TAXONOMIC REVISION OF THE GENUS *Cymbidium* Sw. (ORCHIDACEAE) IN NEPAL

A DISSERTATION SUBMITTED TO THE

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BY

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DECLARATION

I declare that this Dissertation entitled **"Taxonomic Revision of the Genus *Cymbidium* Sw. (Orchidaceae) in Nepal"** which is being submitted to the Department of Botany, Amrit Campus, Institute of Science and Technology, Tribhuvan University, Nepal for the partial fulfillment of the requirements for the Master's degree in Botany is original.

This research work is carried out under the supervision of Prof. Dr. Devendra Mananda Bajracharya, Department of Botany, Amrit Campus. This research is original and has not been submitted earlier in part or full in this or any other form to any university or institute, here or elsewhere, for the award of any degree.

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RECOMMENDATION

This is to recommend that **Amita Twayana** has carried out the research entitled **"Taxonomic Revision of the Genus *Cymbidium* Sw. (Orchidaceae) in Nepal"** for the partial fulfillment of requirements for the Master's Degree in **Botany** under my supervision. To my knowledge, this work has not been submitted for any other degree.

She has fulfilled all the requirements laid down by the Institute of Science and Technology, Tribhuvan University, Kirtipur for the submission of the dissertation for the Master Degree.

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LETTER OF APPROVAL

The M. Sc. Dissertation entitled **"Taxonomic Revision of the Genus *Cymbidium* Sw. (Orchidaceae) in Nepal"** submitted by Amita Twayana to the Department of Botany, Amrit Campus, Tribhuvan University has been accepted for the partial fulfillment of the requirements for Master's Degree in Botany.

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ABSTRACT

Cymbidium is the epiphytic, terrestrial, lithophytic orchid with a distinguishing character of linear to elliptic-lanceolate leaves, 2 or 4 pollinia in 2 unequal pairs, and the genus mostly occur on the tree trunks covered by mosses. This study is based on all the species of the taxa that are naturally distributed in Nepal.

This taxonomic revisionary study is based on the herbarium specimen and fresh plant materials. The herbarium specimens are thoroughly studied from KATH and TUCH and the examination of available images of herbarium specimens collected from Nepal are also done in international herbaria like BM, CAL, E, K and TI. This study confirms the presence of 10 species of *Cymbidium* in Nepal namely; *C. aloifolium, C. crassifolium, C. cyperifolium, C. devonianum, C. elegans, C. erythraeum, C.* × *gammieanum, C. hookerianum, C. iridioides* and *C. lancifolium*.

The synonyms, type specimens, description, ecology, altitudinal range, flowering season, specimen examined and distribution map for all the species present in Nepal is prepared. Also, the illustration and bracketed taxonomic key is made to identify the species. The character of lip is more important in taxonomic view point for delimiting the species of this genus.

Micromorphological character like the stomata complex in 10 species of *Cymbidium* were studied for understanding the taxonomic significance of stomatal complex within the genus. Stomatal index and stomatal frequency were calculated using formula given by Salisbury. Paracytic type of stomata were found in the species that are either arranged in linear form or scattered. The elliptical shape of stomata was found in more species than the circular shape.

Furthermore, the cladistic analysis is also interpreted to find out the phylogenetic relationship among the species. The cladogram showed that *C. aloifolium* and *C. crassifolium* are closely related.

The genus *Cymbidium* is found to be distributed in all 3 regions of Nepal with the altitudinal range from 800 – 2800 m in 23 districts of Nepal. The flowering period of the genus *Cymbidium* is usually throughout the year as several species bloom in different season.

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ABBREVIATIONS AND ACRONYMS

&	and
Ann. Ch. Fl. Pl. Nep.	Annotated Checklist of Flowering Plants of Nepal
Ann. Roy. Bot. Gard.	Annals of the Royal Botanic Garden, Calcutta
˚E	Longitude
˚N	Latitude
BM	Natural History Museum, London
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CAL	Botanical Survey of India, Howrah, Kolkata, India
ca.	approximately
cm	centimeter
E	Royal Botanic Garden Edinburgh, Edinburgh, U.K.
Enum. Fl. Pl. Nep.	Enumeration of Flowering Plants of Nepal
et al	and others
Fig.	Figure
Fl. Bhutan	Flora of Bhutan
Fl. Brit. Ind.	Flora of British India
Fl. China	Flora of China
Ft	feet
Gen. Sp. Orchid. Pl.	The Genera and Species of Orchidaceous Plants
Hand. Fl. Pl. Nep.	Handbook of Flowering Plants of Nepal
K	Royal Botanic Garden, Kew, London
KATH	National Herbarium and Plant Laboratories, Nepal
m	meter
mm	millimeter
Prod. Fl. Nep.	Prodromous Florae Nepalensis
TI	The University of Tokyo, Japan
TUCH	Tribhuvan University Central Herbarium, Nepal

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1. INTRODUCTION

1.1. Background

Orchidaceae is one of the widespread and diverse families of flowering plants distributed in tropical and subtropical regions of the world. This family includes 736 genera and 27000 species worldwide (Chase *et al*., 2015) whereas according to De (2021), 29,199 species of this family have been identified and accepted. It consists of beautiful long-lived flowers having ornamental, medicinal, and nutritional values and are found in a wide variety of ecological conditions, except in marine conditions (Acharya and Rokaya, 2010; Hinsley *et al*., 2017). Orchids are unique flowers with a pleasant aroma and beautiful comical mimics in nature (Raskoti, 2009).

Orchidaceae is the second largest family of flowering plants with 28,237 species after Asteraceae with 32,581 species in the world. However, it is the largest family in Nepal with 440 species belonging to 95 genera (Shrestha, 2022) comprising 7.1% of total flowering plants of Nepal (Rokaya *et al*., 2013), Recently, Rajbhandari (2023) mentioned that Orchidaceae is third largest families having 96 genera and 381 species in Nepal including 18 species known to be endemic (Rajbhandari, 2014) and distributed between 60 and 5200m above sea level in the range of habitats from low tropical land to high Himalayan of Nepal (Rokaya *et al*., 2013; Rajbhandari and Rai, 2017; Shrestha *et al*., 2018; Bhandari *et al*., 2020).

According to Royal Botanic Garden, Kew (2009), it is estimated that more than 850 species of orchids are found in the Himalayan region. 239 species of orchids are reported from Western Himalaya (Singh Jalal and Jayanthi, 2015). 372 species are reported from Central Himalaya and 490 species of orchids are reported from Eastern Himalaya (Acharya *et al*., 2011).

Orchids are mostly epiphytic, terrestrial and rarely saprophytic. Epiphytic orchids are usually beautiful and attractive than the terrestrial orchids and they are also excellent biological indicators of ecological changes in the ecosystem. The diagnostic characters of family Orchidaceae have been enlisted in different points by many scientists till date. According to Jezek (2006), there are four basic features of orchids that admittedly can be found individually with other plants, but which apply all at once in the case of orchids; flowers are bilaterally symmetrical, pollen grains are grouped into sticky

masses termed 'pollinia', the seeds are very minute and contain only undeveloped embryos with no nutritive material and in natural condition, seed can germinate only when symbiotic fungi are present.

They are further characterized by having modified petals called lip or labellum intensely colored with scent attracting the pollinating agent and has a column, the fusion of stamen filaments with the style, presence of rhizomes or tuberous root, stem forming pseudobulbs bearing aerial assimilating roots, pollination mechanism, association with fungal partners and miniscule seeds (Kumar *et al*., 2007).

1.2 Genus *Cymbidium* Sw.

The genus *Cymbidium* was first described in 1799 by Olof Swartz derived from the Latin word "cymba" which means cup, bowl, or boat with the diminutive suffix –idium, i.e. boat, apparently based on the shape of the labellum in some species. *Cymbidium* Sw. belongs to the sub-family Epidendroideae, Cymbidieae, and Cymbidinae (Chase *et al.*, 2015). It is among the most popular winter and spring flowering orchids, widely distributed in tropical and subtropical Asia (De, 2022).

Cymbidium, commonly known as boat orchids, is a genus of evergreen flowering plants characterized by epiphytic, lithophytic, terrestrial, or rarely leafless saprophytic herbs. It is characterized by short and stout pseudobulbs, long, narrow, coriaceous leaves, attractive flowers often large in erect, arching or drooping raceme, equal sepals and petals, lip 3-lobed, embracing the column disc with pubescent ridges, column long, and pollinia 2, deeply grooved or 4 (Bose and Bhattacharjee, 1999).

