and development.

Germinated embryos/seeds with first leaf initials were then transferred on fresh MS medium containing optimum germination supplements and maintained for 2 passages at 4 wk interval. Cultures were monitored at weekly interval for growth of plants with first leaf initials, plant differentiation and generation of root.

***Initiation of culture foliar and aerial root explants*:** Explants from *in vitro* grown plantlets/axenic cultures were harvested and cultured for morphogenic response. Foliar explants (1-1.5 cm size) were collected from 8 wk old cultures from both the species while the aerial roots of ~12 wk old were harvested and used for *in vitro*

culture initiation. The PLBs and shoot buds resulted on initiation medium were maintained for another two passages for further differentiation.

***Experimental design and statistical analysis*:** Completely randomized experimental design was followed in all the experiments. In each experiment 10 test tubes were maintained for each treatment and each experiment was repeated thrice. *In vitro* response was evaluated based on percentage of explants which responded and number of propagules formed in the culture and data was expressed as a mean of replicates ± standard error. Data was further analyzed by one way ANOVA using the general Linear Model procedure in SAS Statistical Package (SAS Ins.) and standard deviation from mean was worked out and compared using Least Significant difference (LSD) test at p=0.05.

3.2.3.B Plant Regeneration and Mass Multiplication

The resulted young plantlets obtained from immature seeds and leaves were then transferred on different nutrient media for regeneration of plantlets and mass multiplication. Three different nutrient media viz., Knudson 'C', Mitra *et al* and MS and subsequently the cultures were maintained on different strengths of MS medium ($1/4^{th}$, 1/2, $3/4^{th}$ and full strength) along with other growth adjuncts for plant regeneration and proliferation. Four different PGRs viz., NAA, IAA, BA and KN (0-12 µM) along with different organic carbon sources (dextrose, glucose and sucrose, 1-4%) for plant regeneration and proliferation. Cultures were maintained for 8-10 wk under normal laboratory condition.

3.2.3.C Hardening and Transplanting of Regenerates

For *in vitro* hardening, regenerated plantlets with healthy shoot and well formed roots were selected and transferred in Jam bottles containing different substrata/hardening mix viz., chopped coconut husk, brick pieces, charcoal chunks, sand, decaying organic matter, dried cow dung in varying combination. The substratum were soaked in laboratory detergent for about 1 h and rinsed with water several times then sundried for 6-7 h. About 50-60 grams of substratum were transferred in Jam bottles separately and autoclaved at 121° C for 30 min at pressure of 1.05 kg cm^{-2}. About 20 ml $1/10^{th}$ strength MS liquid medium with sucrose (1%) was dispensed in all the Jam bottles and autoclaved at 121° C for 20 min at pressure of 1.05 kg cm^{-2}. No PGRs were used. The well rooted plantlets were transferred in the culture vials and maintained in normal laboratory conditions for 7-8 wk. The hardened plants were then transferred to community pots composed of same

substrates used for hardening, covered with perforated poly bags and maintained in the poly house ca. 75% shade for 6-8 wk. The transplants were fed water and 1/10th MS solution once a week. The well established transplants were transferred to wild after 2 months and monitored for survival performance.

3.3 Results

3.3.1 Initiation of Cultures

***Asymbiotic seed germination*:** Immature seeds/embryos from various developmental stages were cultured on different basal medium containing different supplements. The green pod age, basal media composition, quantity of organic carbon, quality and quantity of PGRs were crucial factors for successful culture initiation. Nodular swelling of seeds was the first sign of germination in both the species.

***Effect of seed pod age and basal media*:** Seed pod age was detrimental on survival/optimum germination in both the species. Germination was carried out with seed pod age varying from 120–300 DAP (Days After Pollination) for both the species at an interval of 30 days and germination performance was evaluated (**Figure 3.1 and 3.2**). Younger seeds (~120 DAP) did not show any sign of germination, while seeds from >270 DAP old pods exhibited delayed germination up to 4 months after inoculation with very low germination rate (**Table 3.1 and 3.2**). Seeds collected from burst out seed pods **(Figure 3.1e; Figure 3.2d)** (~300-360 DAP) were also collected and used for asymbiotic germination following different protocols for disinfection but recorded very late germination (6 months) with very low germination rate/no germination and higher contamination. For calculating the germination percentage, firstly the seeds scooped out from capsules were stained in 2% acetocarmine **(Figure 3.3a, d)** for 10 min and viewed under a compound microscope to calculate the average viable seeds **(Figure 3.3b, e).** Nodular swelling of the embryos and separation of testa **(Figure 3.3 c, f)** showing the first sign of germination was recorded at earliest after 20 days of culture in *Paphiopedilum insigne* (**Table 3.1)** and as early as 18 days for *Paphiopedilum villosum* var. *boxallii* **(Table 3.2)**, but no/very few PLBs were formed from seeds/embryos of very young aged pods (< 150 DAP). Healthy PLBs **(Figure 3.5a, b)** were formed only in seeds/embryos from older aged pods (>210 DAP) and subsequently healthy PLBs gave rise to micro plants with leaf initials **(Figure 3.5c, d)** that later converted into healthy plantlets.

Table 3.1: Effect of green pod age on *in vitro* germination of *Paphiopedilum insigne*

Pod age (DAP)	Time taken for (days)			% Germination (±SE)#	Type of response*
	Nodulation	PLBs formation	1st leaf initials		
120	-	-	-	-	No response
150	20	45	65	5.0 (1.5)[e]	Nodular swelling of embryos but very few PLBs formed
180	32	57	82	74.1 (1.5)[b]	Nodular swelling followed by PLBs formation
210	**38**	**70**	**94**	**85.0 (1.5)[a]**	**Most of the geminated embryos converted into healthy PLBs**
240	45	76	102	65.2 (1.5)[c]	Germinated embryos converted into healthy PLBs
270	72	94	117	30.1 (2.5)[e]	Delayed germination with low germination percentage
300	72	98	118	35.1 (2.5)[d]	Delayed germination with low germination percentage

Standard error from mean; data represents mean of three replicates; Data with the same *letters* in the column for the same factor are not significantly different at 5% level. *On MS medium with sucrose (3%, w/v), NAA+ BA (2 + 6 µM respectively) in combination.

Table 3.2: Effect of green pod age on *in vitro* germination of *Paphiopedilum villosum* var. *boxallii*

Pod age (DAP)	Time taken for (days)			% Germination (±SE)#	Type of response*
	Nodulation	PLBs formation	1st leaf initials		
120	-	-	-	-	No response
150	18	-	-	-	No PLBs formed
180	24	44	76	12.1 (1.5)[e]	Nodular swelling of embryos but very few PLBs formed
210	39	54	80	25.2 (1.5)[d]	Nodular swelling followed by PLBs formation
240	**42**	**59**	**82**	**60.0 (1.5)[a]**	**Most of the geminated embryos converted into healthy PLBs**
270	45	83	112	42.2 (2.5)[c]	Delayed germination with fair germination percentage
300	45	89	122	44.2 (2.5)[b]	Delayed germination but with good germination percentage

Standard error from mean; data represents mean of three replicates; Data with the same *letters* in the column for the same factor are not significantly different at 5% level. *On MS medium with sucrose (3%, w/v), NAA+ BA (2 + 6 µM respectively) in combination.

The optimum germination percentage for *Paphiopedilum insigne* (85%) was recorded from 210 DAP seed pods **(Table 3.1)** whereas, *Paphiopedilum villosum* var. *boxallii* recorded optimum germination percentage (60%) from 240 DAP seed pods and fair germination percentage from 270 DAP and 300 DAP though time for germination was prolonged **(Table 3.2)**.

In the present study for both the species five different nutrient media were used for asymbiotic germination of seeds and MS medium supported optimum germination percentage in both the species. *Paphiopedilum insigne* recorded an optimum germination (85%) on MS medium followed by Mitra *et al* (40%) and Knudson 'C' (32%) **(Table 3.3)**. On Gamborg (B5) medium, only nodular swellings but no formation of PLBs were recorded while, on SH medium few germinated seeds formed PLBs but degenerated

subsequently. In *Paphiopedilum villosum* var. *boxallii* optimum germination was achieved on MS medium (60%) followed by Knudson 'C' (40%) and Mitra *et al* (35%) **(Table 3.4)** while, Gamborg (B5) and SH Media supported very low germination. In both the species Gamborg (B5) recorded slight swelling of the embryos but did not convert to PLBs. Knudson 'C' recorded formation of few PLBs in *Paphiopedilum insigne* and more for *Paphiopedilum villosum* var. *boxallii* but degenerated with time. Mitra *et al* followed similar trend in both species as nodular swelling of embryos and formation of PLBs were both observed but the PLBs failed to differentiate with time. Hence, nutrient media used for asymbiotic germination of both the species had approximately similar response but with higher percentage of germination for *Paphiopedilum insigne* as compared to *Paphiopedilum villosum* var. *boxallii* particularly on MS medium.

Effect of organic carbon sources and coconut water (CW) on in vitro embryo culture: For asymbiotic germination of immature seeds, varying concentrations of different carbon sources i.e., dextrose, glucose and sucrose (0-4%, w/v) were incorporated. Exclusion of carbon sources in the nutrient medium recorded only nodular swellings without formation of PLBs in both *Paphiopedilum insigne* and *Paphiopedilum villosum* var. *boxallii*. In *Paphiopedilum insigne* MS medium fortified with dextrose across the concentrations tested supported formation of very few PLBs. A similar trend was also observed with different concentrations of glucose (**Table 3.5)**. For *Paphiopedilum insigne* a derivative is hence drawn that dextrose and glucose hindered germination, but sucrose at all studied concentrations supported better

germination. Of the different concentrations of sucrose tested in the present study, a concentration of 3% invoked 85% germination after 70 days of culture initiation from 210 DAP old immature seeds **(Table 3.5)**. The immature seeds of *Paphiopedilum villosum* var. *boxallii* on the other hand responded more or less identically on dextrose and glucose enriched medium across the concentration and the germination rate ranged between 20-36% and the germination time ranged between 72-78 days (**Table 3.6**). Compare to these two organic carbon sources, sucrose was found to be far better and initiated germination as early as within 59 days. At lower and higher concentrations (1, 2 and 4%) germination rates was significantly lower (38, 42 and 45% respectively). Under the given conditions, optimum germination was achieved on MS medium enriched with 4% sucrose where 60% seed registered germination after 59 days (**Table 3.6**). The germinated seeds converted to PLBs on the same medium in due course of time.

Besides organic carbon sources, CW was also added to germination medium to test the efficacy on asymbiotic *in vitro* seed germination. In general CW had very little effect on seed germination in both the species as there was no improvement in germination rate in comparison to CW control medium (**Table 3.7, 3.8**). Of the two species studied, immature seeds of *Paphiopedilum insigne* responded better compare to *Paphiopedilum villosum* var. *boxallii*. In *P. insigne* though there was no improvement in seed germination rate, PLBs formation was faster and healthier at a concentration of 5-15%, but in *P. villosum* var. *boxallii* both seed germination as well as PLBs formation was negatively affected in presence of CW.

***Effect of activated charcoal on asymbiotic germination*:** Addition of activated charcoal at different concentration did not enhance germination percentage rate, neither did it help in reducing the time for germination. At concentration of AC (0.05–0.1%) in *Paphiopedilum insigne* embryos formed healthy green PLBs **(Table 3.9)**, but with increase in concentration of AC (0.2-0.5%) it had a detrimental negative effect on seed germination and the embryos tend to form nodular swelling/few PLBs that slowly turned gray and degenerated. Similar trend was also recorded for *Paphiopedilum villosum* var. *boxallii* embryos (**Table 3.10**).

***Effects of light intensity on asymbiotic germination*:** Three different light conditions were maintained in the present study for *In vitro* seed germination for both the species. In *Paphiopedilum insigne* nodular swelling of embryos was observed after 27 days in the dark and in *Paphiopedilum villosum* var. *boxallii* nodulation was observed

at 21 days in the dark **(Figure 3.3c, d, 3.4 a, b)**. Nodular swelling was observed to be faster in the dark but the germination rate was lower as compared to embryos kept under diffused light (20 µmol m^{-2} s^{-1}). Full light conditions (40 µmol m^{-2} s^{-1}) on a 12/12 hr photoperiod recorded germination that formed PLBs that degenerated slowly.

Figure 3.1: Green pod morphology at various developmental age of *Paphiopedilum insigne*. a) 180 DAP (Days after pollination) (Immature green pods); **b.** 210 DAP (Imm ature green pods); **c.** 240 DAP (Immature green pods); **d.** 270 DAP(Fully mature pods) and **e.** 300 DAP (Burst out seed pods with microscopic seeds)

Figure 3.2: Different developmental ages and morphology of green pods of *Paphiopedilum villosum* var *boxallii.* : a) 210 DAP (Immature green pods); **b)** *240 DAP (Immature green pods);* **c)** 270 DAP (Mature seed pods); **d)** 360 DAP (Burst out seed pods with microscopic seeds)

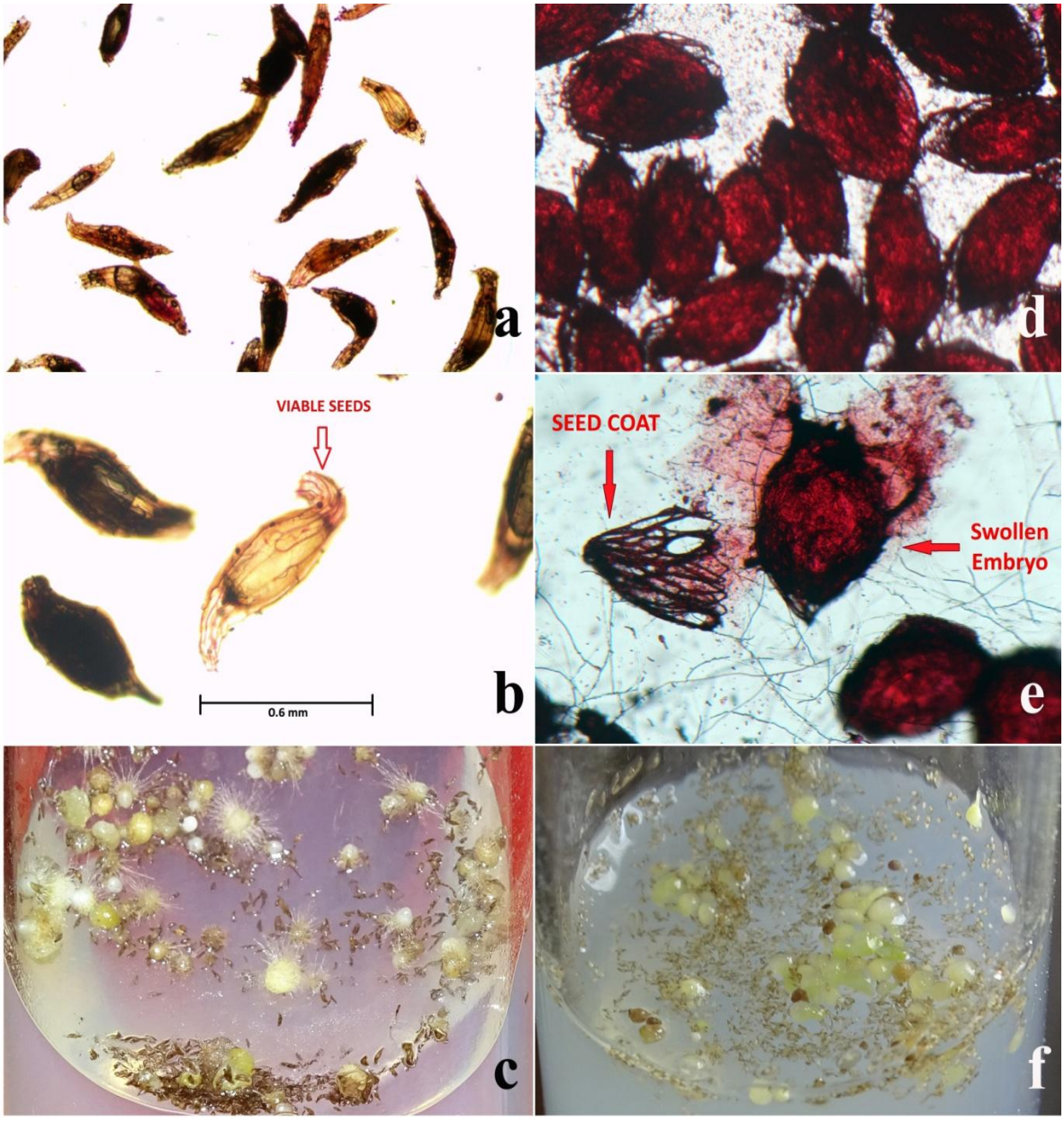


Figure 3.3: Orchid seeds at various stages of culture. a-c: *P. insigne* and **d-f:** *P. villosum* var. *boxallii.* **a)** Stained seeds before inoculation; **b)** Stained viable seeds showing embryo and seed coat; **c)** Nodular swelling of embryos from 210 DAP pods; **d)** Stained seeds before inoculation; **e)** Stained viable seeds showing embryo and seed coat; **f)** Nodular swelling of embryos from 240 DAP.