Total of 71 species of *Cymbidium* are present worldwide (Chase *et al*., 2015). The online database; The World Flora Online (WFO) includes 513 species of *Cymbidium* with 229 accepted name of *Cymbidium* (www.worldfloraonline.org; retrieved on 22 May, 2023). Nepal encompasses about 16 species of *Cymbidium* (Rokaya *et al.,* 2013; Shrestha *et al*., 2018). Rajbhandari and Rai (2017) enlisted 10 species of *Cymbidium* in Nepal.

1.3 Systematic position of the genus *Cymbidium* Sw.

Lindley (1833), the first taxonomist to produce a working classification of the Orchidaceae placed *Cymbidium* in the tribe Vandeae, followed by Bentham (1881), Hooker (1890) and King & Pantling (1898). Schlechter (1924) incorporated many of

Lindley's and later botanist ideas, thus providing a base for the modern classification. He placed *Cymbidium* in tribe Kerosphaerae of sub family Monandreae. Duthie (1970) again placed back the *Cymbidium* in tribe Vandeae.

Dressler (1981) placed *Cymbidium* into the sub-family Vandioideae, the tribe Cymbidieae containing all of the sympodial vandioid orchids. Deva & Naithani (1986) placed *Cymbidium* in subtribe Cymbidiinae of tribe Vandeae within the sub-family Vandioideae. Balogh and Funk (1986) placed *Cymbidium* in subfamily Epidendroideae of tribe Vandeae. Dressler (1993) revised his work and gave the phylogenetic classification of orchids and placed *Cymbidium* in a broadly defined subtribe Cyrtopodiinae of tribe Cymbidieae in the subfamily Epidendroideae. Szlachetko (1995) placed *Cymbidium* in subfamily Vandoideae of tribe Cymbidieae and subtribe Cymbidiinae, Pearce and Cribb (2002) placed *Cymbidium* to sub family Epidendroideae, tribe Cymbidieae and subtribe Cyrtopodiinae followed by and Chen *et al*. (2009) and Yonzone (2015).

Chase *et al*. (2015) updated the classification of Orchidaceae and placed *Cymbidium* in subtribe Cymbidiinae, tribe Cymbidieae within the sub-family Epidendroideae. However, Orchidaceae family is kept in the order Asparagales by classification of 'Angiosperm Phylogeny Group' (APG) and remained same in APG I, II, III and IV based on molecular study. The present study follows the classification by Chase *et al*. (2015).

1.4 Generic and sectional delimitation of *Cymbidium* Sw.

The generic name *Cymbidium* was established by Olof Swartz (1799) including 44 species where majority of them are no longer considered to be members of this genus. Only three of them *C. aloifolium*, *C. ensifolium* and *C. pendulum* (= *C. aloifolium*), remain recognized within *Cymbidium* with the first being selected as the genus type. Lindley (1833) also included many species that are now placed in other genera.

Blume (1848, 1849, 1858) removed *C. elegans* to form genus *Cyperorchis* on the basis of the sessile lip parallel to the column, elongated column with a beaked rostellum and a pair of pyriform pollinia on the middle of a flat, transversely ovoid viscidium. Blume (1858) transferred *C. giganteum* (= *C. iridioides*) to the genus *Iridorchis.*

Reichenbach (1852) initially accepted the separation of *Cyperorchis* from *Cymbidium*. However, he returned *C. elegans* to *Cymbidium* in 1864, noting the difference in the pollinarium and pollinia shape were not sufficient for their separation. Hooker (1891) recognized *Cyperorchis* and included in it *C. elegans*, *C. cochleare* and *C. masterii* from northern India.

King & Pantling (1898) mentioned 16 species of *Cymbidium* under two sections: Eucymbidium and Cyperorchis. Schlechter (1924) recognized *Cyperorchis* as a distinct genus emphasizing the fusion of the base of the lip and the base of the column rather than the pollinium shape, thereby extending the limits of *Cyperorchis* to include all of the large flowered species, including those of Blume's *Iridorchis*. He recognized four sections within the genus including Eucyperorchis and Iridorchis. In his revision, he proposed an infrageneric system with 12 sections forming a basis for the modern infrageneric classification of *Cymbidium*. Hunt (1970) included *Cyperorchis* within *Cymbidium* maintaining Schlechter's sectional divisions.

Seth & Cribb (1984) divided *Cymbidium* into three subgenera based on the number of pollinia and state of the fusion between lip and column: subgenus *Cymbidium* with two pollinia and free lip, subgenus *Cyperorchis* with two pollinia and fusion of the lip and column base and subgenus *Jensoa* with four pollinia and free lip. Du Puy & Cribb (1988) slightly modified the treatment and added section Borneense for *C. borneense*.

Pearce & Cribb (2002) enumerated 18 species of *Cymbidium* from Bhutan and adjoining areas of Sikkim and Darjeeling of Himalaya and described them under ten sections. Liu *et al*. (2006) followed the treatment of DuPuy & Cribb (1988) with some modifications and additions, added sections Nanula and Axillaria, transferred the section Borneense from subgenus *Cymbidium* to subgenus *Jensoa* and reduced the section Maxillarianthe to the synonymy of the section Jensoa.

The present study divided the species under 6 sections namely: Cymbidium, Bigibbarium, Iridorchis, Cyperorchis, Maxillarianthe and Geocymbidium (Table 1).

Table 1: Overview of infrageneric classification of the genus *Cymbidium* Sw.

Botanical Name	**King & Pantling (1898)**	**Schlechter (1924)**	**Hunt (1970)**	**Seth & Cribb (1984)**	**Du Puy & Cribb (1988)**	**Pearce & Cribb (2002)**	**Present study (2023)**
C. aloifolium	Euc	Euc	Cym	Cym	Cym	Cym	Cym
C. crassifolium	-	Euc	-	Cym	Cym	Cym	Cym
C. cyperifolium	Euc	Jen	Jen	Jen	Jen	Maxi	Maxi
C. devonianum	Euc	Big	Big	Big	Big	Big	Big
C. elegans	Cyp	Eucy	Cyp	Cyp	Cyp	Cyp	Cyp
C. erythraeum	Euc	Irid	-	Cyp	Cyp	Irid	Irid
C. × *gammieanum*	Cyp	Irid	-	-	-	-	-
C. hookerianum	Euc	Irid	-	Cyp	Cyp	Irid	Irid
C. iridioides	Euc	Irid	Irid	Cyp	Cyp	Irid	Irid
C. lancifolium	Euc	Geo	Geo	Pachy	Pachy	Geo	Geo

Abb: Big= Bigibbarium, Cym= Cymbidium, Cyp= Cyperorchis, Euc= Eucymbidium, Eucy= Eucyperorchis, Geo= Geocymbidium, Irid= Iridorchis, Jen=Jensoa, Maxi= Maxillarianthe, Pachy= Pachyrhizanthe.

1.5 Statement of the problem

The first major revision of the complete genus was published in 1924 by R. Schlechter. Later, Rathore (1983) did the taxonomic revision of the genus *Cymbidium* in India which was a combined study with the genus *Calanthe*. Regarding the monograph, "The Genus *Cymbidium*" is the only monograph published till date. It was published by DuPuy & Cribb in 1988.

The *Cymbidium* group is a well-defined group of epiphytic and terrestrial orchid species with some saprophytic too in a tribe Cymbidieae under the subfamily Epidendroideae. Although the sectional limits have been revised by Schlechter (1924), Hunt (1970), Seth & Cribb (1984), DuPuy & Cribb (1988) and Pearce & Cribb (2002), there have been no adequate revision of *Cymbidium*. Therefore, the detailed taxonomic treatment of this genus is necessary for delimitation of taxa and easy identification.

1.6 Objectives

The aim of this study is to study all the *Cymbidium* species present in Nepal. The general objective of the study is to carry out the taxonomic revision of *Cymbidium* in Nepal. And the specific objectives of the study are:

- To study the morphological and micro-morphological variation within the species.
- To prepare the taxonomic key for the identification of species.
- To interpret the inter-relationship within different species of *Cymbidium*.
- To study the species diversity and distribution pattern of the genus *Cymbidium* in Nepal.

1.7 Limitation of study

The attempt to collect the fresh specimens from the field at respective flowering season was planned. But the collection of all the species was impossible during the study. Only two species of this genus were collected as live material, therefore, it leads to complete dependency on the herbarium specimens deposited in KATH, TUCH and digital images of international herbaria for the study.

2. LITERATURE REVIEW

2.1 *Cymbidium* Sw. in Nepalese literatures

Don (1825) published the description of 766 species of phanerogams in '*Prodromus Florae Nepalensis*' which includes 52 species of orchids from Nepal. He reported *C. iridioides, C. longifolium* (= *C. erythraeum*), *C. appendiculatum* (= *Cremastra appendiculata*), *C. nitidum* (= *Coelogyne nitida*), *C. strictum* (= *Coelogyne stricta*) and *C. speciosissimum* (= *Coelogyne cristata).*

Suwal (1969) mentioned 2 species of *Cymbidium* from Phulchoki and Godawari viz. *C. elegans* and *C. longifolium* (= *C. erythraeum*) with short description and flowering season. Malla *et al*. (1976) enlisted 6 species of *Cymbidium* in the '*Catalogue of Nepalese Vascular Plants*'; *C. aloifolium, C. elegans, C. giganteum* (= *C. iridioides*), *C. grandiflorum* (= *C. hookerianum*) and *C. longifolium* (= *C. erythraeum*). Hara *et al*. (1978) enumerated 315 species of orchids from Nepal under 90 genera among which 9 species belongs to genus *Cymbidium*; *C. aloifolium, C. devonianum, C. eburneum, C. erythraeum, C. hookerianum, C. iridioides, C. lancifolium, C. longifolium* (= *C. elegans*) and *C. pendulum* (= *C. aloifolium*).

Banerji & Pradhan (1984) reported and illustrated 8 species of *Cymbidium*; *C. aloifolium, C. cyperifolium, C. devonianum, C. erythraeum, C. iridioides, C. hookerianum, C. lancifolium* and *C. longifolium* (= *C. elegans*). Malla *et al*. (1986) reported 5 species of *Cymbidium*; *C. cyperifolium, C. elegans, C. giganteum* (= *C. iridioides*), *C. lancifolium* and *C. longifolium* (= *C. erythraeum*) from Kathmandu valley. Later Shakya *et al*. (1994) also recorded *Cymbidium iridioides, C. longifolium* (= *C. elegans*) and *C. lancifolium* from Kathmandu valley. Banerjee (1996) recorded 8 species of *Cymbidium*; *C. cyperifolium, C. elegans, C. giganteum* (= *C. iridioides*), *C. grandiflorum* (= *C. hookerianum*), *C. lancifolium, C. longifolium* (= *C. erythraeum*), *C. pendulum* (= *C. aloifolium*) and *C. simulans* (= *C. aloifolium*) from Nepal. Bania & Sakya (1999) recorded single species of *Cymbidium*; *C. longifolium* (= *C. erythraeum*) from Chandragiri range.

Press *et al*. (2000) listed 10 species of *Cymbidium*; *C. aloifolium, C. bicolor* subsp. *obtusum* (= *C. crassifolium*), *C. devonianum, C. erythraeum, C. hookerianum*. *C.*

iridioides, *C. lancifolium*, *C. longifolium* (= *C. elegans*) and *C. pendulum* (= *C. aloifolium*) from Nepal (excluding *C. eburneum*). White & Sharma (2000) reported 4 species of *Cymbidium* from tropical region of Tribhuvan Rajpath and Chitwan jungle; *C. aloifolium*, *C. bicolor* subsp. *obtusum* (= *C. crassifolium*), *C. elegans* and *C. iridioides*. Rajbhandari & Bhattarai (2001) mentioned 6 species of *Cymbidium*; *C. devonianum*, *C. elegans*, *C. hookerianum*, *C. iridioides* and *C. lancifolium* (excluding *C. eburneum*) in beautiful orchids of Nepal.

Rajbhandari & Dahal (2004) reported 13 species of *Cymbidium*. Raskoti (2009) reported 11 species of *Cymbidium*; *C. aloifolium, C. bicolor subsp. obtusum* (= *C. crassifolium*), *C. cyperifolium, C. devonianum, C. erythraeum, C. × gammieanum, C. hookerianum, C. iridioides, C. lancifolium* and *C. longifolium* (= *C. elegans*) (excluding *C. eburneum*) from Nepal. Koirala *et al*. (2010) documented *C. elegans* and *C. iridioides* from Rolpa district of Western Nepal.

Rokaya *et al*. (2013) reported 437 species of orchids under 104 genera and 16 species of *Cymbidium* from Nepal; *C. aloifolium*, *C. bicolor*, *C. cyperifolium*, *C. devonianum*, *C. eburneum*, *C. elegans*, *C. erythraeum*, *C. × gammieanum*, *C. hookerianum*, *C. iridioides*, *C. lancifolium*, and *C. mannii* (excluding *C. dayanum*, *C. faberi*, *C. macrorhizon* and *C. micranthum*). Shakya & Bajracharya (2013) reported *Cymbidium iridioides* and *C. longifolium* (= *C. elegans*) from Shivapuri National Park. Rajbhandari (2015) reported 16 species of *Cymbidium* in handbook of orchids of Nepal.

Chapagain *et al*. (2015) enlisted *C. aloifolium, C. erythraeum, C. iridioides* and *C. longifolium* (= *C. elegans*) from Makwanpur district. Rajbhandari *et al*. (2016) enlisted *C. aloifolium* and *C. bicolor* subsp. *obtusum* (= *C. crassifolium*) from Kailai, West Nepal. Rajbhandari and Rai (2017) enlisted 9 species of *Cymbidium*; *C. aloifolium*, *C. cyperifolium*, *C. devonianum*, *C. erythraeum*, *C. hookerianum*, *C. iridioides*, *C. lancifolium*, *C. longifolium* (= *C. elegans*) and *C. mannii* (= *C. crassifolium*).

Bhandari *et al*. (2018) reported 49 genera and 125 species of orchids including 6 species of *Cymbidium* from Panchase protected forest; *C. aloifolium*, *C. elegans*, *C. erythraeum*, *C. × gammieanum*, *C. lancifolium* and *C. mannii* (= *C. crassifolium*). Pant *et al*. (2018) recorded 3 species of *Cymbidium*; *C. cyperifolium, C. erythraeum* and *C. iridioides* from two community forests of Makwanpur district. Shrestha *et al*. (2018)

enlisted 16 species of *Cymbidium*; *C. aloifolium*, *C. bicolor*, *C. cyperifolium*, *C. devonianum*, *C. elegans*, *C. erythraeum*, *C.* × *gammieanum*, *C. hookerianum*, *C. iridioides*, *C. lancifolium*, and *C. mannii* (excluding *C. dayanum*, *C. eburneum*, *C. faberi*, *C. macrorhizon* and *C. micranthum*). Karki and Ghimire (2019) recorded 3 species of *Cymbidium*; *C. elegans*, *C. erythraeum* and *C. lancifolium* from Suspa-Kshamawoti, Dolakha.

Bhandari *et al*. (2020) carried out a study in Panchase forest of mid-hills of Central Nepal and reported 6 species of *Cymbidium*; *C. aloifolium*, *C. elegans*, *C. erythraeum*, *C.* × *gammieanum*, *C. lancifolium* and *C. mannii* (= *C. crassifolium*). Rajbhandari *et al*. (2020) reported 6 species of *Cymbidium* from Province no. 1, East Nepal; *C. aloifolium*, *C. crassifolium*, *C. devonianum*, *C. erythraeum*, *C. hookerianum* and *C. iridioides*. Shrestha *et al*. (2022) reported 10 species of *Cymbidium*; *C. aloifolium*, *C. crassifolium*, *C. cyperifolium*, *C. devonianum*, *C. elegans*, *C. erythraeum*, *C.* × *gammieanum*, *C. hookerianum*, *C. iridioides* and *C. lancifolium* in plants of Nepal.

2.2 *Cymbidium* Sw. in international literatures

Willdenow (1805) described *C. aloifolium*, *C. giganteum* (= *C. iridioides*), *C. grandiflorum* (= *C. hookerianum*) and *C. pendulum* (= *C. aloifolium*) from India. Blume (1825) reported *C. aloifolium*, *C. pendulum* (= *C. aloifolium*) in the Section 1 and *C. cuspidatum* (= *C. lancifolium*) and *C. javanicum* (= *C. lancifolium*) in the Section 2. Roxburgh (1832) recorded 13 species of *Cymbidium* in Flora indica which later on were transferred to several other genera. Most of his collection were from Sylhet district of Assam. He also recorded *Limodorum longifolium* (= *C. cyperifolium*).