Table 3.3: Effects of nutrient media on non-symbiotic seed germination of *P. insigne*

Nutrient media	Avg. Germination time (days)	Germination rate (%) (±SE*)	Type of response**
Gamborg (B5)	110	18.1 (2.0)	Nodular swelling only
Knudson 'C'	130	32.2 (1.5)	Very few PLBs formed but degenerated
Mitra *et al*	92	40.4 (2.5)	Nodular swelling of embryos with formation of few PLBs but degenerated
MS	70	85.0 (1.5)	Most of the germinated embryos converted into healthy PLBs
SH	140	20.3 (2.0)	Very few germinated seeds formed PLBs but degenerated

*Standard error from mean. Data represents mean of three replicates.

** Media incorporated with 3% (w/v) sucrose, NAA+ BA (2 + 6 µM respectively) in combination

Table 3.4: Effects of different nutrient media on non-symbiotic seed germination of *P. villosum* var. *boxallii*

Nutrient media	Germination time (days)	Germination rate (%) (±SE*)	Type of response**
Gamborg (B5)	130	20.1 (1.5)	Slight swelling with no formation of PLBs
Knudson 'C'	90	40.2 (1.5)	Good number of PLBs formed but degenerated before differentiation
Mitra *et al*	80	35.2 (1.5)	Nodular swelling of embryos with formation of few PLBs but degenerated
MS	59	60.0 (1.5)	Healthy green PLBs formed
SH	130	25.2 (2.0)	Very few germinated seeds formed PLBs but degenerated

*Standard error from mean. Data represents mean of three replicates.

** Media incorporated with 3% (w/v) sucrose, NAA+ BA (2 + 6µM respectively) in combination

Table 3.5: Effect of different organic carbon sources on *in vitro* culture of immature embryos of *P. insigne*

Organic carbon source	Conc. (%)	Days for germination	% Germination (±SE)*	Type of response
0	0	82	21.1 (1.50)	Nodular swelling of embryos
Dextrose	1	70	42.1 (1.0)	Very few PLBs formed, degenerated
	2	65	43.1 (1.0)^{e}	Very few PLBs formed
	3	65	32.1 (1.50)^{i}	Few PLBs formed
	4	78	28.1 (1.00)^{j}	Very less germination
Glucose	1	76	38.2 (1.5)^{h}	Very few PLBs formed
	2	76	40.1 (1.5)^{g}	Very few PLBs formed
	3	84	42.3 (2.0)^{f}	Few healthy PLBs formed
	4	92	26.3 (2.0)^{k}	Very less germination
Sucrose	1	63	62.1 (2.0)^{c}	Few green PLBs
	2	65	65.2 (2.0)^{b}	PLBs formed
	3	**70**	**85.0 (1.5)^{a}**	**Healthy green PLBs with white hairy structures**
	4	84	56.1 (1.5)^{d}	PLBs formed

* Standard error from mean; data represents mean of three replicates; Data with the same *letters* in the column for the same factor are not significantly different at 5% level. Note: Immature seeds of ~210 DAP old cultured on MS medium containing NAA + BA (2 + 6 µM respectively in combination).

Table 3.6: Effect of different organic carbon sources on *in vitro* embryo culture of *P. villosum* var. *boxallii*

Organic Carbon Source	Conc. (%)	Days taken to germinate	Germination percentage (%) (±SE)*	Type of response
0	0	92	22.2 (1.5)^{j}	Nodular swelling of embryos
Dextrose	1	76	36.2 (1.5)^{e}	Few green PLBs formed
	2	74	22.3 (1.5)^{j}	Very few green PLBs formed
	3	76	24.1 (1.5)^{i}	Very few green PLBs formed
	4	88	20.2 (2.0)^{k}	Delayed germination with less PLBs formed
Glucose	1	75	28.1 (1.5)^{h}	Nodular swelling of embryos
	2	78	32.1 (1.5)^{f}	Green PLBs formed
	3	72	30.4 (1.5)^{g}	Green PLBs formed
	4	79	32.2 (2.0)^{f}	Green PLBs formed
Sucrose	1	65	38.3 (1.5)^{d}	Very few green PLBs formed
	2	68	42.3 (1.5)^{c}	Green PLBs formed
	3	**59**	**60.0 (1.5)^{a}**	**Most of the geminated embryos converted into healthy PLBs with white hairy structures**
	4	82	45.2 (2.0)^{b}	Delayed germination but good germination percentage

* Standard error from mean; data represents mean of three replicates; Data with the same *letters* in the column for the same factor are not significantly different at 5% level. Note: Immature seeds of ~240 DAP old cultured on MS medium containing NAA + BA (2 + 6 µM respectively in combination).

Table 3.7: Effect of coconut water (CW) on non-symbiotic seed germination of *P. insigne.*

CW Conc. (%, v/v)	Days taken to germinate	Germination percentage (%) (±SE)*	Type of response
0	70	85.0 (1.5)	Healthy green PLBs with white hairy structures
5	68	76.2 (1.5)	Healthy green PLBs formed
10	68	78.3 (1.5)	Healthy green PLBs formed
15	64	75.3 (2.5)	Healthy green PLBs formed
20	65	75.2 (2.5)	Few green PLBs formed
25	74	62.2 (2.5)	Few green PLBs formed

*Standard error from mean, data represents mean of three replicates.

Note: Seeds of ~210 DAP cultured on MS medium containing sucrose (3%), NAA + BA (2 + 6 µM respectively in combination).

Table 3.8: Effect of CW on non-symbiotic seed germination of *P. villosum* var. *boxallii.*

CW Conc. (%, v/v)	Days taken to germinate	% Germination (±SE)*	Type of response
0	59	60.0 (1.5)	Healthy PLBs with white hairy structures
5	53	54.2 (1.5)	Healthy green PLBs formed
10	52	53.3 (1.5)	Healthy green PLBs formed
15	58	56.4 (1.5)	Green PLBs formed
20	62	55.5 (2.5)	Fewer green PLBs formed
25	64	54.2 (2.5)	Fewer green PLBs formed

*Standard error from mean, data represents mean of three replicates.

Note: Seeds of ~240 DAP cultured on MS medium containing sucrose (3%), NAA + BA (2 + 6 µM respectively in combination).

Table 3.9: Effects of activated charcoal (AC) on non-symbiotic seed germination of *P. insigne*

AC Conc. (%, w/v)	Days taken to germinate	% Germination (%) (±SE)*	Type of response
0	70	85.0 (1.5)	Healthy green PLBs with white hairy structures
0.05	73	72.2 (1.5)	Healthy green PLBs formed
0.10	88	68.2 (1.5)	Green PLBs formed
0.20	90	69.3 (2.5)	Green PLBs formed but slowly degenerated
0.30	102	5.1 (2.5)	Nodular swelling of embryos that degenerated
0.50	105	3.1 (2.5)	Nodular swelling of embryos that degenerated

*Standard error from mean, data represents mean of three replicate

Note: About 210 DAP old seeds cultured on MS medium containing sucrose (3%), NAA + BA (2 + 6 µM respectively in combination).

Table 3.10: Effects of activated charcoal (AC) on non-symbiotic seed germination of *P. villosum* var. *boxallii*

AC Conc. (%, w/v)	Days taken to germinate	% Germination (±SE)*	Type of response
0	59	60.0 (1.5)	Healthy PLBs with white hairy structures
0.05	62	52.1 (1.5)	Healthy green PLBs formed
0.10	68	50.4 (1.5)	Green PLBs formed
0.20	73	38.2 (1.5)	Very few PLBs formed that degenerated
0.30	108	4.1 (2.5)	Nodular swelling of embryos that degenerated
0.50	112	3.1 (2.5)	Nodular swelling of embryos that degenerated

*Standard error from mean, data represents mean of three replicate

Note: About 210 DAP old seeds cultured on MS medium containing sucrose (3%), NAA + BA (2 + 6 µM respectively in combination).

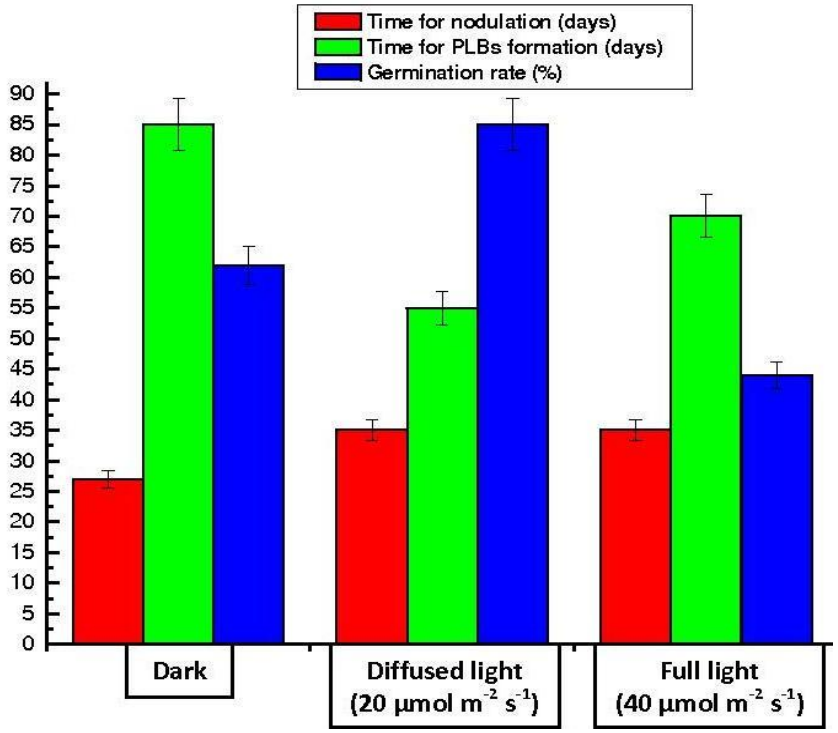


Figure - 3.4 a

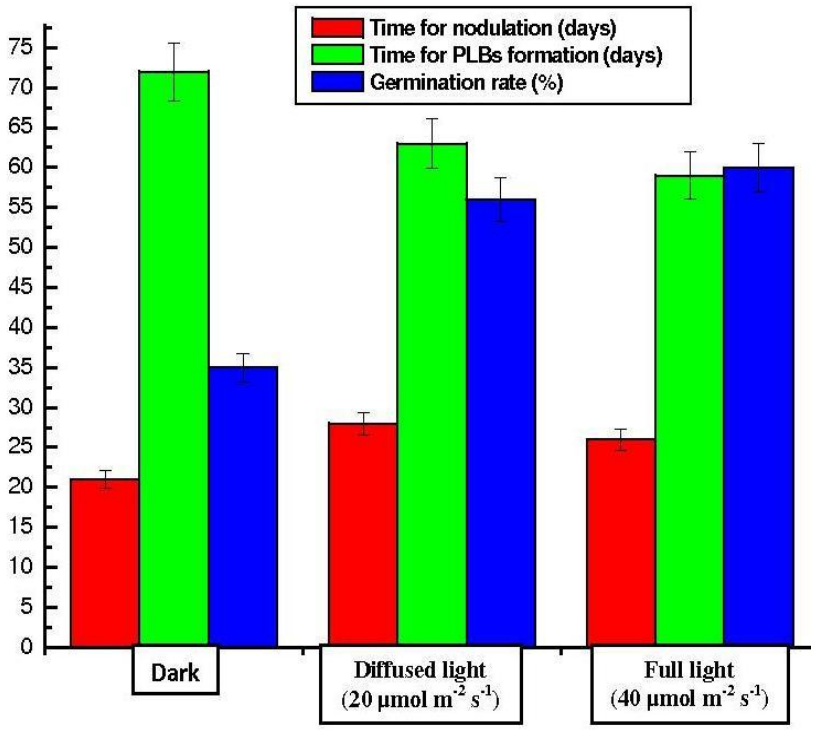


Figure - 3.4 b

Figure 3.4: Effect of light on *in vitro* culture of immature embryos. **A. *P. insigne;* b. *P. villosum* var. *boxallii***

***Effects of quality and quantity of PGRs on asymbiotic embryo culture*:** Besides other adjuncts, two different PGRs (BA and NAA) were used at different concentrations either singly or in combination for asymbiotic seed germination of both the species under study. Quality and quantity of different PGRs exhibited pronounced effect on seed germination,

subsequent PLBs formation and differentiation into plantlets. In both the species singly treatment of either of the growth regulators did not support satisfactory seed germination (**Table 3.11, 3.12**). Of the two PGRs tested at different concentrations, BA was found to be slightly better over NAA in both the species. On NAA fortified medium, though there were swelling of seeds, but failed to form healthy PLBs as exhibited by the BA fortified medium. Nutrient medium fortified with NAA alone at low concentration of 2 µM and 4 µM recorded formation of few PLBs but at higher concentration of 6 µM, 8 µM and 10 µM recorded only swelling of the embryos without any sign of formation of PLBs up to an observation time of 90 days. Conversely, BA at lower concentration of 2 µM and 4 µM responded only as nodular swelling without formation of PLBs but at higher concentration of 6 µM, 8 µM and 10 µM formed green PLBs most of which degenerated with time. On incorporation of NAA at lower concentrations along with BA, germination performance improved significantly in both the species. In *P. insigne*, the optimum germination (~85%) was recorded at combination of NAA + BA (2.0 + 6.0 µM) after 70 days of culture wherein healthy green PLBs formed from embryos subsequently converted into healthy plantlets with leaf initials **(Table 3.11, Figure 3.5 a, c).** Better germination were achieved at concentration wherein both BA and NAA were incorporated in the MS medium keeping the NAA concentration constant at 2 µM and varying the concentration of BA from 4–8 µM, but at 10 µM BA and 2 µM NAA PLBs that were formed consistently degenerated. Higher concentration of NAA from 4-6 µM in combination with BA 4-10 µM recorded mostly only swelling of the embryos with very few/no PLB formed that subsequently degenerated. While, in *Paphiopedilum villosum* var. *boxallii*, optimum germination (~60%) was also recorded at combination of NAA + BA (2.0 + 6.0 µM) with healthy PLBs and young plantlets **(Table 3.12, Figure 3.5 b, d)** following similar trend as that of *P. insigne*.

Table 3.11: Effect of different levels of PGRs on non symbiotic seed germination of *P. insigne*

PGRs Conc. (µM)		Germination time (Days)	% Germination (±SE) *	Type of response
NAA	**BA**			
0	0	78	65.1 (1.5)[e]	Nodular swelling of the embryos
2	0	75	55.2 (1.5)[g]	Few PLBs formed
4	0	74	60.3 (1.0)[f]	Few PLBs formed
6	0	82	50.1 (1.5)[h]	Nodular swelling of the embryos
8	0	88	48.0 (2.0)[h]	Nodular swelling of the embryos delayed germination, No PLBs formed
10	0	90	45.0 (2.0)[i]	Nodular swelling of the embryos, delayed germination, No PLBs formed
0	2	76	55.2 (1.5)[g]	Nodular swelling of the embryos, No PLBs formed
0	4	75	42.3 (1.5)[j]	Same as above
0	6	75	72.2 (1.0)[d]	Green PLBs formed, subsequently degenerated
0	8	63	68.1 (1.0)[d]	Green PLBs formed
0	10	62	52.2 (2.0)[h]	Green PLBs formed
2	2	92	63.1 (1.5)[e]	Delayed germination, PLBs formed subsequently degenerated
2	4	76	74.2 (1.5)[c]	Healthy green PLBs formed
2	**6**	**70**	**85.0 (1.5)[a]**	**Healthy green PLBs that subsequently converted into plantlets**
2	8	73	77.1 (2.5)[b]	Same as above
2	10	67	70.2 (1.5)[d]	PLBs formed degenerated
4	2	92	44.2 (2.0)[i]	Nodular swelling of embryo, delayed germination
4	4	83	38.2 (2.0)[k]	Nodular swelling of embryo
4	6	84	36.1 (2.0)[k]	Same as above
4	8	70	64.2 (1.5)[e]	Green PLBs formed
4	10	72	65.1 (1.5)[e]	Green PLBs formed
6	2	82	56.2 (2.0)[g]	Nodular swelling of embryo, degenerated
6	4	80	50.1 (2.0)[h]	Same as above
6	6	80	54.2 (2.0)[g]	Same as above

* Standard error from mean; data represents mean of three replicates; Data with the same *letters* in the column for the same factor are not significantly different at 5% level. Note: Immature seeds of ~210 DAP old cultured on MS medium containing sucrose (3%).