Lindley (1830-1840) described about 40 species of *Cymbidium* and among them 4 species are present in Nepal; *C. longifolium* (= *C. elegans*), *C. giganteum* (= *C. iridioides*), *C. elegans* and *C. lancifolium*. Later Lindley (1840) reported *C. pendulum* (= *C. aloifolium*) from India. Griffith (1851) reported 9 species of *Cymbidium* from East India and 3 of them are present in Nepal; *C. giganteum* (= *C. iridioides*) and *C. grandiflorum* (= *C. hookerianum*). Wight (1852) illustrated 4 species of *Cymbidium* from India and *C. aloifolium* is present in Nepal.

Reichenbach (1864) described 19 species of *Cymbidium* and 6 species present in Nepal; *C. aloifolium*, *C. bicolor* (= *C. crassifolium*), *C. devonianum*, *C. elegans*, *C. giganteum* (= *C. iridioides*) and *C. pendulum* (= *C. aloifolium*). Parish (1883) reported 4 species

of *Cymbidium* from Burma where *C. aloifolium* is present in Nepal. Hooker (1890) has described 15 species of *Cymbidium* from India and 9 of them are present in Nepal; *C. aloifolium*, *C. bicolor* (= *C. crassifolium*), *C. cyperifolium*, *C. devonianum*, *C. giganteum* (= *C. iridioides*), *C. grandiflorum* (= *C. hookerianum*), *C. lancifolium*, *C. longifolium* (= *C. erythraeum*) and *C. sikkimense* (= *C. devonianum*). He also further reported 3 species of *Cyperorchis* that later transferred to the genus *Cymbidium*.

King & Pantling (1898) described 16 species of *Cymbidium* from Sikkim-Himalaya and 9 species of them are present in Nepal; *C. aloifolium*, *C. cyperifolium*, *C. devonianum*, *C. elegans*, *C.* × *gammieanum*, *C. giganteum* (= *C. iridioides*), *C. grandiflorum* (= *C. hookerianum*), *C. lancifolium*, and *C. longifolium*. Smith (1905) mentioned 7 species of *Cymbidium* from Java where *C. aloifolium* and *C. lancifolium* are present in Nepal. Duthie (1906) described 7 species of *Cymbidium* from North-Western Himalaya where 5 of them are present in Nepal; *C. aloifolium*, *C. cyperifolium*, *C. giganteum* (= *C. iridioides*), *C. longifolium* (= *C. erythraeum*) and *C. pendulum* (= *C. aloifolium*).

Ridley (1907) reported 5 species of *Cymbidium* from Malayan Peninsula and *C. lancifolium* is present in Nepal. Later Ridley (1924) reported 7 species of *Cymbidium* from Malay Peninsula and *C. lancifolium* is present in Nepal. Deva & Naithani (1986) described 8 species of *Cymbidium* including *C. aloifolium*, *C. cyperifolium*, *C. hookerianum*, *C. iridioides* and *C. longifolium* (= *C. erythraeum*) from North West Himalaya.

Pangtey *et al*. (1991) reported 8 species of *Cymbidium* from Kumaun Himalaya and 6 of them are present in Nepal; *C. aloifolium*, *C. bicolor* (= *C. crassifolium*), *C. cyperifolium*, *C. hookerianum*, *C. iridioides* and *C. longifolium* (= *C. elegans*). Chowdhery (1998) recorded 19 species of *Cymbidium* from Arunachal Pradesh along with the taxonomic indented keys, description and illustrations. Among them 7 species are present in Nepal; *C. aloifolium*, *C. cyperifolium*, *C. devonianum*, *C. elegans*, *C.* × *gammieanum*, *C. hookerianum* and *C. iridioides*. Bose *et al*. (1999) described 23 species of *Cymbidium* from India and 11 of them are present in Nepal; *C. aloifolium*, *C. cyperifolium*, *C. devonianum*, *C. elegans*, *C.* × *gammieanum*, *C. hookerianum*, *C. iridioides*, *C. lancifolium*, *C. longifolium* (= *C. erythraeum*), *C. pendulum* (= *C. aloifolium*) and *C. sikkimense* (= *C. devonianum*).

Pearce & Cribb (2002) described 18 species of *Cymbidium* from Bhutan and adjoining area of Sikkim and Darjeeling among which 9 species are found in Nepal; *C. aloifolium*, *C. bicolor* subsp. *obtusum* (= *C. crassifolium*) in section Cymbidium; *C. devonianum* in section Biggibarium; *C. erythraeum*, *C. hookerianum* and *C. iridioides* in Iridorchis; *C. longifolium* (= *C. elegans*) in Cyperorchis; *C. cyperifolium* in Maxillarianthe; *C. lancifolium* in Geocymbidium. Besides that, they also enumerated 3 species of *Cymbidium* as the hybrid, doubtful and imperfectly known species and *C.* × *gammieanum* is found in Nepal.

Jalal *et al*. (2008) listed 8 species of *Cymbidium* from Uttarakhand, Western Himalaya, India among which 4 species are present in Nepal; *C. aloifolium*, *C. cyperifolium*, *C. hookerianum* and *C. iridioides*.

Chen *et al*. (2009) illustrated and described 49 species of *Cymbidium* from China where 9 of them are present in Nepal which are *C. aloifolium*, *C. cyperifolium*, *C. devonianum*, *C. elegans*, *C. erythraeum*, *C. hookerianum*, *C. iridioides*, *C. lancifolium* and *C. mannii* (= *C. crassifolium*).

Rao (2010) updated the flora of Arunachal Pradesh reporting 20 species of *Cymbidium* among which 9 species are present in Nepal; *C. aloifolium*, *C. cyperifolium*, *C. devonianum*, *C. erythraeum*, *C. hookerianum*, *C. iridioides*, *C. lancifolium* and *C. longifolium* (= *C. elegans*).

Yonzone (2015) reported 13 species of *Cymbidium* from Darjeeling Himalaya among which are 6 species are found in Nepal; C. aloifolium, C. *devonianum*, *C. erythraeum*, *C. hookerianum*, *C. iridioides* and, *C. lancifolium*.

Zhou *et al*. (2016) updated the checklist of Orchidaceae for China and reported 49 species of *Cymbidium* among which 9 species are present in Nepal; *C. aloifolium*, *C. cyperifolium*, *C. devonianum*, *C. elegans*, *C. erythraeum*, *C.* × *gammieanum*, *C. hookerianum*, *C. iridioides*, *C. lancifolium* and *C. mannii* (= *C. crassifolium*).

Maity *et al*. (2019) reported 17 species of *Cymbidium* from Sikkim among which 8 species are found in Nepal; *C. aloifolium*, *C. cyperifolium*, *C. devonianum*, *C. elegans*, *C. erythraeum*, *C. hookerianum*, *C. iridioides* and *C. lancifolium*.

Schuiteman *et al*. (2022) reported 28 species of *Cymbidium* in India, among them 9 species are recorded from Nepal in their works.