Table 3.12: Effect of quality and quantity of PGRs on non symbiotic seed germination of *P. villosum* var. *boxallii*

PGRs Conc. (µM)		Germination time (Days)	% Germination (±SE) *	Type of response
NAA	BA			
0	0	64	40.2 (1.5)^{e}	Nodular swelling of the embryos
2	0	62	42.3 (1.5)^{e}	Nodular swelling of the embryos
4	0	62	40.1 (1.5)^{e}	Nodular swelling of the embryos
6	0	60	35.2 (1.5)^{g}	Same as above
8	0	62	38.3 (1.5)^{f}	Same as above
10	0	62	27.5(2.0)^{h}	Same as above
0	2	92	32.3 (2.0)^{g}	Nodular swelling of the embryos, No PLBs formed
0	4	94	34.2 (2.0)^{g}	Same as above
0	6	76	42.3 (1.5)^{e}	Green PLBs formed with first leaf initials
0	8	76	43.4 (1.5)^{e}	Green PLBs formed with first leaf initials
0	10	78	38.5 (1.5)^{f}	Same as above
2	2	74	40.2 (1.5)^{e}	Delayed germination, PLBs formed subsequently degenerated
2	4	63	52.3 (2.0)^{b}	Healthy green PLBs formed
2	**6**	**59**	**60.0 (1.5)^{a}**	**Most of the geminated embryos converted into healthy PLBs and released first leaflets**
2	8	62	54.2 (1.5)^{b}	Same as above
2	10	64	48.1 (1.5)^{c}	Most of the geminated embryos converted into healthy PLBs
4	2	72	32.1 (1.5)^{g}	Nodular swelling of embryo, delayed germination
4	4	76	28.2 (1.5)^{h}	Nodular swelling of embryo, No PLBs formed
4	6	82	30.1 (2.0)^{g}	Same as above
4	8	65	43.2 (1.5)^{e}	Green PLBs formed
4	10	64	42.2 (1.5)^{e}	Germinated embryos converted into healthy green PLBs
6	2	68	40.3 (2.0)e	Nodular swelling of the embryos, no PLBs formed
6	4	70	42.2 (2.0)^{e}	Same as above
6	6	70	45.0 (2.0)^{d}	Same as above

* Standard error from mean; data represents mean of three replicates; Data with the same *letters* in the column for the same factor are not significantly different at 5% level. Note: Immature seeds of ~240 DAP old cultured on MS medium containing sucrose (3%).

***Effect of PGRs on morphogenetic response of leaf and root explants from in vitro source*:** Foliar explants from *in vitro* raised young plantlets with first leaf initials (~8 wk old) were cultured for inducing *in vitro* morphogenesis. Leaf explants were cultured on MS medium fortified with two different PGRs (NAA and BA) at various concentrations either singly or in combination. Further initiation of PLBs/direct shoot buds and explants. NAA and BA were used singly and in combination. For *Paphiopedilum insigne* maximum of ~9 shoot buds developed from foliar explants at a combination of NAA and BA in the ratio 4:10 µM v/v (**Figure 3.6a)** on MS media fortified with sucrose (3%) and subsequently multiple shoot growth were observed **(Figure 3.6b).** Other combination keeping NAA constant at 4 µM v/v and BA (4, 6, 8, 10 µM v/v) recorded fair response **(Table 3.13)**. Shoot buds did not develop while using NAA or BA alone. NAA alone in different concentration (2, 4, 6, 8, 10 µM v/v) recorded no response or only browning of the foliar explants that subsequently degenerated. BA alone recorded shoot growth but no appearance of root and subsequently degenerated NAA at lower concentration (< 2µM v/v) in combination with BA (2 - 10µM v/v) recorded healthy shoot growth that developed roots but no shoot buds and converted into single healthy plantlets **(Figure 3.7a)**. Higher values of NAA (> 6µm v/v) in combination with BA recorded abnormal root growth **(Figure 3.7c)** but with healthy shoots. *Paphiopedilum villosum* var. *boxallii* also recorded similar response as *Paphiopedilum insigne* when NAA or BA was used alone. A maximum of ~7 shoot buds developed from foliar nodal explants at a combination of NAA and BA in the ratio 2:6 µM v/v **(Figure 3.6c)** and subsequently multiple shoot growth were observed **(Figure 3.6d)**. *Paphiopedilum villosum* var. *boxallii* responded fairly and formed shoot buds only at lower concentration of NAA (2µM v/v) in combination with BA (4 & 6µM v/v) on MS media fortified with sucrose (3%) **(Table 3.14)**. Healthy single shoot and root growth was recorded keeping NAA constant at 2 µM v/v and BA at 8 & 10µM v/v **(Figure 3.7b)**. No response was obtained from root segments culture across various treatments but the root segments produced exudates and dried eventually.

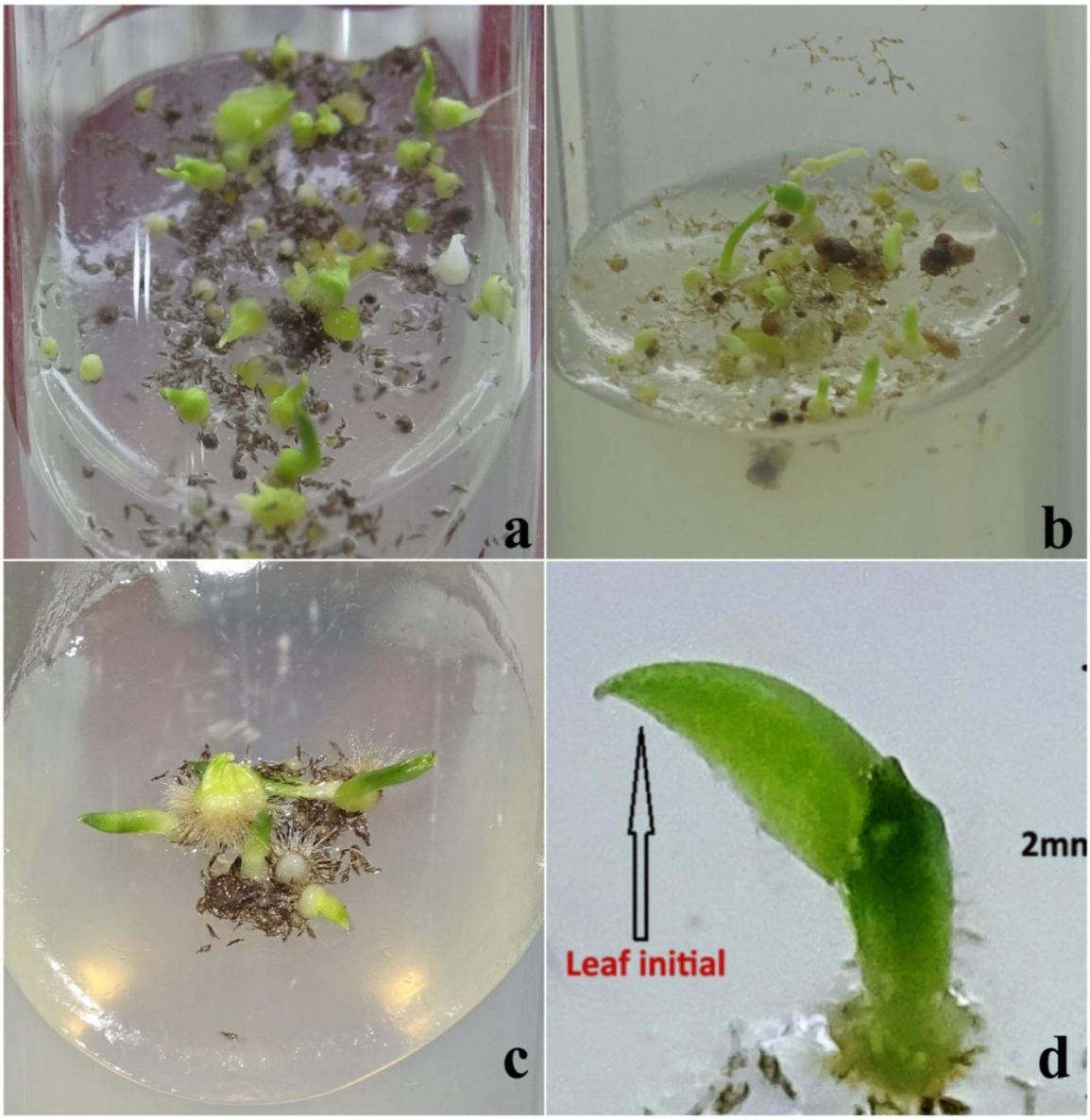


Figure 3.5: a) PLBs formation *Paphiopedilum insigne*; **b)** PLBs formation *Paphiopedilum villosum* var. *boxallii* ; **c)** Micro plants with leaf initials of *P. insigne* and **d)** Micro plants with leaf initials of *P. villosum* var. *boxallii*

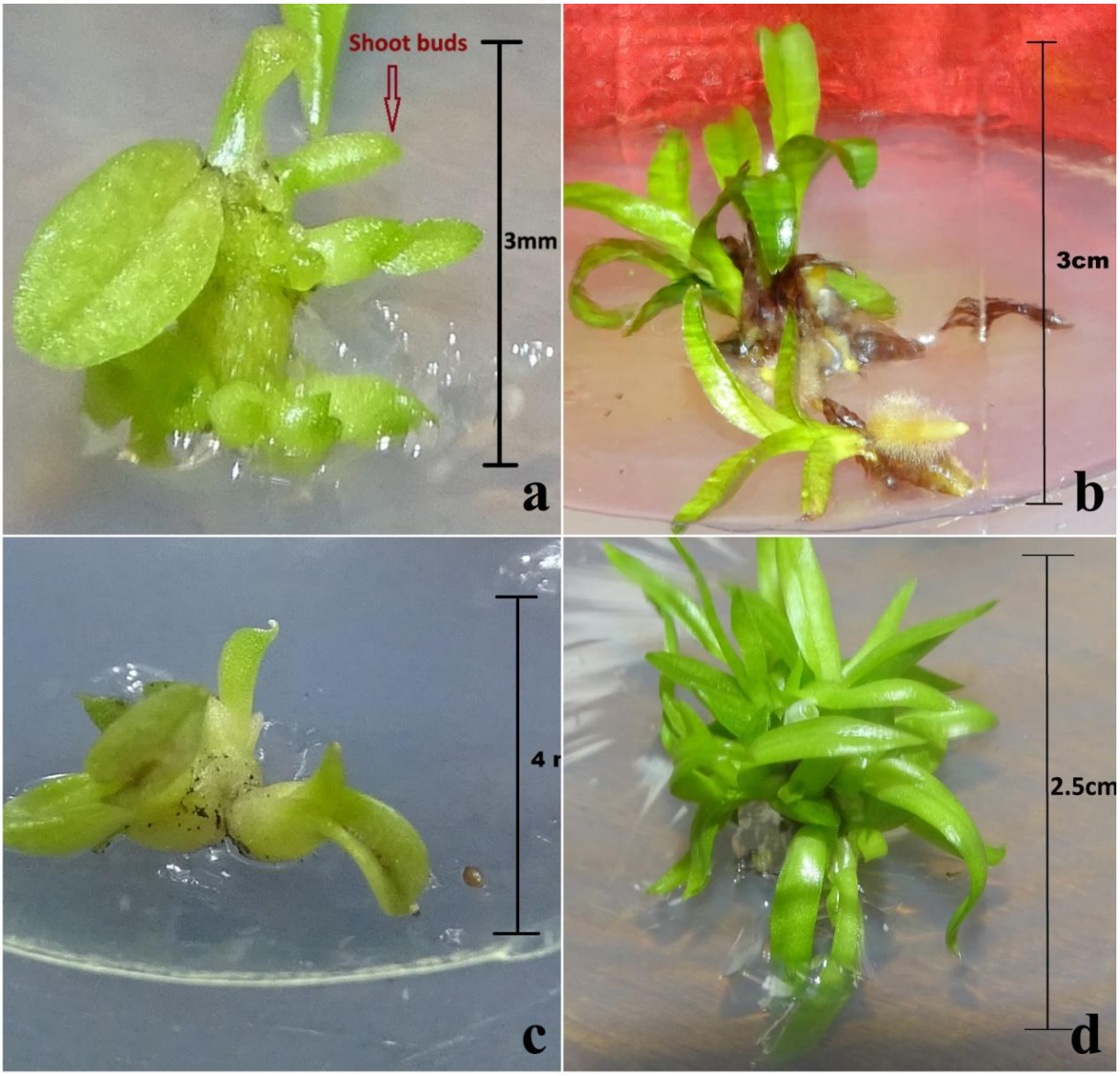


Figure 3.6: Different stages of in vitro morphogenetic response from foliar explants
a) Shoot buds developed from foliar explants of *P. insigne*; **b)** Multiple shoot growth *P. insigne*; **c)** Shoot buds developed from foliar explants of *P. villosum* var. *boxallii*; **d)** Multiple shoots developed from foliar explants of *P. villosum* var. *boxallii.*

Table 3.13: Effect of PGRs on morphogenetic response of foliar explants (~8 wk old) of *P. insigne* from *in vitro* source

PGRs Conc. (µM)		No of meristemoids per explants	% response (±SE)*	Type of response
NAA	BA			
0	0	-	-	No response
2	0	-	-	Swelling at the base of the leaf, plantlet degenerated
4	0	-	-	Same as above
6	0	-	-	Same as above
8	0	-	-	Browning of leaves and degeneration
10	0	-	-	Browning of leaves and degeneration
0	2	-	-	No response
0	4	-	-	No response
0	6	-	-	Shoot growth, subsequently degenerated
0	8	-	-	Shoot growth
0	10	-	-	Stunted shoot growth
2	2	-	-	Shoot growth
2	4	-	-	Single shoot growth, appearance of root
2	6	-	-	Single shoot growth, healthy root growth
2	8	-	-	Single shoot growth, healthy root growth
2	10	-	-	Stunted root growth
4	2	-	-	Abnormal root growth
4	4	3	25.1 (1.5)	PLBs formed from basal part of leaf
4	6	5	28.2 (1.5)	Same as above
4	8	6	32.2 (2.0)	Shoot buds/PLBs formed and differentiated into rooted plantlets
4	10	9	60.0 (1.5)	Multiple shoot buds/PLBs formed and differentiated into rooted plantlets
6	2	-	-	Abnormal root growth
6	4	-	-	Slight swelling at the base
6	6	-	-	Slight swelling at the base
8	8	2	15.3 (1.5)	Same as above
8	10	1	18.1 (1.5)	Abnormal root growth

*Standard error from mean, data represents mean of three replicates.
** Cultured on MS medium containing sucrose (3%).

Table 3.14: Effect of PGRs on morphogenetic response of foliar explants (~8 wk old) of *P. villosum* var *boxallii* from *in vitro* source

PGRs Conc. (µM)		No of meristemoids per explants	% response (±SE)*	Type of response
NAA	BA			
0	0	-	-	No response
2	0	-	-	No response
4	0	-	-	No response
6	0	-	-	Slight swelling at the base, degenerated
8	0	-	-	Browning of leaves and degeneration
10	0	-	-	Browning of leaves and degeneration
0	2	-	-	No response
0	4	-	-	Slight shoot growth, degenerated
0	6	-	-	Good shoot growth, no root
0	8	-	-	Good shoot growth, no root
0	10	-	-	Stunted shoot growth
2	2	-	-	Very slow root and shoot growth
2	4	4	38.2 (1.5)	PLBs formed from basal part of leaf
2	6	7	65.1 (1.5)	Multiple shoot buds/PLBs formed and differentiated into rooted plantlets
2	8	-	-	Single shoot growth, healthy root growth
2	10	-	-	Same as above
4	2	2	32.4 (1.5)	Slight swelling at the base
4	4	2	30.2 (1.5)	PLBs formed from basal part of leaf, degenerated
4	6	2	30.2 (1.5)	Same as above
4	8	3	28.2 (2.0)	Same as above
4	10	-	-	Single shoot growth, healthy root growth
6	2	-	-	Abnormal root growth
6	4	-	-	Same as above
6	6	-	-	Same as above
6	8	-	-	Single shoot growth, degenerated
6	10	-	-	Single shoot growth, degenerated

*Standard error from mean, data represents mean of three replicates.
** On MS medium containing sucrose (3%) (w/v).