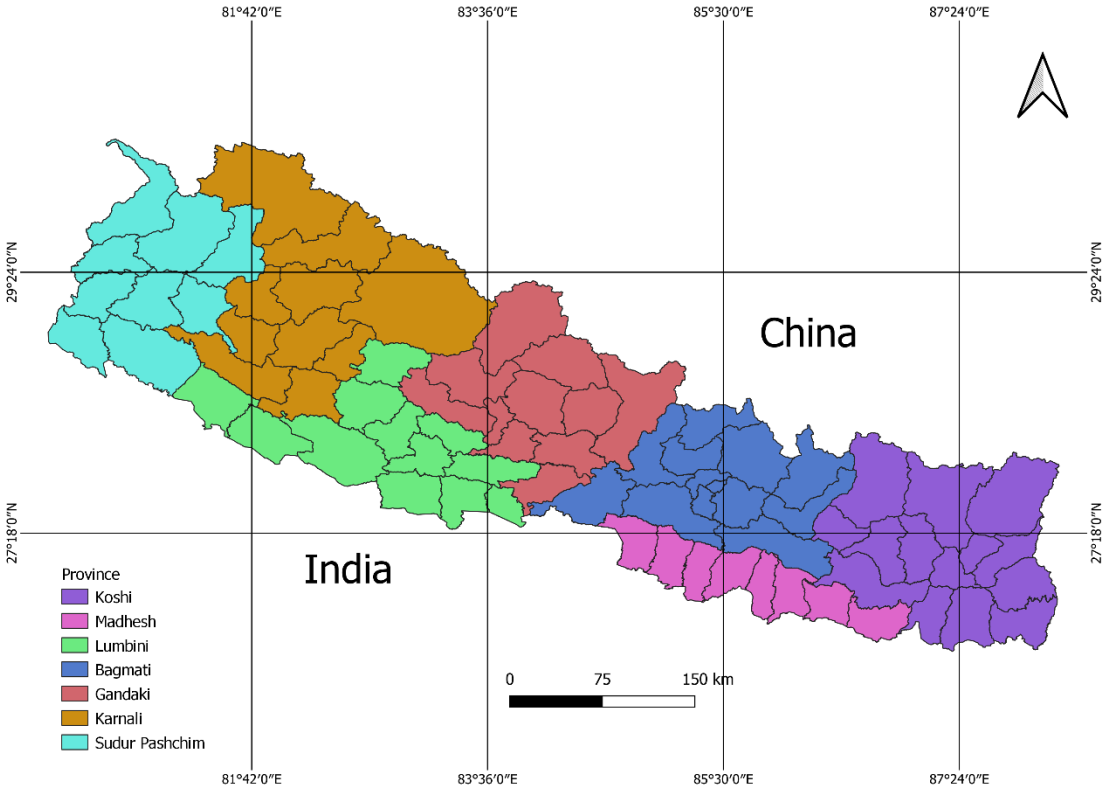
World Checklist of Selected Plant Families (WCSP 2022) has recorded 13 species of *Cymbidium* from Nepal.

3. MATERIALS AND METHODS

3.1 Study area

Nepal is a landlocked country that lies between 26˚12' to 30˚27' N and 80˚04' to 88˚12' E geographically in between China in North and India in South, West and East covering

the area of 1,47,516 km^2 with diverse physiography whose altitude ranges from 60 to 8848.86 m. It is located centrally in the Himalaya which is transitional zone for many floristic elements.



Map 1: Study area, Map of Nepal with provinces.

According to Takhtajan (1986), Nepal's complex biogeography is due to the result of its geological history and presence of crossroads of two biogeographic realms (the Palaearctic and Indomalaya realms) and two major phytogeographical kingdoms (the Holarctic and Paleotropic division in North and South).

Nepal is divided into 3 phytogeographic regions (Western, Central and Eastern) whereas it is broadly divided into 6 bioclimatic zones based on climate and climate and they are:

- Tropical zone (Below 1000 m)
- Sub-tropical zone (1000-2000 m)
- Temperate zone (2000-3000 m)
- Sub-alpine zone (3000-4000 m)

- Alpine zone (4000-5000 m)
- Nival zone (Above 5000 m)

3.2 Protologues and literature based character matrix

Protologue is a scientific publication where new species is described that helps in achieving nomenclature accuracy and also for knowing about the type specimen. The protologues for all the species were consulted using online library like Biodiversity Heritage Library (BHL), websites like TROPICOS. The original literatures, Floras or book, journal and articles were also consulted. The necessary protologues were translated into English using Stearn (1983).

After reviewing and translating the necessary protologues and consulting different literatures, a character matrix was prepared.

3.3 Selection of Characters

The morphological characters play vital role in identifying the species and its relation. After the clear and complete literature review, the characters to be studied are selected with the help of the prepared character matrix. The characters like pseudobulb, leaf, inflorescence, floral bracts, flower, sepals, petals, lip, column and stomata were selected for the taxonomic study.

3.4 Collection of fresh plant specimen

Firstly, the permission letter was taken and field visits were done according to the records of herbarium specimens to collect live specimens but only two species were collected. Its photograph was taken in its natural habitat, field notes were taken and illustration was made. The fresh specimen was then pressed and dried following the techniques provided by Rajbhandari & Rajbhandary (2015). Finally, well dried and complete specimen were mounted using standard method of herbarium by Bridson and Forman (1998). It was then deposited in ASCOL herbarium.

3.5 Study of herbarium specimens and Identification

The dried herbarium specimens were studied by visiting KATH and TUCH thoroughly through Radical Stereo-microscope of RSM-4 model. Similarly, specimens of Nepal available at international herbaria were also studied virtually. For international herbaria,

CAL, BM, K, E and TI were studied as far as possible. JSTOR and WFO were used for the type specimens and synonyms of the species. Harris and Harris (1994), Cullen (2006) and Chen *et al*. (2009) were used as reference for morphological description and botanical terminology.

The herbarium specimens were identified with the help of available literatures. The literatures used were Flora of British India (Hooker, 1890), The orchids of Sikkim Himalaya (King & Pantling, 1898), Orchids of Nepal Himalaya (Banerji & Pradhan, 1984), Orchid flora of North West Himalaya (Deva & Naithaini, 1986), Orchid flora of Arunachal Pradesh (Chowdhery, 2013), Flora of China (Lin, 2013) etc. Not only this but also the specimens were also confirmed by comparing the standard specimens that are deposited in different herbaria such as KATH, TUCH and different international herbaria such as Royal Botanic Garden, Kew, The Natural History Museum, etc.

3.6 Illustration

The free hand illustrations were made for all the species including habit sketch, detail structure of flower with proper scaling. The comparative illustration for the floral parts like floral bract, dorsal sepal, lateral sepal, petal and lip were also made.

3.7 Construction of identification keys

Based on the observed morphological characters and character states, the bracketed identification keys were prepared for easy identification.

3.8 Micro-morphological study

The micro-morphological variation on leaves was studied. For this the leaf anatomy and the variation in stomata was studied.

Leaf anatomy

For stomatal study, approximately 1 cm^2 of leaf tissue was removed from the section of the leaf and placed in test tube. Equal parts of glacial acetic acid and 5 ml of hydrogen peroxide was added in sufficient quantity to cover the material. The material was then heated for about 2 hours. After 2 hours, the epidermal layer was teased apart washed in water and stained by safranin and the slides were prepared.

3.9 Cladistic analysis

Cladistic analysis was performed based on the morphological characters to find the maximum similarity among the species under the study. The characters were chosen based upon their consistency traced during the study and performed with the help of Winclada version 09.99 (Kervin 1999-2000). Simpson (2010) was used for its terminology.

3.10 Distribution map

All the herbarium records from KATH, TUCH as well as from international herbaria (E, K, BM and TI) were listed and an excel sheet was prepared. Herbarium records include the collection date, place of collection, its altitude and its latitude and longitude along with remarks. By collecting all the places of collection, its latitude and longitude, distribution map was prepared using QGIS 3.16.

4. RESULTS

In this study, the morphological, micromorphological and phylogenetic relations of 10 species of *Cymbidium* present in Nepal were studied. The 10 species of *Cymbidium* that are present in Nepal are *C. aloifolium, C. crassifolium, C. cyperifolium, C. devonianum,*

C. elegans, *C. erythraeum*, *C. × gammieanum*, *C. hookerianum*, *C. iridioides* and *C. lancifolium*.

4.1 Morphological Study

Total 10 species of the genus *Cymbidium* were morphologically studied. *C. elegans* and *C. lancifolium* were studied thoroughly through live as well as herbarium specimens and the rest of the species were studied using herbarium specimens only. The overall characters studied were described in two major topics: vegetative structures and reproductive structures.

4.1.1 Vegetative structures

4.1.1.1 Habit and Habitat

Cymbidium Sw. is a genus which are usually autotrophic, terrestrial, epiphytic and lithophytic herbs varying in their plant size. Most of the species are epiphytic on the tree trunks covered by mosses with long, linear, fleshy, coriaceous leaves and can grow equally well in lithophytic conditions in the shades and damp places along the valleys or stream-sides and humus rich rocks and cliffs. Generally, the humid forests are suitable for the growth of the epiphytic orchids (Table 2).

4.1.1.2 Pseudobulbs

The long-lived, well developed pseudobulbs are present in all the species of *Cymbidium*. The pseudobulbs are often slightly flattened but may be reduced to a slight swelling of the base of the stem that are enclosed by the persistent leaf bases. Every year the new pseudobulbs are produced marking the sympodial growth habit of pseudobulbs.