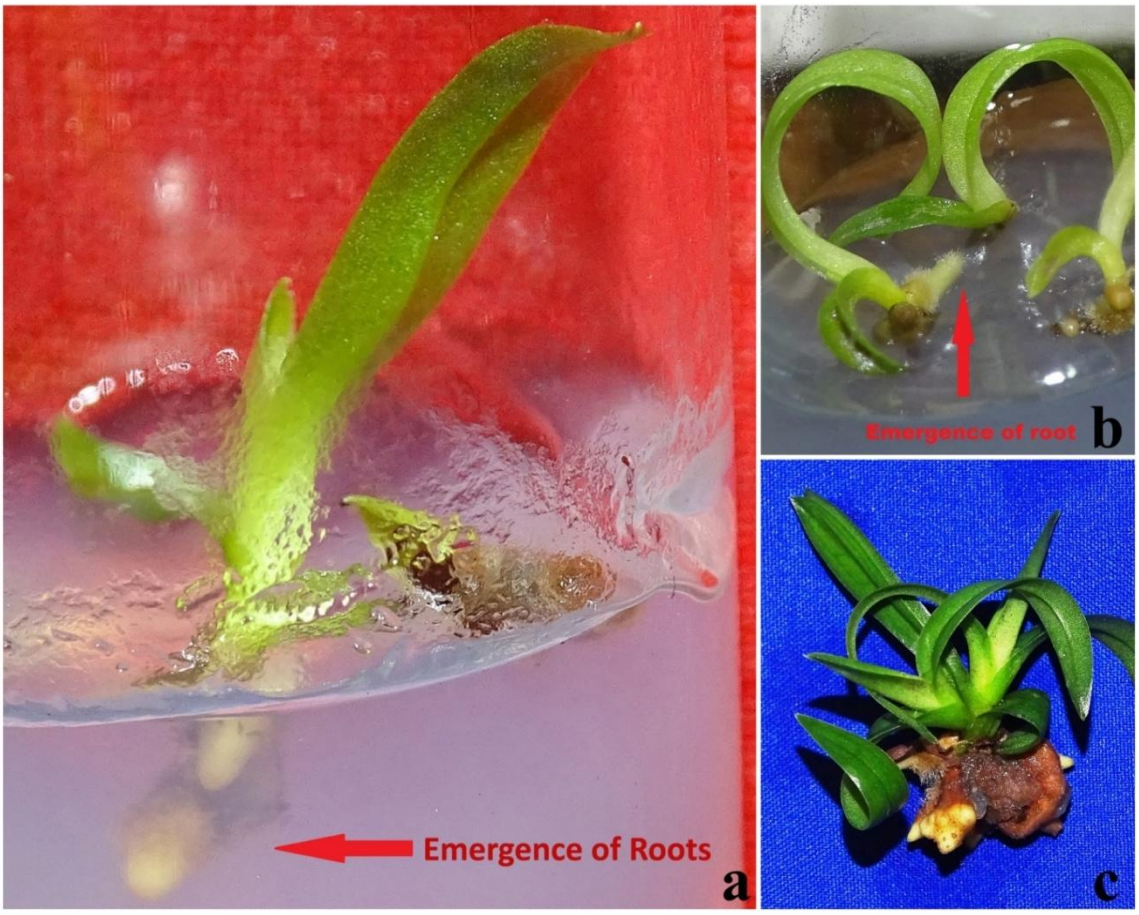


Figure 3.7: Plantlets a) *P. insigne* with root and shoot but no multiple shoot buds; **b)** *P. villosum* var. *boxallii* with root and shoot but no multiple shoot buds; **c)** *P. insigne* abnormal root growth with multiple shoots

3.3.2 Regeneration and Mass Multiplication

Shoot buds/PLBs that were developed from the cultured embryos/seeds and foliar of *Paphiopedilum insigne* and *Paphiopedilum villosum* var. *boxallii* were transferred to fresh MS medium and left to grow for another ~6-8 wk on optimum initiation conditions for further growth and differentiation. Plant regeneration and culture proliferation in both the species were effected various factors like quality and quantity of nutrient medium, organic carbon source and quantity, quality and quantity of PGR etc.

***Effect of basal medium on regeneration and mass multiplication*:** Three different media viz., Knudson 'C', Mitra *et al* and MS media with different growth adjuncts were used to study the effect on differentiation of PLBs to shoot buds and young plantlets. Under the given conditions in the present study, better regeneration and multiplication of culture was observed on MS medium for both the species as compared to the other two media **(Table 3.15, 3.16).** In *Paphiopedilum insigne* an average of 9 shoot buds/PLBs developed per explants per subculture on optimum condition. On MS medium differentiation was faster and within 16 and 29 day of culture first leaf and root respectively developed followed by multiple shoot buds/PLBs developed. On other two media morphogenic differentiation were delayed. On Knudson 'C' and Mitra *et al* media first leaf formed only after 29 and 21 days of culture while first root developed only after 42 and 70 days respectively (**Table 3.15**, **Figure 3.6a, Figure 3.7a**) Where as in *Paphiopedilum villosum* var. *boxallii* 7 shoot buds/PLBs developed per explants per subculture **(Table 3.16, Figure 3.6b)** and within 21 and 32 days first leaf and root formed respectively. On Mitra *et al* medium differentiation was significantly delayed and only after 25 and 56 days the first leaf and root respectively differentiated. While, on Knudson 'C' medium through there was leaf initiation, but failed to support formation of root. Following optimization of nutrient medium effort was made to test the effect of different strengths of MS medium ($1/4^{th}$, 1/2, $3/4^{th}$ & full strength) on plant regeneration and growth in both the species **(Table 3.17, 3.18)**. In *Paphiopedilum insigne* lower strengths of MS medium ($1/4^{th}$, 1/2 strengths) exhibited stunted/slower growth with very few shoot buds formed per subculture. A maximum of 9 shoot buds were formed on full strength MS medium with an average plant height of 5 cm **(Table 3.17)**. While in *Paphiopedilum villosum* var. *boxallii* on $1/4^{th}$ strength MS medium recorded stunted growth, whereas 1/2, $3/4^{th}$ and full strength MS medium supported better growth and differentiation. Under the given conditions optimum differentiation and growth was registered on full strength MS medium where as many as 7 shoots/PLBs formed and average plant height was 4 cm (**Table 3.18)**.

Table 3.15: Effect of nutrient media on regeneration of plantlets of *Paphiopedilum insigne*

Basal medium	No. of shoot buds formed/ explant	Time taken for formation of (days)		Type of response *
		1st leaf	1st root	
Knudson 'C'	2	29	42	Leaves etiolated, Browning of explant and subsequent degeneration of shoot buds
Mitra *et al*	4	21	70	Plantlets with no significant formation of shoot buds, rooting delayed
MS	9	16	29	Rooted healthy plantlets with multiple shoot buds

*On medium containing sucrose 3% (w/v), NAA + BA (4 + 10 µM) in combination

Data represents the mean of three replicates

Table 3.16: Effect of different basal media on regeneration of plantlets of *Paphiopedilum villosum* var *boxallii*

Basal medium	No. of shoot buds formed/ explant	Time taken for (days)		Type of response *
		1st leaf	1st root	
Knudson 'C'	1	32	-	Lone shoot bud formed from explants, no rooting observed
Mitra *et al*	3	25	56	Healthy plantlets but leaf and root growth stunted
MS	7	21	32	Healthy plantlets with significant roots and multiple shoot buds

*On media containing sucrose 3% (w/v), NAA + BA (2 + 6 µM) in combination

Data represents the mean of three replicates

***Effects of different organic carbon sources on regeneration and mass multiplication*:** Different levels of various organic carbon sources like dextrose, glucose and sucrose (0-4%) besides other adjuncts were incorporated in the MS medium with optimum growth condition. In both the species presence of at least one of the organic carbon source was prerequisite. Under organic carbon source controlled medium there was no differentiation and cultures degenerated subsequently. In the present study with two species of *Paphiopedilum* three different organic carbon sources (dextrose, glucose and sucrose) at different concentrations (1-4%). In both the species at lower concentrations (1-2%) and at higher concentration (4%) plant regeneration and growth was not satisfactory. When analyzed the effect of individual organic carbon, in general 3% concentration was found to be optimum. *Paphiopedilum insigne* recorded insignificant plantlet growth/stunted growth with few etiolated leaves at lower concentration of dextrose (1-2%), but at concentration of 3-4% healthy plantlets with fully opened leaf blades were formed. Glucose enriched medium at lower concentration (1-2%) exhibited etiolated leaves while at higher concentrations plantlets were stunted in growth. Of the three organic carbon sources tested in the present study, sucrose (3%) was found to be ideal for plant generation and growth **(Table 3.19)** where up to 9 shoot buds developed per cycle per explants. In *Paphiopedilum villosum* var. *boxallii* on dextrose enriched medium recorded stunted root growth across studied concentrations though shoot growth recorded fair results. Sucrose enriched medium produced healthy rooted plantlets with multiple shoot buds/PLBs across all studied concentration (1-4%) and producing up to 7 shoot buds/PLBs at 3% **(Table 3.20)**.

***Effect of PGRs on regeneration and mass multiplication*:** Differentiated PLBs and young plantlets obtained from germinated embryos and leaf explants of both the species were subjected to regeneration and mass multiplication. The effect of different plant growth regulators on regeneration and mass multiplication were studied and results recorded therein:

Table 3.17: Effect of different strengths of MS medium for PLBs differentiation, plant regeneration and mass multiplication of *Paphiopedilum insigne*

MS medium strength	Avg. plant height (cm)	No. of shoot buds formed/subculture	Type of response *
Control	-	-	No response
1/4th	0.5	1	Stunted plantlet growth
1/2	1	2	Slower growth, almost stunted
3/4th	3	5	Rooted healthy plantlets
Full	5	9	Well rooted healthy plantlets

*Medium containing sucrose 3% (w/v), NAA + BA (4 +10 µM in combination)

Data represents the mean of three replicates

Table 3.18: Effect of strengths of MS medium for PLBs differentiation, plant regeneration and mass multiplication of *Paphiopedilum villosum* var. *baoxallii*

MS medium strength	Avg. plant height (cm)	No. of shoot buds formed/subculture	Type of response *
Control	-	-	No response
1/4th	1	-	Stunted growth
1/2	2.5	4	Slower growth with multiple shoot buds
3/4th	4	5	Healthy plantlets with multiple shoot buds
Full strength	4	7	Healthy plantlets with significant roots and multiple shoot buds

*Medium containing sucrose 3% (w/v), NAA + BA (2 + 6 µM in combination)

Data represents the mean of three replicates

Table 3.19: Effect of different organic carbon sources on plant regeneration and mass multiplication of *Paphiopedilum insigne*

Organic carbon source	Conc. (%)	No. of shoot or PLBs formed	Time taken for 1st leaf formation	Type of response*
Dextrose	0	-	-	No regeneration
	1	1	13	No significant plantlet growth
	2	3	16	Stunted growth with etiolated leaves
	3	2	16	Plantlets healthy with proper leaf growth
	4	3	29	Healthy plantlets some of which degenerated
Glucose	0	-	-	No regeneration
	1	2	15	Plantlets etiolated subsequently degenerated
	2	2	15	Same as above
	3	3	21	Plantlets with few healthy leaves, but growth stunted
	4	1	16	Plantlets growth stunted
Sucrose	0	-	-	No regeneration
	1	2	25	Slower shoot growth, no shoot buds/PLBs
	2	5	22	Rooted plantlets with lesser shoot buds
	3	9	16	Healthy rooted plantlets with multiple shoot buds/PLBs
	4	5	19	Plantlets with few shoot buds/PLBs

*MS medium containing NAA + BA (4 µM +10 µM) in combination

Data represents mean of three replicates.

Table 3.20: Effect of different organic carbon source on plant regeneration and mass multiplication of *Paphiopedilum villosum* var. *boxallii*

Organic carbon source	Conc. (%)	No. of shoot/PLBs formed per explants	Time taken for 1st leaf formation	Type of response*
Dextrose	0	-	-	No regeneration
	1	2	18	Plantlets degenerated
	2	2	18	Root growth stunted
	3	3	18	Root growth stunted
	4	4	15	Healthy plantlets, root growth stunted
Glucose	0	-	-	No regeneration
	1	2	16	Slow plantlet growth, degenerated
	2	2	14	Healthy shoot growth with very less shoot buds/PLBs formed
	3	3	14	Recurved leaf, growth stopped
	4	2	15	Abnormal shoot growth with very less shoot buds/PLBs formed
Sucrose	0	-	-	No regeneration
	1	2	19	Slower initial shoot growth
	2	5	20	Plantlets with multiple shoot buds/PLBs
	3	7	21	Healthy rooted plantlets with multiple shoot buds/PLBs
	4	6	24	Plantlets with multiple shoot buds/PLBs

*MS medium containing CW (15%, v/v), NAA + BA (2 µM + 6 µM) in combination

Data represents mean of three replicates

***Paphiopedilum insigne*:** Different levels of PGRs were used alone or in combination and results were recorded. Use of NAA and BA (4µM +10 µM) in combination recorded the optimum results for regeneration and mass multiplication wherein at least 9 shoots were formed and first leaf appeared after 16 days of subculture and rooting was observed after 29 days of subculture (**Table 3.21, Figure 3.8a, b**). While, NAA and BA in combination in other concentrations also recorded formation of PLBs/shoot buds that later differentiated into rooted plantlets. Optimum shoot and root growth without formation of multiple shoots were recorded at a combination wherein NAA was kept constant at 2 µM and BA varied from 4µM, 6µM or 8 µM **(Figure 3.9)**. NAA alone neither supported PLBs formation at lower concentrations nor any significant growth was recorded and at higher concentration. The plantlets etiolated and subsequently degenerated. IAA alone supported formation of few PLBs but with time the explants and PLBs degenerated. Use of BA alone at specific concentration supported formation of new shoots that differentiated but root formation was negligible and slowly plantlets without root degenerated, moreover at higher concentration of BA alone shoot growth was enhanced. Use of KN alone recorded almost average results across different concentration with few PLBs formed though at higher concentration stunted growth was observed, KN alone also did not support the formation of healthy roots. IAA and KN in combination recorded fair results and formation of PLBs/ shoot buds was observed at lower concentration (4-6 µM) in combination but at higher concentration (>6µM) in combination the plantlets either etiolated or browned and subsequently degenerated.

***Paphiopedilum villosum* var. *boxallii*:** The best results for regeneration and mass multiplication was recorded at combination where NAA was kept constant at 2 µM and BA concentration varying from 4 µM – 8 µM wherein multiple shootbuds were formed. At NAA + BA (2µM + 6 µM) a maximum of 7 shoots were formed and the first leaf was observed after 21 days of subculture while rooting observed after 32 days of subculture **(Table 3.22, Figure 3.8c, d)**. Optimum results for healthy root and shoot growth without formation of multiple shoots were observed at combination of NAA 4µM and BA (8µM, 10 or 12 µM) **(Figure 3.10)** and these plantlets were beneficial for easier hardening. Singly use of different PGRs in culture medium for formation of shoot buds which subsequently produced healthy shoots on BA (4, 6 and 8 µM) and KN (2 and 4 µM) alone. The other two PGRs viz, NAA and IAA used alone did not perform well and though formation of some shoot buds were observed which were etiolated and degenerated. IAA and KN in combination did not produce desired results and plantlets etiolated and browned ultimately degenerated.

Table 3.21: Effect of different PGRs on plant regeneration and mass multiplication of *Paphiopedilum insigne*

PGRs Conc. (µM)				No. of shoot buds formed/ explants	1st leaf (days)	1st root (days)	Type of response *
NAA	IAA	BA	KN				
0	0	0	0	-	-	-	Plantlet growth initially then stunted
2	-	-	-	-	-	-	No PLBs/explants formed, insignificant shoot growth
4	-	-	-	-	-	-	Plantlets healthy, but no PLBs/explants formed
6	-	-	-	-	-	-	Plantlets etiolated
8	-	-	-	-	-	-	Same as above
-	2	-	-	-	-	-	Plantlets etiolated, no PLB's or explants formed
-	4	-	-	1	42	-	Plantlet and explants degenerated
-	6	-	-	1	63	-	Same as above
-	8	-	-	-	-	-	Plantlet etiolated
-	-	2	-	-	-	-	Healthy shoot growth but degenerated
-	-	4	-	-	-	-	Same as above
-	-	6	-	3	38	-	Healthy shoot growth with PLBs formation, no root growth
-	-	8	-	4	40	-	Same as above
-	-	-	2	1	32	46	Healthy growth
-	-	-	4	2	34	52	Plantlets healthy
-	-	-	6	2	28	68	Stunted growth
-	-	-	8	2	28	132	Poor rooting and degenerated
2	-	2	-	-	-	-	Shoot growth, no PLBs/ explants neither roots, degenerated
2	-	4	-	1	48	52	Healthy plantlets with roots but no PLBs formed
2	-	6	-	1	37	54	Healthy plantlets with roots but no PLBs formed
2	-	8	-	1	36	49	Same as above
4	-	4	-	3	24	38	PLBs formed from basal part of leaf and formed healthy shoots and roots
4	-	6	-	3	21	34	Same as above
4	-	8	-	3	18	34	PLBs formed and differentiated into rooted plantlets

4	-	10	-	9	16	29	Multiple PLBs formed from leaf base and differentiated into healthy rooted plantlets
-	4	-	4	3	41	92	Healthy plantlets, but slow growth
-	4	-	6	3	42	98	Same as above
-	4	-	8	2	37	-	Plantlets etiolated
-	6	-	4	1	32	-	Same as above
-	6	-	6	1	32	-	Same as above
-	8	-	8	-	-	-	Complete browned plantlet, degenerated

*On MS medium containing sucrose (3%) (w/v).

Data represents mean of three replicates.

Table 3.22: Effect of different PGRs on plant regeneration and mass multiplication of *Paphiopedilum villosum* var *boxallii*

PGRs Conc. (µM)				No. of shoot buds / PLBs formed/ explants	1st leaf (days)	1st root (days)	Type of response *
NAA	IAA	BA	KN				
0	0	0	0	1	68	79	Explants formed, browning than degenerated
2	-	-	-	-	-	-	No PLBs/explants formed, plantlet degenerated
4	-	-	-	-	-	-	Same as above
6	-	-	-	1	38	-	Shoot formed but subsequently degenerated
8	-	-	-	-	-	-	Browning of leaves and degeneration
-	2	-	-	-	-	-	Plantlets etiolated, no PLB's or explants formed
-	4	-	-	-	-	-	Same as above
-	6	-	-	1	32	43	Plantlet and explant degenerated
-	8	-	-	-	-	-	Plantlet etiolated
-	-	2	-	-	-	-	Growth stunted, no response, subsequently degenerated
-	-	4	-	3	28	-	Shoot growth with thinner leaves, browning and degenerated, no root
-	-	6	-	2	27	-	Same as above
-	-	8	-	3	23	-	Same as above
-	-	-	2	2	34	-	Healthy growth of shoots but no root formation,
-	-	-	4	1	33	-	Plantlets healthy
-	-	-	6	1			Stunted growth
-	-	-	8	-	-	-	Plantlet browning, degenerated
2	-	4	-	3	32	39	Healthy plantlet and explants growth
2	-	6	-	7	21	32	Multiple new shoots formed and differentiated into rooted plantlets
2	-	8	-	4	39	40	Same a above
2	-	10	-	-	-	-	Single shoot growth, healthy root growth, healthy plantlet growth
2	-	12	-	-	-	-	Single shoot growth, healthy root growth, healthy plantlet growth

4	-	6	-	2	42	54	Shoot buds formed from basal part of leaf, converted into rooted plantlets
4	-	8	-	1	34	49	Single shoot growth, with healthy root growth
4	-	10	-	1	32	53	Single shoot growth, appearance of root
4	-	12	-	1	26	56	New Shoots formed and differentiated into rooted plantlets
6	-	8	-	2	42	48	Shoot buds converted into shoots but degenerated
6	-	10	-	2	46	50	Same as above
-	2	-	4	1	32	112	Very slow root growth, degenerated
-	2	-	6	1	34	96	Same as above
-	2	-	8	2	28	-	No root, plantlets etiolated
-	4	-	4	-	-	-	Plantlets etiolated
-	4	-	6	-	-	-	Same as above
-	4	-	8	1	26	45	Browning of shoots, degenerated
-	6	-	8	-	-	-	Browning of plantlets, degenerated
-	8		6	-	-	-	Same as above
-	8		8	-	-	-	Same as above

*On MS medium containing sucrose (3%) (w/v).

Data represents mean of three replicates.

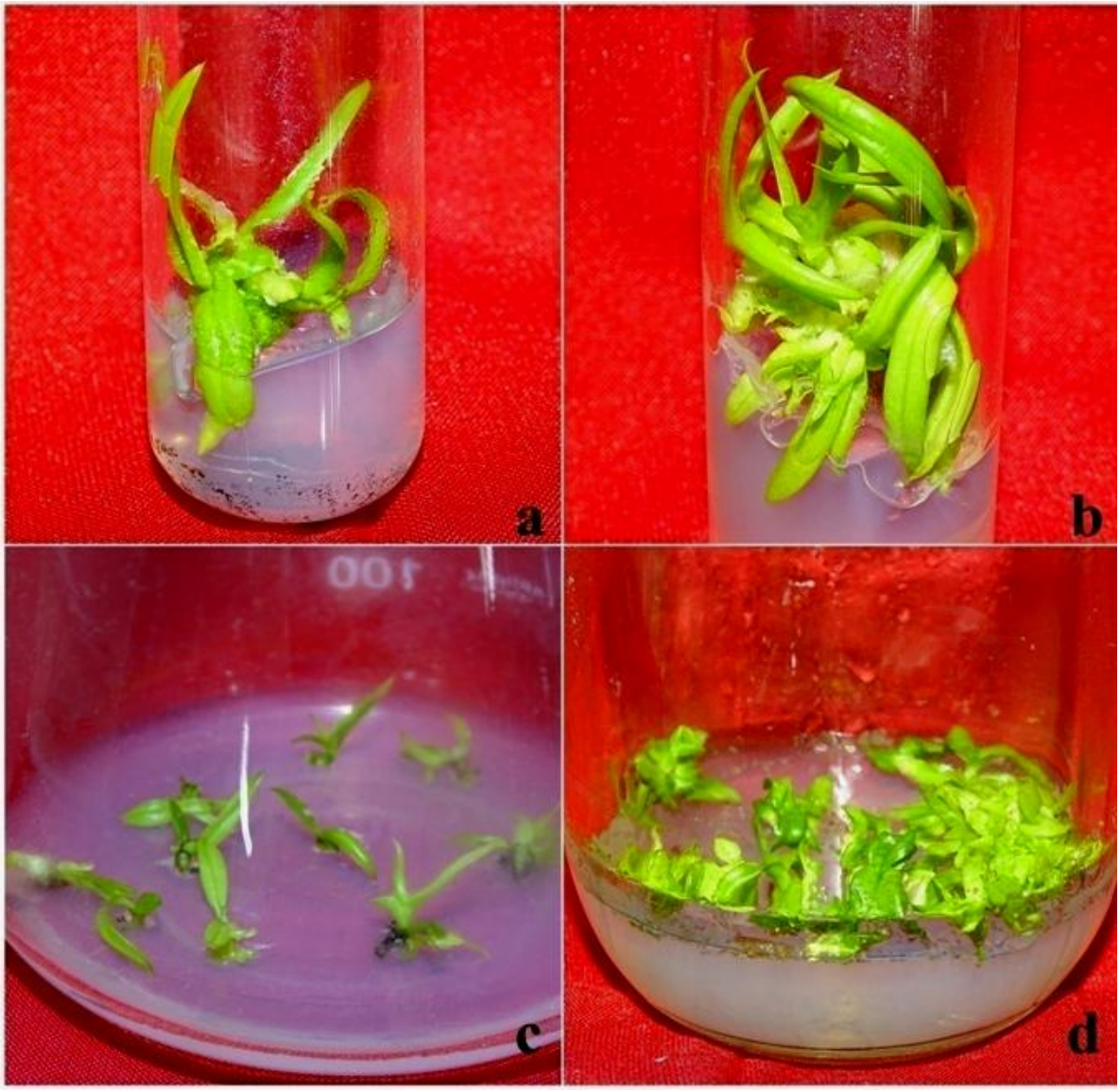


Figure 3.8: Plant regeneration and culture proliferation. a and **b.** *P. insigne;* **c** and **d.** *P. villosum* var. *boxallii.*

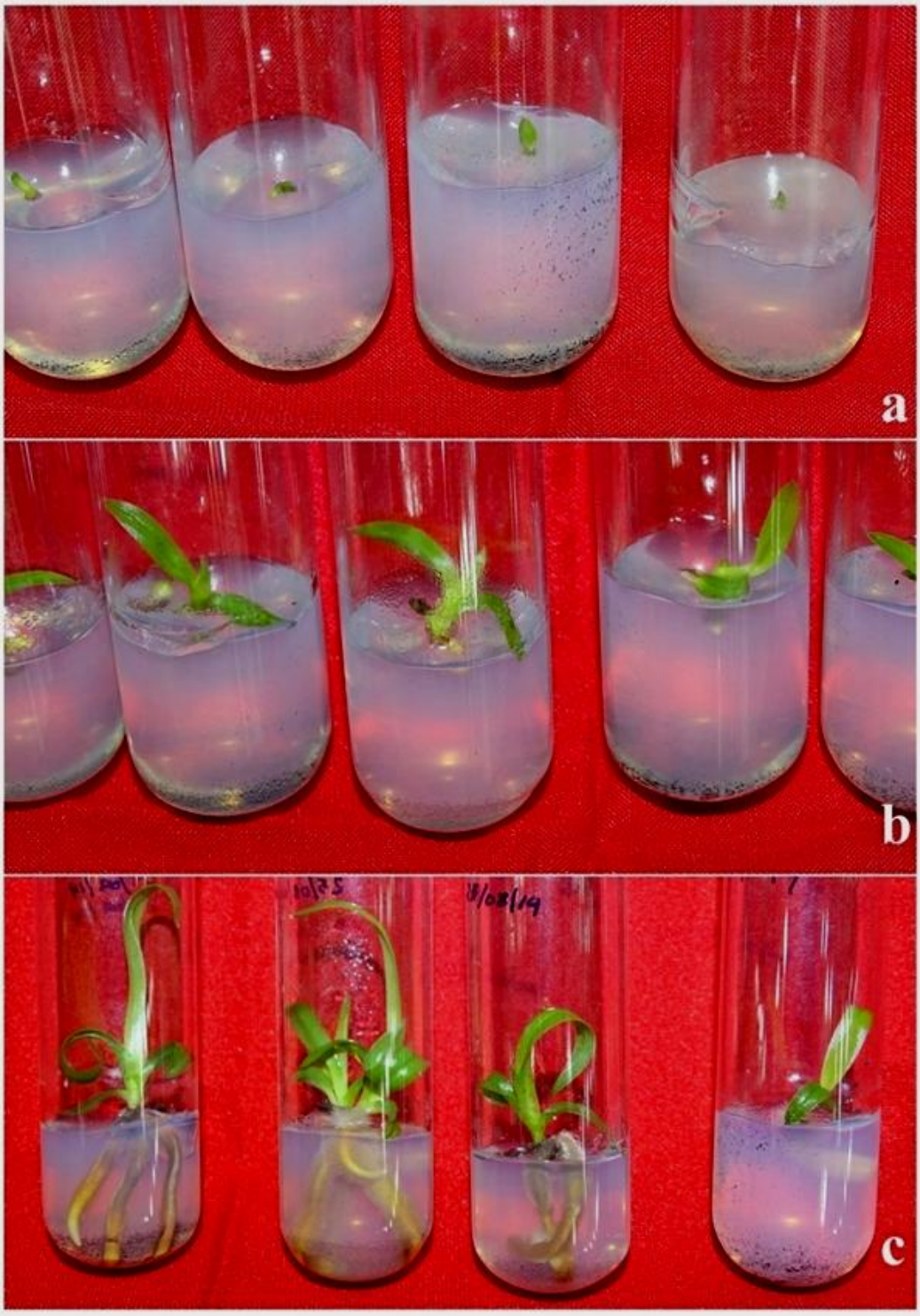


Figure 3.9: Different stages plant regeneration of *P. insigne*; a) Advance stage PLBs/shoot buds on regeneration medium; **b)** Regenerated plantlets; **c)** Wellrooted plantlet ready for hardening.

3.3.3 Hardening and Field Trials of the Regenerates

Plantlets of approximately 4-5 cm in height were first primarily hardened *in vitro* using different substrata viz., coconut husk, brick pieces, charcoal chunks, sand, decaying organic matter, dried cow dung in different combination and $1/10^{th}$ strength MS liquid solution fed into the mixture for initial two wk **(Figure 3.11). S**ubsequently the *in vitro* hardened plantlets were transferred in community pots containing different potting mix and covered with perforated transparent polybags and kept in the shade for 2 wk. After two wk the transplants were exposed to normal sunlight for 1 h a day for two wk. The transplants of both the species were fed with $1/10^{th}$ strength MS liquid solution at weekly interval for one month. After a month the community pots with plantlets were transferred to greenhouse under normal greenhouse light and observed for the next three months (**Figure 3.12 a, b**). Of the different potting mix combination tested in the present study the potting mix prepared mixing brick pieces + charcoal chunks + coconut coir (at 1:1:1 ratio) performed well and recorded approximately 60% survival rate for *Paphiopedilum insigne* with an average shoot growth of 3 cm in three months (Table 3.23). While, ~40% survival rate with an average shoot growth of 2.5 cm was recorded in *Pahiopedilum villosum* var. *boxalli.* Burning of leaf tips were observed initially on substrate containing charcoal in both the species. The optimum result for growth in both the species was recorded wherein sand + decaying organic matter + brick pieces + charcoal + dried cow dung was used as substrate at 1:1:1:1:1 ratio and watering interval after every 5 days with maximum survival rate recorded at approximately 75% for *Paphiopedilum insigne* with an average shoot growth of 6.5 cm in five months and 65% for *Pahiopedilum villosum* var. *boxallii* with an average shoot growth of 5.3cm in 5 months **(Table 3.23).** Well hardened plants **(Figure 3.12a,b)** with healthy growth were then observed in the greenhouse for later transfer to field.

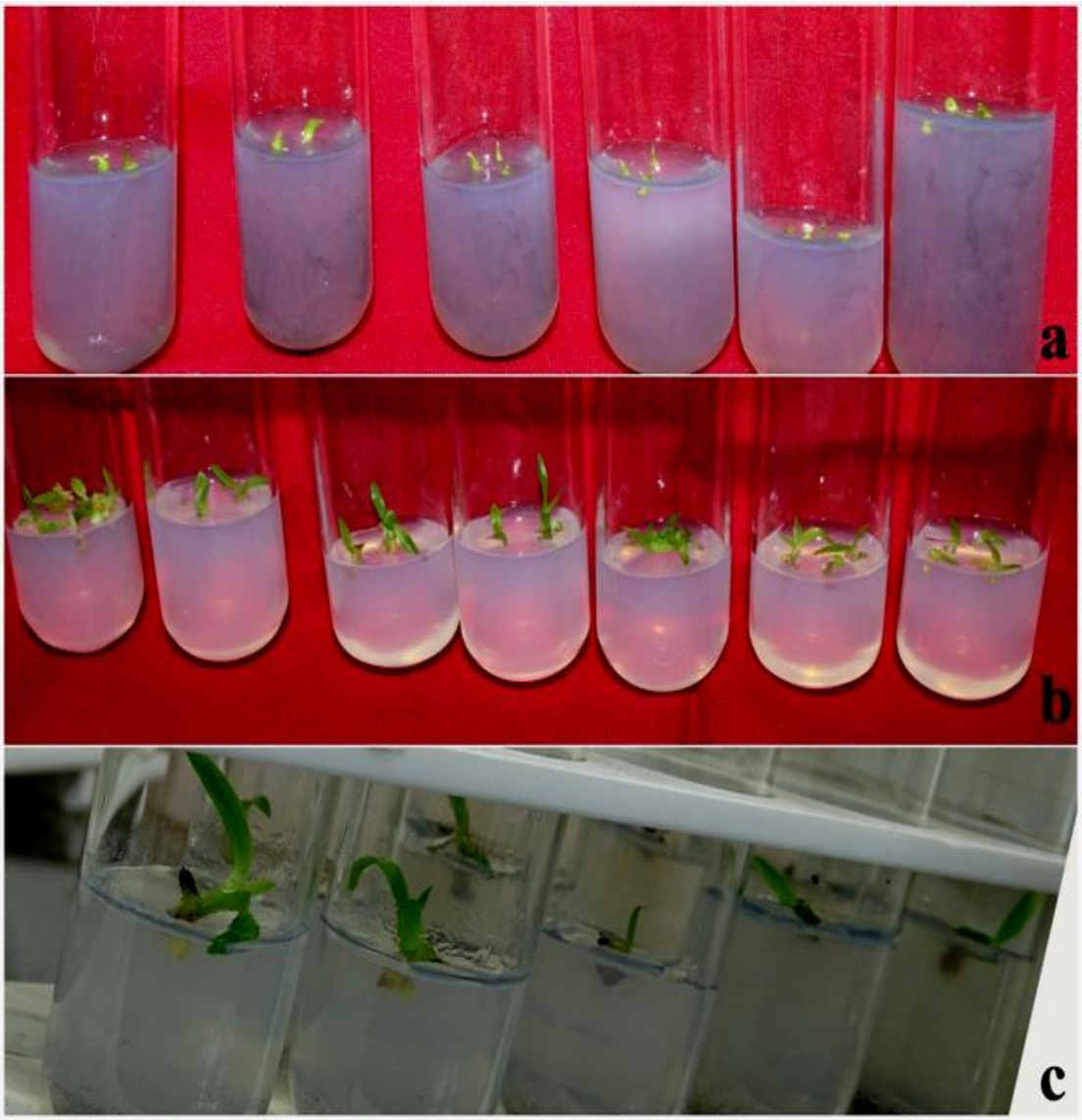


Figure 3.10: Different stages plant regeneration of P. villosum var *boxallii* : **a)** Advance stage PLBs/shoot buds on regeneration medium**; b)** Regenerated plantlets; **c)** Fully formed plantlet ready for hardening.