The pseudobulbs are small, inconspicuous and cylindric *C. cyperifolium*, ovoid in *C. aloifolium*, *C. crassifolium*, *C. erythraeum*, *C. × gammieanum*, *C. iridioides* and *C. elegans*, elliptic-ovoid in *C. hookerianum* and fusiform, cylindric in the section *C. devonianum* and *C. lancifolium* (Table 2).

Table 2: Comparative study of plant height, pseudobulb, pseudobulb size, habit and host species in *Cymbidium* Sw.

S.N.	Botanical Name	Height (cm)	Pseudobulb	Pseudobulb size (cm)	Habit	Host species
1	*C. aloifolium*	20-50	Ovoid	3-7 × 1-4	Epiphytic	*Shorea robusta*
2	*C. crassifolium*	40-50	Ovoid	2.5-5 × 2-3	Epiphytic	*Quercus semecarpifolia*
3	*C. cyperifolium*	30-40	Cylindric	3 × 1.5	Terrestrial	
4	*C. devonianum*	20-40	Cylindric	2-4 × 1-2	Epiphytic	*Lyonia ovalifolia*
5	*C. elegans*	20-60	Ovoid	4-5 × 2-2.5	Epiphytic	*Quercus semecarpifolia* *Daphniphyllum himalense*
6	*C. erythraeum*	47-60	Ovoid	4-5 × 2.5-5	Epiphytic	*Daphniphyllum himalense* *Quercus semecarpifolia* *Rhododendron arboreum*
7	*C. × gammieanum*	30-40	Ovoid	3 × 2	Epiphytic	*Quercus semecarpifolia* *Daphniphyllum himalense*
8	*C. hookerianum*	45-55	Elliptic-ovoid	5 × 5	Epiphytic	*Quercus semecarpifolia*
9	*C. iridioides*	40-60	Ovoid	3-4 × 2.5	Epiphytic	*Quercus semecarpifolia* *Rhododendron arboreum*
10	*C. lancifolium*	14-25	Cylindric	3 × 2	Terrestrial	

4.1.1.3 Leaves

The leaves show a range of variation in their number, shapes, texture and apices. Its number varies from 2-11. Usually the leaves are sessile and petiolate in *C. devonianum* and *C. lancifolium*. The leaves are broad, elliptic in *C. devonianum* and lanceolate in *C. lancifolium* while in most of the other species, the leaves are long, thin and linear. The size of the leaf ranges from 8-70 × 0.4-3 cm. The leaf apex varies from acuminate, acute, unequally bilobed to obtuse. In the section Cymbidium, the leaf apex is obtuse and unequally bilobed. Leaves margin is entire in all the species (Table-3).

Table 3: Comparative study of leaves in *Cymbidium* Sw.

S.N.	Botanical Name	No. of leaves	Shape	Size (cm)	Apex
1	*C. aloifolium*	2-8	Linear	18-62 × 1-2.5	Obtuse and unequally bilobed
2	*C. crassifolium*	4-7	Linear	22-70 × 1-3	Obtuse
3	*C. cyperifolium*	6	Linear	42-65 × 0.4-0.5	Acute
4	*C. devonianum*	2-4	Elliptic	15-28 × 2.5-5	Obtuse to subacute
5	*C. elegans*	4-8	Linear	30-74 × 1-1.5	Acute and minutely bilobed
6	*C. erythraeum*	6-11	Linear	23-64 × 0.5-1.5	Acuminate
7	*C. × gammieanum*	10	Linear	28-36 × 1	Acuminate
8	*C. hookerianum*	5	Linear	32-48 × 2	Acute
9	*C. iridioides*	6	Linear	32-50 × 1-2	Acute
10	*C. lancifolium*	3	Lanceolate	8-15 × 2-3	Acute

4.1.2 Reproductive Structures

4.1.2.1 Inflorescence

The inflorescence in *Cymbidium* is unbranched and simple raceme which may be erect, arching or pendulous. One or two inflorescences are produced from the base of the pseudobulbs in all the species except *C. lancifolium* where the inflorescence arises from the middle of the pseudobulb.

4.1.2.2 Floral bracts

The floral bracts are present at the base of pedicel and ovary. They are usually persistent and scarious to membranous. The floral bracts are ovate in *C. aloifolium, C. devonianum, C. elegans, C.* × *gammieanum, C. hookerianum* and *C. iridioides,* triangular in *C. crassifolium* and *C. erythraeum* and lanceolate in *C. cyperifolium* and *C. lancifolium*. The size of the floral bracts ranges from 1-20 × 1-3 mm among the species. The apex of the floral bract is acute in most of the species except *C. cyperifolium* and *C. elegans* which have acuminate apex (Table 4) (Figure 1).

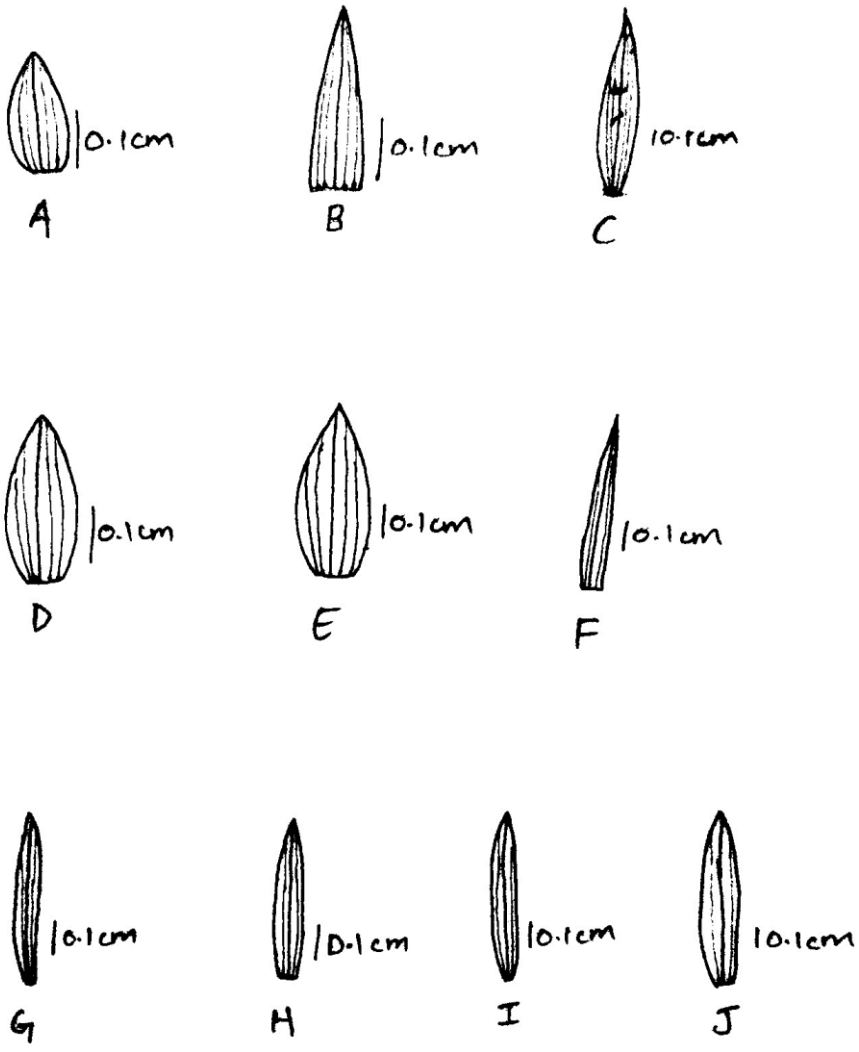


Figure 1: Floral bracts of *Cymbidium* species (A-J). A. *C. aloifolium*, B. *C. crassifolium*, C. *C. cyperifolium*, D. *C. devonianum*, E. *C. elegans*, F. *C. erythraeum*, G. *C.* × *gammieanum*, H. *C. hookerianum*, I. *C. iridioides*, J. *C. lancifolium*.

Table 4: Comparative study of floral bracts in *Cymbidium* Sw.