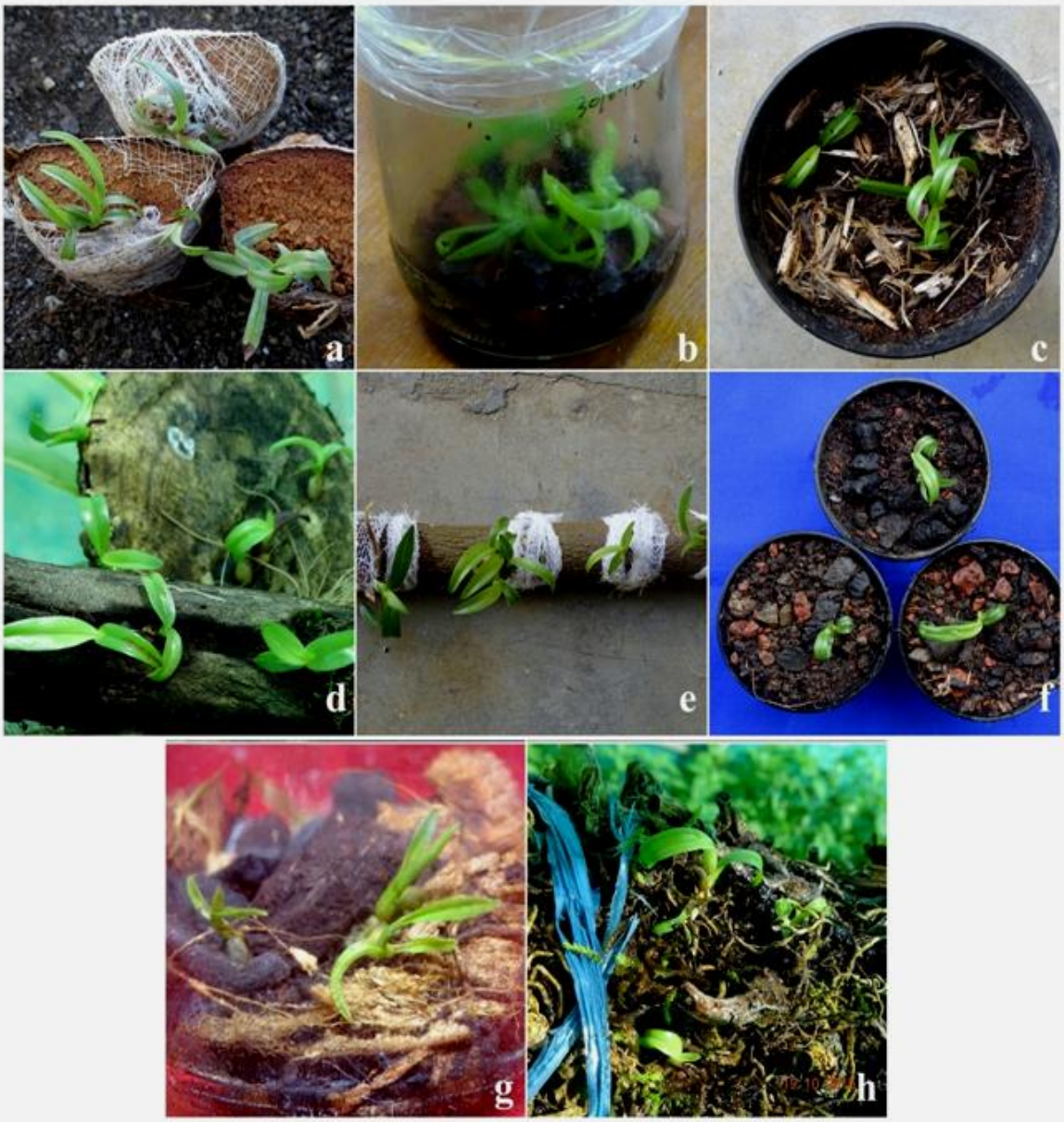


Figure 3.11: Different types of hardening of regenerates of *P. insigne* and *P. villosum* var. *boxallii* : a) Coconut husk **(***P. insigne***); b, g)** Brick pieces, charcoal chunks, coconut coir (at 1:1:1 ratio) (*P. insigne* and *P. villosum* var. *boxallii*); **c)** Sand + Decaying organic matter (1:1) (*P. villosum* var. *boxallii*); **d, e)** Wooden pieces (*P. insigne* and *P. villosum* var.*boxallii*); **f)** Sand + Decaying organic matter + brick pieces + Charcoal + Dried cow dung (1:1:1:1) (*P. insigne* and *P. villosum* var. *boxallii*); **h)** Moss (*P. villosum* var. *boxallii*).

Table 3.23: Percentage survival of *in vitro* grown plantlets of *Paphiopedilum insigne* and *Pahiopedilum villosum* var *boxallii* in different potting mix

Species → / **Treatments** ↓	***Paphiopedilum insigne***		***P. villosum* var *boxallii***	
	% Survival (±SE)#	**Avg. Plantlet height (cm)**	**% Survival (±SE)#**	**Avg. Plantlet height (cm)**
Coconut husk	35.2 (2.0)	7.2	20.1 (2.0)	6.8
Brick pieces + Charcoal chunks + Coconut coir (1:1:1)	60.4 (0.5)	8.0	40.0 (1.0)	7.5
Sand + Decaying organic matter (1:1)	55.1 (0.5)	7.5	58.2 (2.0)	6.8
Sand + decaying organic matter + brick pieces + charcoal + dried cow dung (at 1:1:1:1 ratio)	**75.0 (0.5)**	**11.5**	**65.1 (0.5)**	**10.3**
Wooden pieces	30.2 (0.5)	6.2	10.5 (0.5)	6.0

Standard error from mean, Data represents mean of three replicates.

Data recorded after 20 weeks of transfer.

Figure 3.12: Hardened regenerates estalished in potting mix ready for field transfer, Plants in the Nursery a) *P. insigne*, b) *P. villosum* var. *boxallii*

3.4 Discussion

3.4.1 Initiation of culture

***Immature embryos/seeds*:** Orchid seeds possess little or no endosperm. Though a single orchid capsule contain millions of seeds, they are microscopic and lack proper metabolic machinery in itself for independent germination. Hence a very specific symbiotic association with specific mycorrhizal fungus only provides an essential physico-chemical stimulus for initiating germination (Harley, 1959). One of the main reasons why orchids are fast disappearing in the wild is due to changes in microclimate as a result of human interference wherein the specific condition for growth is hindered. Fortunately fungal requirement can be compensated by incorporation of sugars along with adjuvant *in vitro*. When Knudson (1922) established the possibility to bypass the fungal requirement of orchid seeds during *in vitro* germination, asymbiotic/non-symbiotic seed germination has since then emerged as an important tool for propagating a large number of orchid species and their hybrids (Arditti *et al*., 1982). Aymbiotic germination of orchid seeds is an important tool for conservation programme, as the 'microscopic seeds' contain limited food reserves and do not easily germinate in the wild. The fertilized ovules/immature embryos are used successfully for micro propagation and rapid mass multiplication of several commercially viable and or threatened orchids (Sharma and Tandon, 1990; Devi *et al.*, 1998; Temjensangba and Deb, 2005a, c). Orchids are also propagated by vegetative means like keikis, back bulbs and or shoot buds, though these methods of propagation produce very little plant material and are time consuming.

Non-symbiotic seed germination and or immature embryo culture of orchids are greatly influenced by several factors such as seed pod age, different nutrient media, media supplements, plant growth regulators and other culture conditions (Temjensangba and Deb 2005a, 2006; Deb and Sungkumlong, 2008, 2009; Deb and Temjensangba, 2006, 2007b; Sungkumlong and Deb, 2008). The medium used for asymbiotic germination is also complex than that for symbiotic germination, as all organic and inorganic nutrients and sugars must be in a form readily available to the cultured immature embryos/seeds without the intermediary fungus (Mc Kendrick, 2000). Different orchid species respond differently on various basal medium incorporated with varied adjuvant and hence homogeneity of a single protocol is not possible across all orchid species. Moreover, studies on some *Paphiopedilum* species

such as the germination percentage of seeds of the same species on the same medium, have been shown to be inconsistent, for example, the germination percentage of 120-days after pollination (DAP) *Paphiopedilum armeniacum* seed was 25.2% (Chen *et al*., 2004b) and 18.4% (Ding *et al*., 2004) on Robert Ernst medium (Arditti *et al*., 1982) proving the possibility of influence of other factors. *Paphiopedilum* seed germinates relatively slowly due to seed morphological and physiological characteristics, which is similar to other terrestrial orchids (Lee *et al*., 2006; Rasmussen, 1995; Zeng *et al*., 2012). Nevertheless, the present study on the asymbiotic seed/immature embryo germination of *Paphiopedilum insigne* and *Paphiopedilum villosum* var. *boxallii* was initiated on five basal media viz., Knudson 'C', Gamborg (B5), Mitra *et al*., MS and SH. The immature embryos/pods of varied developmental stages of both *Paphiopedilum insigne* and *Paphiopedilum villosum* var. *boxallii* (120-300 DAP) were harvested at 30 days interval and used for initiation of culture. Nodular swelling/rupturing of the testa by an emerging embryo was the first sign of germination in both the species wherein visible color change to creamish yellow was first observed followed by greening of the embryo tips. Finally, embryos differentiated into PLBs. The time taken for the germination differed in the two species; moreover seed pod age was detrimental in germination time. In *Paphiopedilum insigne* nodulation was observed as early as after 20 days of culture to 72 days, while in *Paphiopedilum villosum* var. *boxallii* as early as 18 days after culture to 45 days.

***Effect of seed pod age on in vitro*:** The physiological age of orchid pods/capsules is a crucial factor for successful non-symbiotic seed germination of orchids and different species of orchids exhibit a particular threshold, a factor genetically structured in the organism. A window period of seed development for every orchid species is present, which supports optimum *in vitro* germination. In orchids, the zygotic embryo is poorly differentiated, and meristems and cotyledons are absent at the time of seed dispersal (Yeung *et al*., 1996). Moreover, information on embryo development in *Paphiopedilum* species are limited, and there are only a few reports about *Paphiopedilum insigne* (Nagashima, 1982; Zinger and Poddubnaya-Arnoldi, 1966), *Paphiopedilum delenatii* (Lee *et al*., 2006) and *Paphiopedilum hirsutissimum*, *Paphiopedilum appletonianum* and *Paphiopedilum armeniacum* (Zhang *et al*., 2013). It is therefore advantageous to determine the right age to harvest the orchid capsule/pods to achieve an optimal germination. The earliest stage at which the

embryos can be cultured successfully varies within the orchid genotype and local conditions (Deb and Temjensangba, 2006; Sauleda, 1976; Temjensangba and Deb, 2005a). Embryos from immature orchid capsule/pods culture ensures sterility but usually requires prolonged period for germination while, the culture of comparatively mature capsules/embryos before dehiscing may support better germination but the chances of contamination increases due to establishment of mycorrhizal association (Mc Kendrick, 2000). In the present study, *Paphiopedilum insigne* recorded optimum germination from capsule /pod age of 210 DAP with ~ 85% germination rate and *Paphiopedilum villosum* var. *boxallii* recorded optimum germination of 60% from seeds of 240 DAP capsules/pods. Seeds from < 150 DAP capsule/pods recorded nodular swellings, but very few PLBs were formed in *Paphiopedilum insigne* and seeds from <180 DAP capsules/pods recorded similar results for *Paphiopedilum villosum* var. *boxallii* this may be due to the fact that very young orchid ovules do not support good germination as they need time for organogenesis and synthesis of nutrients to occur, moreover the embryos need time to recognize stimulating agents present in the medium that allow them to germinate as recorded by Nhut *et al*., 2005 and Zeng *et al*., 2012. Alternatively, the embryo may be too underdeveloped to absorb nutrients from the medium (Long *et al*., 2010). Seeds from >270 DAP capsules/pods recorded very late germination in both *Paphiopedilum insigne* and *Paphiopedilum villosum* var. *boxallii* which may have resulted because of an impermeable testa as recorded by Van Waes and Debergh, 1986. Moreover, germination rate was low which may have been due to the presence of chemical inhibitors such as abscisic acid (ABA) and the lack of certain germination promoting hormones as reported by Van der Kinderen (1987). The zygotic embryo from seeds of 180-240 DAP capsules/pods from both the two species viz., *Paphiopedilum insigne* and *Paphiopedilum villosum* var. *boxallii* may have formed fully and the testa might not have lignified, allowing it to be permeable to water and nutrients, hence better germination in lesser time. While mature embryos/seeds from > 270 DAP capsule/pods may have lignified making it slightly hydrophobic and hence longer time for germination. Zhang *et al*. (2013) reported that older aged seeds have a greater potential for storage because of a fuller testa and lower water content.

***Effect of nutrient medium*:** Five different basal media were used for asymbiotic culture in the present study for initiation from immature seeds/embryos of both the species. Optimum germination was achieved on MS medium for both the species. In

Paphiopedilum insigne germination rate of~ 85% was achieved on MS medium followed by Mitra *et al.* (~40%) and Knudson 'C' (32%). SH and B_5 recorded very low germination (~20 and~18 % respectively). Whereas, for *Paphiopedilum villosum* var. *boxallii* germination rate was recorded highest on MS medium (~60%) followed by Knudson 'C' (~ 40%), Mitra *et al* (35%), SH (25%) and B5 (20%). Nodular swelling/rupturing of the testa by an enlarging embryo showing signs of germination was observed across all studied media though their percentage varied. Different species of orchids exhibit a preferential requirement to specific nutrient media for seed germination and no standard medium can be prescribed for all the orchid taxa, hence a comparative analysis of different basal media and performance of species has been carried out by various authors. Deb and Temjensangba (2006) reported better seed germination of *Malaxis khasiana* on MS medium while, *Arachnis labrosa* on Mitra *et al* medium (Temjensangba and Deb, 2005a), *Cleisostoma racemiferum* on MS medium (Temjensangba and Deb, 2006), *Coelogyne suaveolens* on MS medium (Sungkumlong and Deb, 2008), *Cymbidium macrorhizon* on Mitra *et al.* medium (Vij and Pathak, 1988), *Dactylorhiza hatagirea* in Knudson 'C' medium (Vij *et al*., 1995), *Dendrobium chrysotoxum* in Vacin and Went medium (Rao *et al*., 1998), *Dendrobium primulinum* on MS medium (Deb and Sungkumlong, 2009), *Eulophia alta* on 'Phyto Technology Orchid Seed Sowing Medium' (Johnson *et al*., 2007), *Geodorum densiflorum* on PM medium (Bhadra and Hossain, 2003), *Habenaria macroceratitis* on LC and KC media (Stewart and Kane, 2006), *Rhynchostylis gigantea* on MS medium (Li and Xu, 2009), *Taenia latifolia* on MS medium (Deb and Sungkumlong, 2008), *Vanda coerulea* on Ichihashi and Yamashita (Rao *et al*., 1998) and VW medium (Devi *et al*., 1998), *Aerides rosea* in Knudson 'C', VW and MS medium (Sinha *et al*., 1998). To date, 75 studies have been reported on the *in vitro* propagation of *Paphiopedilum* species and cultivars, including about 32 native species and more than 30 hybrids and 58 studies reported for seed germination and PLB formation subsequently (Zeng *et al.*, 2016)). Nagashima (1982) reported Hypnonex medium to be better than MS medium for seed germination in *Paphiopedilum insigne* var. *sandarae* though the percentage values were not quantified in these studies. Nhut *et al.* (2005) reported 9-month-old seeds of *Paphiopedilum delenatii* cultured on Knudson C (KC) medium (Knudson, 1946), to be most advantageous for *in vitro* germination than on MS or 1/2 MS medium. *Paphiopedilum wardii* showed significantly lower seed germination on MS than on 1/2 MS medium and highest seed

germination on Vacin and Went medium (Vacin and Went, 1949), but only 14% of protocorms like bodies converted to seedlings stage (Zeng *et al*., 2012). Pierik *et al.* (1988) reported highest seed germination of *Paphiopedilum ciliolare* on KC and 1/4 MS but KC resulted in plant death. A similar trend was observed in the present study wherein *Paphiopedilum insigne* on KC medium germinated and formed few PLBs but subsequently degenerated whereas *Paphiopedilum villosum* var. *boxallii* on the same medium formed a good number of PLBs but subsequently degenerated before differentiation.

***Effect of different organic carbon sources and CW on in vitro embryo culture*:** For *in vitro* culture of immature embryos, carbohydrates as an energy source in medium have significant effects on seed germination and protocorm development. *Paphiopedilum* seed germination does not occur without sugar (Pierik *et al.*, 1988). In the present study, three different organic carbon sources (viz., dextrose, glucose and sucrose) were used at varying strengths (1-4%) on MS medium. The requirements of the quality and quantity of exogenous supply of the organic carbon sources vary with nutrient medium, species and developmental stage of the cultured embryos (Temjensangba and Deb, 2005c). Sucrose is the most utilized carbon source for seed germination of *Paphiopedilum* orchids (Hossain *et al*., 2013; Zeng *et al*., 2012) but as Long *et al*. (2010) reported a significantly higher germination percentage of *Paphiopedilum villosum* var. *densissimum* on glucose-amended medium. Absence of carbon source recorded only nodular swelling of embryos and rupturing of the testa without formation of PLBs that subsequently degenerated in the species viz., *Paphiopedilum insigne* and *Paphiopedilum villosum* var. *boxallii*. Incorporation of at least one of the three organic carbon sources was perquisite for successful *in vitro* culture of embryos/seeds of both the selected species. The different levels of organic carbon sources showed different effect on seed germination. In the present study, amongst the different organic carbon sources tested optimum seed germination of *Paphiopedilum insigne* and *Paphiopedilum villosum* var. *boxallii* was registered on MS medium containing 3% sucrose. In *Paphiopedilum insigne*, healthy seed germination was recorded across the concentrations of different carbon source used at concentration of 1-3% w/v though at lower concentration very few PLBs were formed and subsequently degenerated. But at higher concentration of 4% dextrose and glucose supported very less germination in all the three replicates. In *Paphiopedilum villosum* var. *boxallii* similar result was recorded.