S.N.	Botanical Name	Shape	Size (mm)	Apex
1	*C. aloifolium*	Ovate	2-3 × 1-1.5	Acute
2	*C. crassifolium*	Triangular	1-3 × 1.-1.5	Acute
3	*C. cyperifolium*	Lanceolate	20 × 2	Acuminate
4	*C. devonianum*	Ovate	2-3 × 1.5-3	Acute
5	*C. elegans*	Ovate	4-5 × 1.5-2	Acuminate
6	*C. erythraeum*	Triangular	7 × 1.5	Acute
7	*C. × gammieanum*	Ovate	5 × 1.5	Acute
8	*C. hookerianum*	Ovate	3-5 × 1-1.5	Acute
9	*C. iridioides*	Ovate	4-6 × 1.5	Acute
10	*C. lancifolium*	Lanceolate	15 × 1-2	Acute

4.1.2.3 Flowers

The flowers show a great diversity in number, size and colour. The flowers are usually about 2-12 cm in diameter and the number varies from 3 in *C. cyperifolium* and *C. lancifolium* to 26 in *C. aloifolium* and *C. crassifolium*. The flowers may be fully blooming or semi-blooming. Each flower has an inferior ovary and short pedicel that are difficult to delimit from each other and is subtended by small scarious bract. The colour of the flowers varies greatly within *Cymbidium* from pale yellow, green, pale pink, red to brown, plain or tinged with streaks, blotches and spots of various hues.

4.1.2.4 Pedicel and Ovary

Pedicel and ovary are usually narrow, slender and glabrous in all the species of this genus. Its length ranges from 10-30 mm.

4.1.2.5 Sepals

The number of sepals present in the species is 3 in which the upper one is dorsal sepal (1) and the lower one is lateral sepals (2). Dorsal and lateral sepals are usually similar and sub-equal to each other. Their shape varies from oblong, linear-lanceolate, elliptic, obovate, oblanceolate and obovate-oblong. The oblong type is present in *C. aloifolium, C. crassifolium* and *C. hookerianum,* linear-lanceolate in *C. cyperifolium* and *C. × gammieanum,* elliptic in *C. devonianum,* obovate in *C. elegans,* obovate-oblong in *C. iridioides* and oblanceolate in *C. erythraeum* and *C. lancifolium*. The size of the dorsal

sepal ranges from 11-55 × 3-20 mm among the species. Lateral sepals are usually slightly oblique and their shape is similar to that of dorsal sepal (Table 5) (Figure 2 and Figure 3).

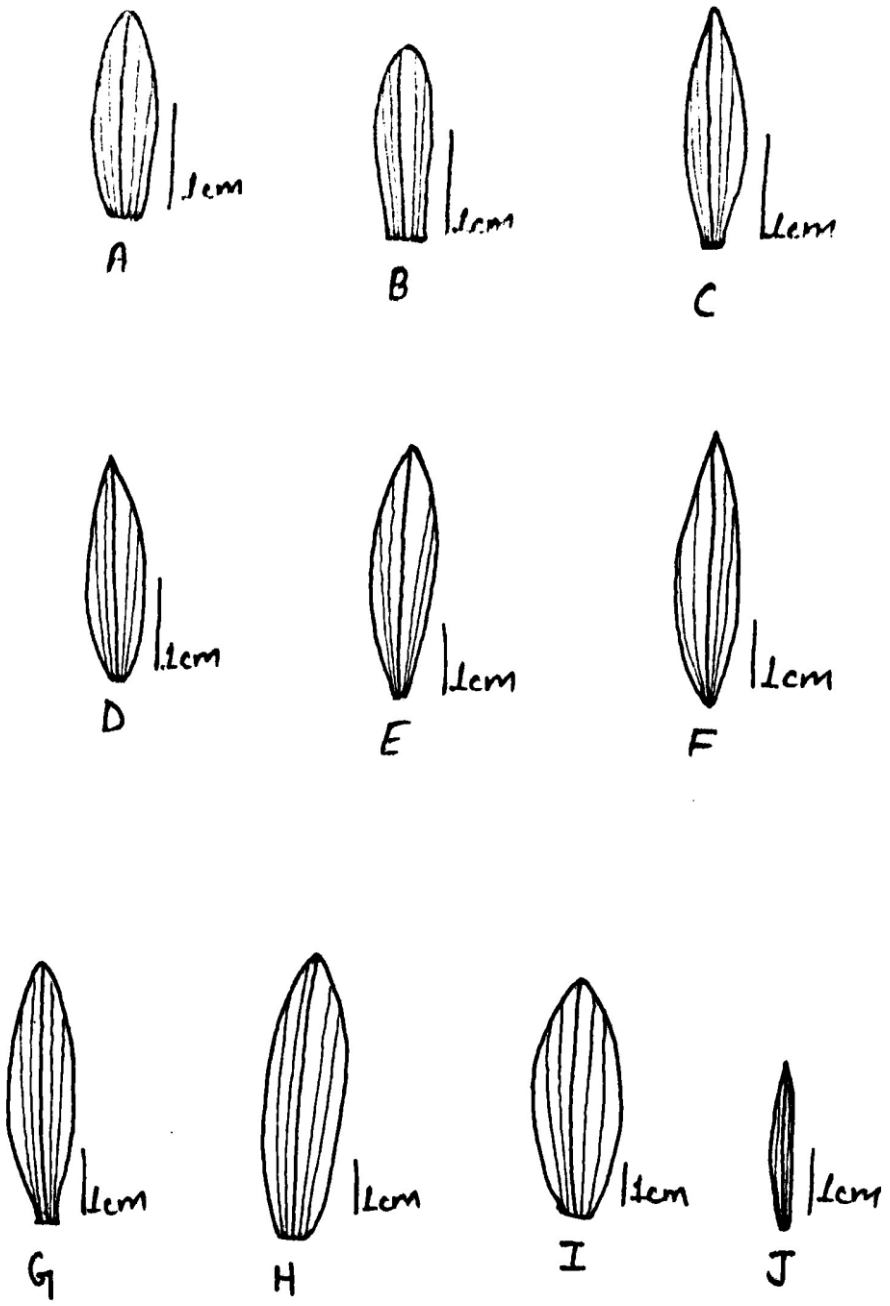


Figure 2: Dorsal sepals of *Cymbidium* species (A-J). A. *C. aloifolium,* B. *C. crassifolium*, C. *C. cyperifolium,* D. *C. devonianum,* E. *C. elegans*, F. *C. erythraeum,* G. *C.* × *gammieanum,* H. *C. hookerianum,* I. *C. iridioides,* J. *C. lancifolium*.