Organic supplements such as coconut water (CW), banana homogenate (BH), potato homogenate (PH), and organo-mineral complexes such as casein hydrolysate, yeast extract, tryptone and peptone are usually used in different media for orchid seed germination and protocorm development. Organic amendments have a stimulatory or inhibiting effect (Chen *et al*., 2004b; Zeng *et al*., 2012) on orchid seed germination. The stimulatory effect of CW was reported in *Coleogyne suaveolens* (Sungkmnlong and Deb, 2008), *Taenia latifolia* (Deb and Sungkumlong, 2008). Leetham (1974) reported that a plant growth regulator like substance (cytokinins) is present in coconut water. Long *et al.* (2010) reported highest germination percentage of *Paphiopedilum villosum* var. *densissimum* seeds with 10% coconut milk. Zeng *et al.* (2012) also reported a significant increase in germination percentage when *Paphiopedilum wardii* seeds were cultured on 1/2 MS medium supplemented with 7.5, 10 and 15% CW (but not 5%) than without CW. In the present study CW was used to study its effect on seed germination and PLBs development. In general incorporation of CW in germination medium did not increase the germination in both the species studied in the present investigation, however differentiation into PLBs was faster. In *Paphiopedilum insigne* healthy green PLBs were formed on medium fortified with CW (5 - 15%) but medium containing CW >15% delayed germination and fewer PLBs formed. In *Paphiopedilum villosum* var. *boxallii* also recorded lesser formation of PLBs at >15% of CW in MS medium incorporated with sucrose (3%).

***Effect of activated charcoal*:** Role of AC in medium to improve the germination of orchid seeds is debatable and there is no comprehensive and specific ratio of use. Different orchid species respond in a different way to varied concentration of AC. However, the first attempt to darken culture media used for orchid seed germination seems to have been reported as an effort to germinate Native American *Cypripedium* (Curtis, 1943). Ernst (1974) reported that darkening with charcoal (not AC) had a positive effect on seed germination and the growth of *Paphiopedilum* seedlings. Ding *et al.* (2004) also reported that the seed germination percentage of *Paphiopedilum armeniacum* was promoted on $1/5^{th}$ strength of MS medium containing 2 g L^{-1} AC, 36.1% higher than on AC controlled $1/5^{th}$ MS medium (9.6%). In the present study, at concentration of 0.05-0.1% AC *Paphiopedilum insigne* embryos formed healthy green PLBs, but with increase in concentration (0.2-0.5%) it had a detrimental negative effect on seed germination and the embryos tend to form nodular swelling/few PLBs that slowly turned gray and degenerated. Similar trend was also recorded in

Paphiopedilum villosum var. *boxallii* embryos; i.e., increase in concentration of activated charcoal (AC) had a negative co-relation with germination rate. Present findings are in agreement with past workers (Pierik *et al.*, 1988) where 0.1-0.2% AC did not affect the germination significantly in *Paphiopedilum ciliolare*. Instead at higher concentration (0.2-0.5 %), AC was lethal for seed germination. This effect may be due to absorbing certain compounds including certain vitamins and hormones by AC resulting in a passive effect as reported by Thomas (2008).

***Effects of light intensity on asymbiotic germination*:** Cultures were maintained in three different light conditions for *in vitro* seed germination for both the species. In *Paphiopedilum insigne* nodular swelling of embryos was observed after 27 days in the dark and in *Paphiopedilum villosum* var. *boxallii* nodulation was observed at 21 days in the dark. Nodular swelling was observed to be faster in the dark but the germination rate was lower as compared to embryos kept under diffused light (20 µmol m^{-2} s^{-1}). In both *Paphiopedilum insigne* and *Paphiopedilum villosum* var. *boxallii* optimum germination (85% in *P. insigne* and 60% in *P. villosum* var. *boxallii*) was recorded under diffused light (20 µmol m^{-2} s^{-1}) as compared to cultures maintained in the dark or full light (40 µmol m^{-2} s^{-1}) and the present findings are in agreement with Deb and Temjensangba (2006) where diffused light condition was found to be ideal for seed germination of *Malaxis khasiana*. Full light registered lower germination rate as compared to dark treatment or diffused light treatment, moreover the PLBs recorded a burnt brownish tip under full light maintained at 12/12 h photoperiod for a longer period. PLBs formed in the dark were continuously kept in the dark and it was observed that no leaf initials formed even after a prolonged period suggesting that light was an important factor controlling seedling growth but not necessarily germination in the two studied species.

***Effect of quality and quantity of PGRs*:** Plant growth regulators have varying effects on seed germination of different orchid species (Teixeira da Silva, 2013). Concentration of PGRs alone or in combination had a marked effect on the growth, differentiation and development of PLBs. In the present study, the absence of PGRs recorded nodular swellings of the embryos and emergence of shoot tip, but it failed to differentiate further. Seed germination of both *Paphiopedilum insigne* and *Paphiopedilum villosum* var. *boxalli* recorded optimum germination (85% and 60% respectively) on medium containing NAA and BA in combination. A combined action of auxin and cytokinin was observed to be best for seed germination of the two

species which is in agreement to the findings of Li and Xu (2009) where they reported the stimulatory effect of NAA in conjunction with cytokinins in *Rhynchostylis gigantea* using NAA (0.2 mg/l) and BA (0.05 mg/l). NAA used alone in various concentration (2µM +10 µM) recorded nodular swelling only but no PLBs were formed in both the species, instead the swelled embryos browned and consequently degenerated. Moreover, NAA at higher concentration of (4-6 µM) in combination with BA neither helped in growth and development of PLBs. While, BA alone at concentration 4-10 µM supported seed germination and formed PLBs with first leaf initials but no roots were formed even after observation for longer period. Overall BA supported germination and green PLBs formation similar to the findings of Deb and Temjensangba (2006) wherein BA alone supported better germination in *Malaxis khasiana*.

***Initiation of culture from foliar explants*:** Leaf cuttings, aerial root cuttings and foliar explants of germinated embryos with first leaf initials (~8 wk old) from *in vitro* source were cultured for further initiation of PLBs/direct shoot buds and explants. When Wimber (1965) successfully developed PLBs from the leaves of *Cymbidiums*, a new and effective alternative to apical shoot meristem culture was started. The regenerative capability of foliar explants has since then been positively tested for more than 60 orchid species (Temjensangba and Deb, 2005b). In the present study though, culture could not be initiated from leaf tip and root cuttings even under optimum growth condition using varying concentration of available PGRs. Root and leaf tip cuttings tend to brown and degenerated subsequently in culture medium, moreover phenolic substance with cloudy colored tincture was observed as exudation on media with root cuttings across all replicates. Leaf tip cuttings to initiate formation of PLBs may thus be restricted to epiphytic orchids and some species of terrestrial orchids, ground orchids being less amenable to *in vitro* regeneration as suggested reported by Deb and Sungkumnlong (2010). Basal parts of foliar and nodal explants were hence used for initiation of morphogenetic response in both the species. The morphogenetic potential of leaf base has been reported in *Coelogyne*, *Dendrobium*, *Oncidium* and *Phalaenopsis* (Abdul Karim and Hairani, 1990), *Arachnis labrosa* (Deb and Temjensangba, 2007a), *Cleisostoma racemiferum* (Temjensangba and Deb, 2005b), *Coelogyne suaveolens* and *Taenia latifolia* (Deb and Sungkumlong, 2010), *Vanda coerulea* (Vij and Aggarwal, 2003). *Paphiopedilum insigne* recorded an average maximum of 9 shoot buds that developed from base of foliar nodal explants

in about 60% of culture in 42 days. The optimum combination for shoot bud formation was recorded when NAA and BA was used at 4 and 10 µM respectively in combination on MS medium fortified with sucrose (3%) and subsequently multiple shoot growth were resulted. At fixed concentration of NAA (4 µM) with varying BA concentration (4-10 µM) supported formation of shoot buds. Lower levels of NAA (2 µM) with varying BA concentrations (4-10 µM) recorded single healthy shoot and root growth forming no new shoot buds. Whereas, *Paphiopedilum villosum* var. *boxallii* recorded an average of 7 shoot buds in 65 % of culture after 54 days at a combination of NAA and BA (2 and 6 µM in combination) and subsequently multiple shoot formation. The only suitable concentration of PGRs for formation of healthy shoot buds in *Paphiopedilum villosum* var. *boxallii* was recorded when NAA was kept constant at 2 µM in combination with BA (4 and 6 µM). Both *Paphiopedilum insigne* and *Paphiopedilum villosum* var. *boxallii* formed shoot buds when PGRs were used at very specific concentration and increase or decrease in concentration of PGRs either led to the growth of a single plantlet with no shoot buds or degeneration of the explants. Hence, for stimulating meristematic activity and promoting proliferation in foliar nodal explants, concentration of growth hormones is vital as documented in other orchid species by various authors (Vij and Pathak, 1990; Arditti and Ernst, 1993; Nayak *et al*., 1997; Temjensangba and Deb, 2005b; Deb and Temjensangba, 2007a; Li and Xu, 2009; Deb and Sungkumlong, 2010). KN and IAA were also used singly and in combination to induce formation of shoot buds, but in both the species no response was observed and foliar nodal explants degenerated. Use of Auxin (NAA) singly impaired regeneration in both the species. Only swelling at the base and degeneration of the foliar nodal explants was observed at lower concentration (< 6µM) and at higher concentration (6-10 µM) browning of leaves was recorded. Moreover, BA alone also did not support formation of shoot buds, instead only leaf elongation was observed without roots and subsequently degenerated. The combined effect of auxin (NAA) and cytokinin (BA) at specific concentration only led to the formation of shoot buds and subsequently formed healthy plantlets similar to reports made by Kosir *et al*. (2004) in *Phalaenopsis* wherein BA (2 mg L^{-1}) and NAA (0.5 mg L^{-1}) in combination proved to be optimum for breaking axillary buds and formation of multiple shoot buds. Other past reports (Tisserat and Jones, 1999; Roy and Banerjee, 2003) also reported that an appropriate combination of NAA and BA stimulated multiple shoot buds formation.

3.4.2 Regeneration of plantlets and mass multiplication

The cultured immature embryos/seeds and foliar explants of both the species were maintained for another 60-120 days for further differentiation and proliferation on optimum initiation conditions. The advanced stage PLBs, shoot buds developed from the foliar explants were again subjected to regeneration of plantlets and mass multiplication.

***Effect of nutrient media*:** Knudson 'C', Mitra *et al.* and MS media were the three different media used for regeneration and mass multiplication along with different growth adjuncts to study their effect on differentiation of PLBs to shoot buds and young plantlets formation. Amongst the three media tested, MS medium found to be ideal for differentiation and plant regeneration in both the species. Chen *et al.* (2004a), George and Sherrington (1984), and Temjensangba and Deb (2005a) noted that the change in culture conditions and medium altered the pattern of organogenesis and thus, by altering the nutrient composition desirable response could be achieved in many orchid taxa. In *Paphiopedilum insigne* an average of 9 shoot buds/PLBs developed per explants per subculture on MS medium with optimum condition and the first leaf initials was observed as early as 16 days after culture, where as in *Paphiopedilum villosum* var. *boxallii* 7 shoot buds/PLBs developed per explants per subculture and first leaf initials were observed after 21 days of culture. Subsequently, the shoot buds developed leaves with roots and differentiated into rooted plantlets in both the species. On the other two media viz., Knudson 'C' and Mitra *et al.* average results were recorded. *Paphiopedilum villosum* var. *boxallii* on Knudson 'C' medium recorded no formation of roots even after prolonged culture period.

MS medium in different strengths ($1/4^{th}$, 1/2, $3/4^{th}$ and full strength) were also used in the present investigation for plant regeneration and plant growth. In *Paphiopedilum insigne* lower strengths ($1/4^{th}$, 1/2 strengths) recorded stunted plantlet growth/slower growth with fewer shoot buds formed per subculture suggesting that lower nutrient composition had an adverse effect on plant regeneration. Long *et al.* (2010) suggested that most *Paphiopedilum* species preferred a low mineral medium for seed germination and the inhibition of *Paphiopedilum* germination on MS medium may be due to its high total mineral content. Conversely, for further growth and regeneration lower levels of nutrient composition had an adverse effect on further regeneration as recorded in the present study. Maximum of 9 shoot buds were formed

on full strength MS medium with an average plant height of 5 cm in *Paphiopedilum insigne*, 3/4th strength performed fairly whereas, *Paphiopedilum villosum* var. *boxallii* on 1/4th strength MS medium plantlets exhibited stunted growth with no formation new shoot buds. Performance improved with increase in strength of nutrient medium. The optimum results were recorded on full strength MS medium wherein 7 shoot buds were formed that later formed plantlets with an average height of 4 cm recorded after 63 days.

***Effects of different organic carbon sources on regeneration and mass multiplication*:** Three organic carbon sources viz., dextrose, glucose and sucrose (0-4%) besides other adjuncts were incorporated in the basal media for growth and regeneration under optimum conditions in the present investigation and the results recorded**.** Temjensangba and Deb (2005a) noted that requirements of the quality and quantity of exogenous supply of the organic carbon sources varies with the species, the media compositions used, the endogenous level of organic carbon and the developmental stage of the cultured embryos. In both species viz., *Paphiopedilum insigne* and *Paphiopedilum villosum* var. *boxallii* sucrose fortified medium supported optimum differentiation and culture proliferation. *Paphiopedilum insigne* recorded best results on sucrose enriched medium at a concentration of 3% wherein at least 9 shoot buds were formed that converted into rooted plantlets. At lower concentrations of sucrose (1-2%) slower shoot growth was recorded suggesting that concentration of carbon source was a significant parameter on overall growth. On glucose enriched medium growth seems to be non-supportive across the concentrations tested. *Paphiopedilum villosum* var. *boxallii* on dextrose enriched medium recorded stunted root growth though shoot growth was satisfactory. Glucose enriched medium supported moderate differentiation up to a concentration of 2% but at higher concentration (3-4%) abnormal shoot growth was recorded. Compare to above two organic carbon sources, sucrose fortified medium supported healthy plant regeneration and proliferation. Under the given conditions, optimum regeneration and proliferation was achieved on MS medium containing 3% sucrose where as many as 7 shoots buds/PLBs formed per subculture.

***Effect of PGRs on regeneration and culture proliferation*:** Four different PGRs viz., NAA, IAA, BA and KN were used in the present investigation for plant regeneration culture proliferation. Differentiated PLBs and young plantlets obtained from germinated embryos and nodal explants of both the species were cultured in optimum

culture conditions. Use of NAA and BA in combination found to be beneficial for regeneration and mass multiplication in both the species. In *Paphiopedilum insigne* at least 9 shoot buds were formed on MS medim incorporated with PGRs BA and NAA (4 +10 µM respectively in combination) and for *Paphiopedilum villosum* var. *boxallii* NAA + BA (2 + 6 µM) produced a maximum of 7 shoot buds wherein the first leaf was observed after 21 days of culture while rooting observed after 32 days of culture. Similar results were reported by Huang *et al.* (2001) for shoot proliferation and rooting in three *Paphiopedilum* hybrids viz., *Paphiopedilum philippinense* x *Paphiopedilum* Susan Booth, *Paphiopedilum bellatulum* "Big spot" x *Paphiopedilum* Jo Ann's Wine and *Paphiopedilum* micranthum x *Paphiopedilum glaucophyllum*) wherein shoots doubled every 12 wk when treated with 13 µM BA and 1.6 µM NAA in combination. NAA and BA in combination across different concentration recorded best results in formation of PLBs/shoot buds or single growth of plantlet without formation of PLBs/ shoot buds. NAA alone did not support PLBs formation in both the species across studied concentrations (2–8 µM) and at higher concentration the plantlets etiolated or browned quickly and subsequently degenerated. BA alone on the other hand at studied concentrations recorded multiple shoot growth in both species but rooting was not observed in both the species. For *Paphiopedilum villosum* var. *boxallii* rapid elongation of leaves were observed with no root and subsequently browning and degeneration over prolonged period. Whereas, *Paphiopedilum insigne* was more tolerant wherein healthy shoot growth was observed with PLBs formation but also subsequently degenerated due to non production of roots. At higher concentration of BA (10µM and above) alone, explants from both the species exhibited extensive necrosis showing an intolerance to the PGR similar to reports by Long *et al.* (2010) for *Paphiopedilum insigne* explants. IAA alone supported formation of no/very few PLBs but with time the explants and PLBs degenerated. IAA at 0.1 mg L^{-1} is reported to promote seed germination and seedling development of *Cymbidium punctulata* (Sharma and Tandon, 1986) but the inhibitory effect of IAA on seedling development is also reported in *Orchis purpurella* (Hadley and Harvais, 1968), *Dactylorhiza purpurella*, *Coeloglossum viride* and *Platanthera bifolia* (Hadley, 1970). Observations in the present study in both the species are in agreement with the above reports. IAA in combination with KN across studied concentration had the same inhibitory effect on seedling growth and development wherein etiolating of leaves and browning was observed that subsequently degenerated. Very slow growth

was observed on IAA and KN (4 + 4 µM) for *Paphiopedilum insigne* across replicates. Overall the performance of PGRs for organogenesis and mass multiplication was recorded optimum on medium wherein auxin (NAA) and cytokinin (BA) were used in combination for both the species.

3.4.3 Hardening and field trials of the regenerates

Before field trials, hardening of *in vitro* raised plantlets is necessary for better survival and successful establishment of the regenerates. The survival percentage is hence, finally determined by the hardening of the plantlets. Usually, the tissue culture raised plants are hardened by transferring on a low nutrient medium having low organic carbon sources and maintained at increasing light intensity. In the present study plantlets of ~5 cm in height from both the species were first hardened *in vitro* using different hardening substrates viz., coconut husk, brick pieces, charcoal chunks, sand, decaying organic matter, dried cow dung in different combination and $1/10^{th}$ strength MS liquid solution fed into the mixture for initial two wk and observed since, degeneration of micropropagated plants after transferring to nature are usually attributed to low humidity, high levels of light and non-sterile condition of the *in vivo* environment (Lavanya *et al*., 2009; Deb and Imchen, 2010). The hardened *in vitro* plantlets were then transferred in community pots containing different percentage of different hardening substrates and covered with perforated transparent polybags and kept in the shade for 2 wk. The transplants were exposed to low intensity sunlight for ~1 hr a day for 2 wk and transplants were fed with $1/10^{th}$ strength MS liquid solution was fed weekly. Feeding the plantlets with nutrient salt solution has been reported to be beneficial for the promotion of orchid survival and growth (Kumaria and Tandon, 1994; Temjensangba and Deb, 2005a; Deb and Temjensangba, 2007b). After a month the community pots with plantlets were transferred to greenhouse under normal greenhouse light and observed for the next three months. The best result for growth in both the species was recorded wherein sand + decaying organic matter + brick pieces+ charcoal + dried cow dung was used as substrate in the same ratio and watering interval after every 5 days with maximum survival rate recorded at approximately 75% for *Paphiopedilum insigne* with an average shoot growth of 6.5 cm in five months and 65% for *Pahiopedilum villosum* var. *boxallii* with an average shoot growth of 5.3cm in 5 months. Brick pieces + charcoal chunks + coconut coir (1:1:1) performed well and recorded approximately 60% survival rate for *Paphiopedilum insigne* with an average shoot growth of 3 cm in four months. 40%

survival rate with an average shoot growth of 2.5 cm was recorded in *Pahiopedilum villosum* var. *boxalli*. Burning of leaf tips were observed initially on substrate containing charcoal in both the species. Well hardened plants with healthy growth were then observed in the greenhouse for later transfer to field.

3.5 Summary and Conclusion

The traits of *in vitro Paphiopedilum* hybrid protocorms or seedlings are variable and unpredictable, which is unacceptable in commercial production (Liao *et al*., 2011), moreover the phenotype of plants must be predictable and uniform to be commercially viable on a large scale and since at present, there are few protocols for the tissue culture of *Paphiopedilum* from explants of mature plants. *Paphiopedilum* species and their hybrids are the only commercially grown orchids that are not cloned since explants from mature plants of *Paphiopedilum* species are recalcitrant to shoot induction and plant regeneration (Arditti, 2008), moreover aseptic explants from mature plants are difficult to survive without contamination as surface sterilization steps for *in vitro* culture of *Paphiopedilum* are inefficient due to presence of endogenous bacteria (Chugh *et al*., 2009). *Paphiopedilum* available commercially are almost entirely from *in vitro* germinated seeds of hybrid species. Factors such as seed maturity, basal medium, organic amendments, light, temperature, carbon source, choice of PGRs, and culture method have a strong impact on the outcome of *in vitro* propagation; hence an understanding of the physiogy and ecology of seeds and whole plant ecology of *Paphiopedilum* is necessary for commercial propagation (Zeng *et al.*, 2016). Further research on *in vitro* tissue culture protocols including the use of aseptic explants from mature plants and increasing the speed of propagation and growth of *Paphiopedilum* is thus required. The present investigation protocols serves as one of the initial starting points for establishment of more defined protocols in culture initiation from immature seeds/embryos of various developmental stages, foliar explants, regeneration of plantlets and mass multiplication of *Paphiopedilum insigne* and *Paphiopedilum villosum* var. *boxallii*.

Chapter - 4

Summary

In general Orchids are known for their strikingly beautiful flowers of different size range, fascinating shapes and beautiful colors. They belong to a family Orchidaceae, which has outsmarted and outnumbered some other family of flowering plants by evolving higher levels of specialization in its vegetative and reproductive traits. North-East India is a part of The Himalayas as well as Indo-Burma biodiversity hotspot, as a result of which this region is fascinating for researchers. North-East India has the richest reservoir of plant diversity in India and Indian orchids are mostly confined to North-Eastern region and Western Ghats constituting about 1378 species and about 890 species are found in North-East India. Nagaland, one of the states of North-East India contributes significantly with about 396 species of 92 genera to family Orchidaceae which occupies a prominent place in the rich flora, many more being added lately. Unfortunately, in recent years excessive human intervention has led to the rapid decline of floral diversity and orchids being intolerant to slight changes in microclimates have experienced massive decline in population. All orchid species are thereby included under Annex B of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and subsequently all *Paphiopedilum* species (Lady's slippers) are listed under Appendix I of CITES. The need for conservation both *in-situ* and *ex-situ* is necessitated therein for further sustainable utilization of this rich resource. The present study was thus undertaken with an objective to document orchid resource of three districts of Nagaland viz., Kiphire, Tuensang and Zunheboto and mass multiplication and conservation of two horticulturally important and threathened orchid species viz., *Paphiopedilum insigne* (Wallich ex Lindley) Pfitzer and *Paphiopedilum villosum* var. *boxallii* (Reichenbach fil.) Pfitzer commonly known as Lady's slipper of which 9 species of the genera is

found in India, 8 species restricted to Eastern Himalaya and North-East India with *Paphiopedilum druryi* (Bedd.) Pfitzer being endemic to Western Ghats.

The present documentation work has unearthed 180 species belonging to 58 genera from the three study area districts viz., Kiphire, Tuensang and Zunheboto. The Genus *Dendrobium* recording a maximum of 29 species followed by *Bulbophyllum* with 17 species and *Coelogyne* with 15 species. Out of the 58 genera, 30 genera were strictly epiphytic, while 15 genera were terrestrial and 11 genera belonging to the mixed type i.e. either terrestrial or epiphytic. Species from the genus *Epipogium* and *Eulophia* are saprophytic and was represented by 1 species each i.e., *Epipogium roseum* and *Eulophia zollengeri*. *Arachnis labrosa* var. *zhaoi* and *Thrixspermum laurisilvaticum* are new records for the country while *Polystachya concreta, Esmeralda clarkei, Dendrobium tamenglongense, Arachnis senapatiana Phalaenopsis braceana, Cymbidium bicolor, Erythrodes blumei, Eriodes barbata, Crepidium calophyllum, Pendulorchis himalaica* are new records for the state reported by the author from the study districts. With this study the diversity of orchid taxa for the state at present is thus 426 species belonging to 101 genera.

Protocols for efficient micro propagation were also studied under the present investigation starting with the initiation of cultures from embryos/seeds followed by use of *in-vivo* shoot buds and foliar explants from the two selected species.

Seed pods/capsules of different developmental stages were used for culture initiation in both the species. *P. insigne* recorded optimum germination from capsule/pod age of 210 DAP while *P. villosum* var. *boxallii* recorded from seeds of 240 DAP capsules/pods. Seeds from <150 DAP and <180 DAP capsule/pods either failed to germinate or supported poor germination in *P. insigne* and *P. villosum* var. *boxallii* respectively. Consequently, Seeds from >270 DAP capsules/pods recorded very late germination and low germination rate in both species. The first sign of germination was noted as nodular swelling of seeds after 38 days of culture in *Paphiopedilum insigne* and 42 days in *Paphiopedilum villosum* var. *boxallii*.

Different nutrient media were also used for asymbiotic germination viz., Gamborg (B5), Knudson 'C', Mitra *et al.*, Murashige and Skoog (MS), and Schenk and Hildebrand (SH). In *P. insigne* germination rate of~ 85% was achieved on MS medium followed by Mitra *et al* (~ 40%) and Knudson 'C' (~ 32%) all containing 3% sucrose (w/v). SH and B5 recorded very low germination rate at~ 20% and~ 18 % respectively. Whereas for *P. villosum* var. *boxallii* germination rate was recorded

highest on MS medium (~60%) followed by Knudson 'C' (~40%), Mitra *et al* (~35%), SH (~25%) and B5 (~20%). Organic carbons from different source were also used and optimum seed germination of *P. insigne* and *P. villosum* var. *boxallii* was obtained on basal media containing 3% sucrose. Dextrose and glucose performed fairly but did not support healthy germination. Significant contrasting results were not recorded with or without the use of coconut water in the media. Addition of AC in culture media was also not detrimental in increasing the germination rate of *P. insigne* and *P. villosum* var. *boxallii* though at higher concentration (0.2-0.5 %) AC was lethal for seed germination in both species wherein swelling of embryos led to degeneration. Different Plant Growth Regulators (PGRs) were used in varying combination and in both *P. insigne* and *P. villosum* var. *boxalli* optimum germination was recorded on medium containing NAA + BA (2µM +6 µM) in combination. In both *P. insigne* and *P. villosum* var. *boxallii* optimum germination was recorded under diffused light (20 µmol m^{-2} s^{-1}) at 12/12 hr dark and light photoperiod followed by dark treatment as compared to full light (40 µmol m-2 s-1).

Leaf cuttings, root cuttings and foliar explants of germinated embryos with first leaf initials (~8 wk old) from *in vitro* source of both the species were cultured for further initiation of PLBs/direct shoot buds in the present study. Culture could not be initiated from leaf tip and root cuttings even under optimum growth condition using varying concentration of available PGRs. Basal parts of foliar explants and shootbuds were hence used for initiation of morphogenetic response in both the species wherein *P. insigne* formed ~9 shoot buds per explants from base of foliar explants in about 60 % of culture on MS media containing sucrose (3%), NAA and BA (4 µM + 10 µM v/v). Whereas in *P. villosum* var. *boxallii* ~7 shoot buds formed in ~ 65 % of culture on MS media containing sucrose (3%), NAA and BA (2 µM + 6 µM v/v) in combination.

The shoot buds formed from non-symbiotic seed germination, foliar explants and shootbuds of both the orchid species were then sub-cultured on three different basal media viz., Knudson 'C', Mitra *et al* and MS media incorporated with various adjuncts for regeneration of plantlets as well as for mass multiplication. MS media proved to be the best medium for regeneration wherein the first leaf initials were observed as early as 16 days and 21 days after culture in *P. insigne* and *Paphiopedilum villosum* var. *boxallii* respectively. Different strengths of MS medium ($1/4^{th}$, 1/2, $3/4^{th}$ & full strength) were also used for regeneration of plantlets and

culture proliferation. Optimum performance was recorded on full strength MS medium as compared to other strengths. The basal medium was supplemented with different organic carbon sources (dextrose, glucose and sucrose at a concentration of 0-4%) and both the species recorded optimum regeneration/ shoot bud formation on basal media containing sucrose (3%).

Further, four different PGRs viz., NAA, IAA, BA and KN were used alone or in combination for studying its response on regeneration and mass multiplication. Use of NAA and BA (4µM +10 µM) in combination recorded the best results for regeneration in *P. insigne* wherein average of 9 shoot buds were formed per explants with the first leaf and root emerging after 16 and 29 days of subculture. Whereas in *P. villosum* var. *boxallii* NAA + BA (2µM + 6 µM) recorded optimum results producing an average of 7 shoot buds and the first leaf and root emerging after 21 days and 32 days of sub-culture.

The tissue-raised plants were then hardened on different substrates viz., coconut husk, brick pieces, charcoal chunks, sand, decaying organic matter, dried cow dung in different combination and a low nutrient medium i.e. $1/10^{th}$ strength MS liquid solution having low organic carbon sources was fed into the mixture for initial two weeks and observed. The hardened *in vitro* plantlets were then transferred to community pots containing different percentage of different hardening substrates and covered with perforated transparent polybags and kept in the shade for 2 weeks. 1 hour treatment under weak sunlight everyday for the next two weeks followed. $1/10^{th}$ strength MS liquid solution was fed weekly. After a month the community pots with plantlets were transferred to greenhouse under normal greenhouse light for the next three months. The best result for growth in both the species was recorded wherein Sand + Decaying organic matter + brick pieces+ Charcoal + Dried cow dung was used as substrate in the same ratio and watering interval after every 5 days with maximum survival rate recorded at approximately 75% for *Paphiopedilum insigne* and 65% for *Pahiopedilum villosum* var. *boxallii*. Darkening of leaves to healthy green colour along with rooting was observed gradually.

The present investigation protocols is an initiative for establishment of more defined protocols in culture initiation of the two threatened lady's slipper orchids viz., *Paphiopedilum insigne* and *Paphiopedilum villosum* var. *boxallii*. from immature seeds/embryos of various developmental stages as well as for regeneration of plantlets and mass multiplication from foliar explants and shoot buds observing the decrease of

their population in the wild, the introduction of plantlets among its wild relatives would increase its overall population. Subsequently private and public institutions associated with floriculture could use these protocols for commercialization of this native orchid species and aid the country's economy taking into account the recent increasing trends in the international floriculture trade.

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List of Publications

1. **Deb, C.R., Jamir, N.S., Jakha, H.Y., Kikon, Z.P. and Dey, S. 2014.** *Esmeralda clarkei* Reichenbach f. (Orchidaceae): a new report for the flora of Nagaland, India. *Pleione,* 8(1): 181-183.
2. **Jakha, H.Y., Deb, C.R., Dey, S. and Jamir, N.S. 2014.** *Arachnis senapatiana* (Phukan & A.A. Mao) Kocyan & Schuiteman (Orchidaceae): an addition to the flora of Nagaland, India. *Pleione,* 8(2): 516-518.
3. **Jakha, H.Y., Deb, C.R., Dey, S., Jamir, N.S. and Kikon, Z.P. 2014.** *Dendrobium tamenglongense* R. Kishor, Y.N. Devi, H.B. Sharma,J. Tongbram & S.P. Vij (Orchidaceae): an addition to the flora of Nagaland. *Pleione,* 8(2): 526-528.
4. **Dey, S., Jamir, N. S., Gogoi, R., Chaturvedi, S. K.., Jakha, H.Y., and Kikon, Z.P. 2014.** *Musa nagalandiana* sp. nov. (Musaceae) from Nagaland, northeast India. *Nordic Journal of Botany* 000: 001–005.
5. **Jakha, H.Y., Deb, C.R., Dey, S. and Jamir, N.S. 2015.** *Arachnis labrosa* var. Zhaoi (Orchidaceae): A new record for India. *Rheedea,* 25(2): 120-122.
6. **Jakha, H.Y., Deb, C.R., Singh, S.K., Verma, D., Dey, S. and Jamir, N.S. 2015.** *Pendulorchis* (Orchidaceae) - A new generic record for Nagaland, India. *Keanean J Sci,* 4: 31-34.
7. **Deb, C.R., Jakha, H.Y and Dey, S. 2015.** Report of *Dendrobium regium* Prain (Orchidaceae) from Nagaland, India – a new record for North-East India. *Pleione,* 9(1): 258-260.
8. **Imchen, T., Jakha, H.Y. and Deb, C.R. 2015.** *Phalaenopsis braceana* (Hook.f.) Christenson – a new distributional record for Nagaland, India. *Pleione,* 9(1): 244-246.
9. **Deb, C.R., Jakha, H.Y. and Jamir, N.S. 2016.** *Polystachya concreta* (Jacquin) Garay & H.R. Sweet (Orchidaceae): a new record for Nagaland, India. *Pleione,* 10(1): 189-191.
10. **Jakha, H.Y. and Dey, S. 2017.** Addition of *Crepidium calophyllum* (Rchb.f.) Szlach., *Eriodes barbata* (Lindl.) Rolfe and *Erythrodes blumei* (Lindl.) Schltr.to the orchid flora of Nagaland, India. *Indian Jf Fundamental Appl Life Sci,* 7(2): 1-4.
11. **Deb, C. R., Kamba, J., Longchar, T. B. and Jakha, H. Y. 2017.** *Cymbidium bicolor* lindl. (orchidaceae): ba new report for the orchid flora of Nagaland, India. *Pleione,* 11(2): 498-500.

Papers Presented in Seminars and Conferences

1. **Jakha, H.Y. and Deb, C.R. 2014.** *Esmeralda Clarkei* Rchb.f. (Orchidaceae) – New report for the orchid flora of Nagaland. In: **National Symposium on Gene Conservation of Medicinal and Horticultural Orchids of the North Eastern Region and their Sustainable Use through Community Participation**, The Orchid Research and Development Centre, FEEDS, KVK, Sylvan campus, Henbung, Senapati, Manipur, India, April 5-6.
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