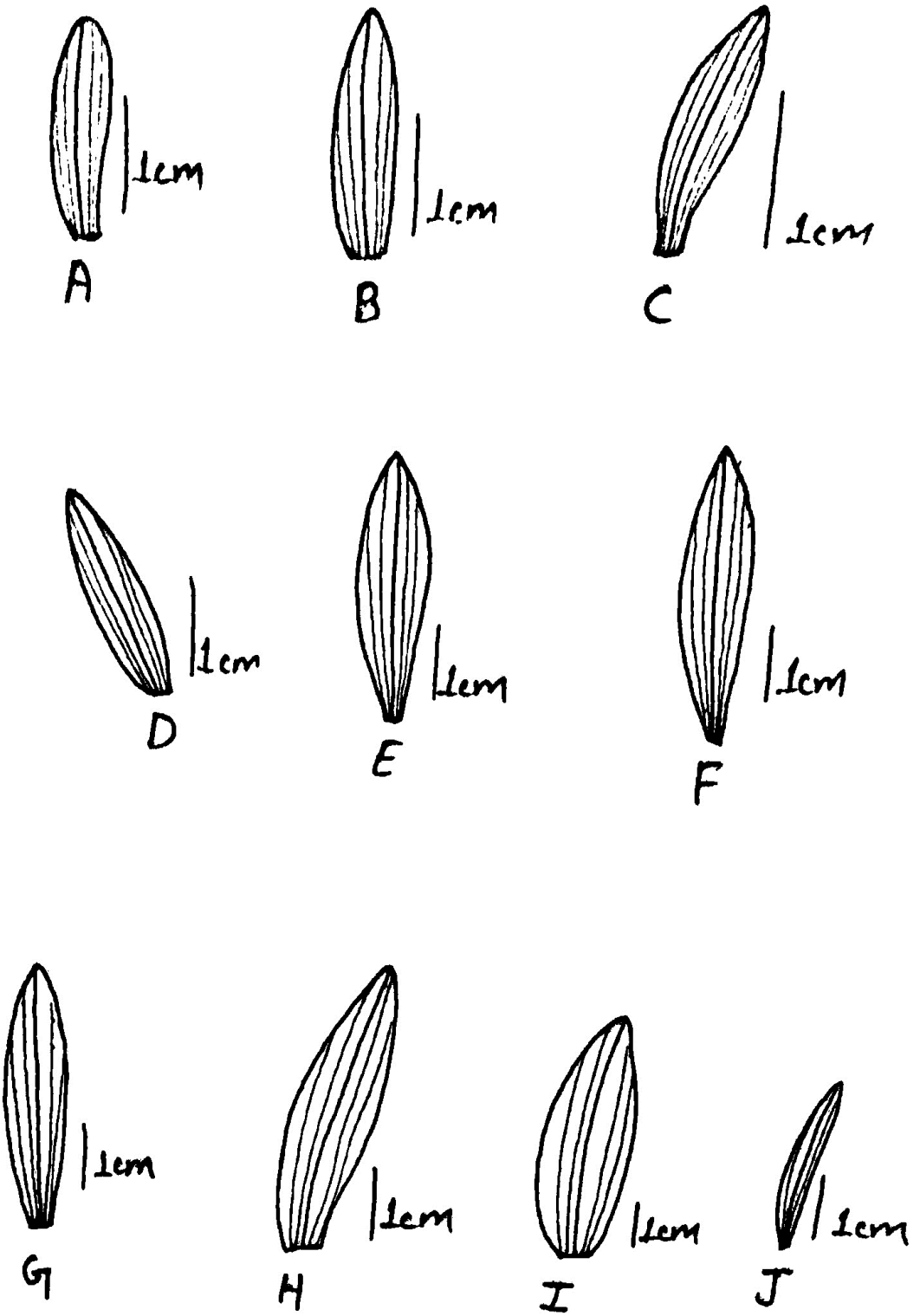


Figure 3: Lateral sepals of *Cymbidium* species (A-J). A. *C. aloifolium*, B. *C. crassifolium*, C. *C. cyperifolium*, D. *C. devonianum*, E. *C. elegans*, F. *C. erythraeum*, G. *C.* × *gammieanum*, H. *C. hookerianum*, I. *C. iridioides*, J. *C. lancifolium*.

4.1.2.6 Petals

The shape of the petal is more different than the sepals and they are usually smaller than sepals in most of the species. The shape of petals is elliptic, ovate, elliptic-lanceolate, oblanceolate and oblong. The elliptic petals are present in *C. aloifolium*, *C. crassifolium* and *C. lancifolium*, ovate in *C. cyperifolium*, elliptic-lanceolate in *C. devonianum*, oblanceolate in *C. elegans* and oblong in *C. erythraeum*, *C.* × *gammieanum*, *C. hookerianum* and *C. iridioides*. The size of the petal ranges from 12-55 × 3-12 mm among the species (Table 5) (Figure 4).

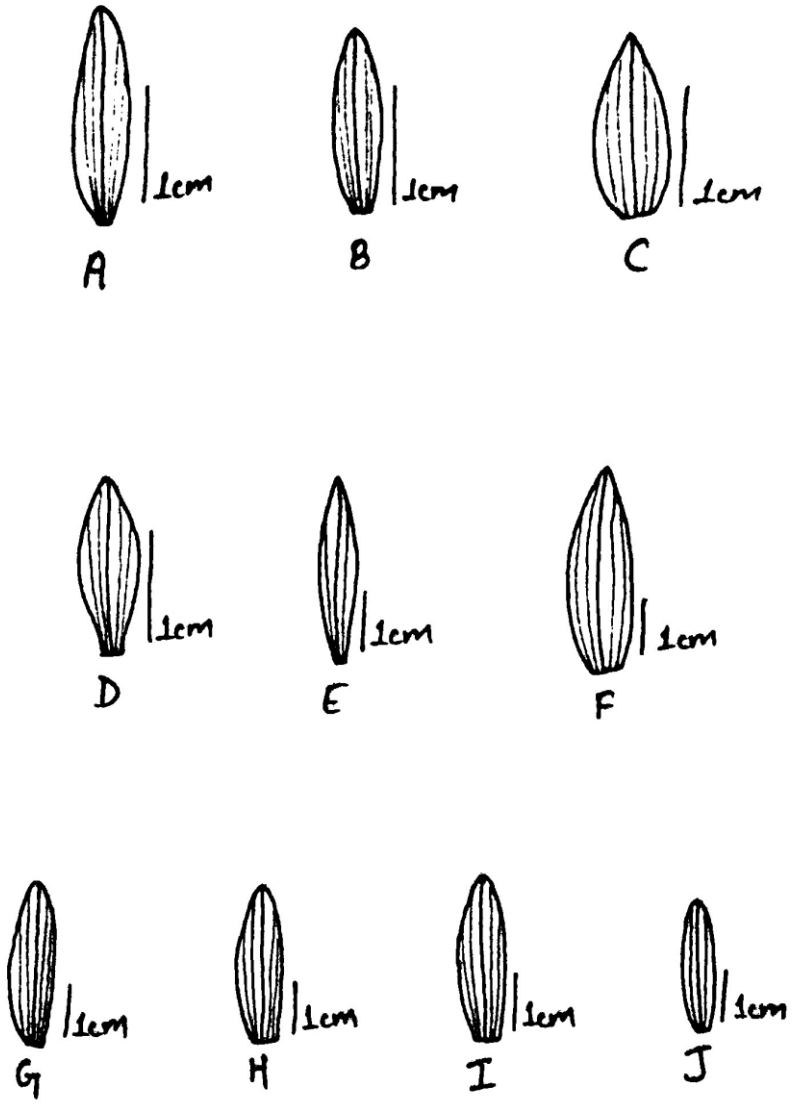


Figure 4: Petals of *Cymbidium* species (A-J). A. *C. aloifolium*, B. *C. crassifolium*, C. *C. cyperifolium*, D. *C. devonianum*, E. *C. elegans*, F. *C. erythraeum*, G. *C.* × *gammieanum*, H. *C. hookerianum*, I. *C. iridioides*, J. *C. lancifolium*.

Table 5: Comparative study of flower, pedicel and ovary, sepals and petals in *Cymbidium* Sw.

S.N.	Botanical Name	Flower	Pedicel and Ovary (mm)	Dorsal sepal shape and size	Lateral sepals shape and size	Petals shape and size
1	*C. aloifolium*	Yellowish	10-15	Oblong (16-20 × 3 mm)	Oblong (17-20 × 3 mm)	Elliptic (18 × 4 mm)
2	*C. crassifolium*	Yellowish	10	Oblong (16× 3 mm)	Oblong (15× 3 mm)	Elliptic (15 × 3 mm)
3	*C. cyperifolium*	Yellowish green	20-30	Linear-lanceolate (22× 4 mm)	Linear-lanceolate (25× 4 mm)	Ovate (15 × 5 mm)
4	*C. devonianum*	Yellowish green	15	Elliptic (20-22 × 5 mm)	Elliptic (22-25 × 5 mm)	Elliptic-lanceolate (15-20 × 5 mm)
5	*C. elegans*	Yellowish	15-20	Obovate (34-36 × 6 mm)	Obovate (35-40 × 8 mm)	Oblanceolate (32 × 3 mm)
6	*C. erythraeum*	Greenish	20-30	Oblanceolate (11-37 × 7-12 mm)	Oblanceolate (11-37 × 7-12 mm)	Oblong (36-44 × 5-8 mm)
7	*C.* × *gammieanum*	Yellowish	15	Linear-lanceolate (40 × 10 mm)	Linear-lanceolate (30 × 5 mm)	Oblong (28 × 5 mm)
8	*C. hookerianum*	Greenish	25	Oblong (50 × 20 mm)	Oblong (55 × 17 mm)	Oblong (50 × 12 mm)
9	*C. iridioides*	Yellowish green	25-40	Obovate-oblong (55 × 20 mm)	Obovate-oblong (60 × 17 mm)	Oblong (55 × 12 mm)
10	*C. lancifolium*	Greenish	25	Oblanceolate (22-25 × 2 mm)	Oblanceolate (22 × 2 mm)	Elliptic (23 × 5 mm)

4.1.2.7 Lip

The lip or labellum, which is a modified petal is the most attractive and significant part of the flower. Its shape, size, margins, colouration and ornamentation varies considerably and offer diagnostic feature for taxonomic recognition. The three-lobed lip is weakly saccate at the base in *C. aloifolium*. The lip is usually three-lobed and weakly three-lobed in *C. devonianum*. The lip is adnate to the column at its base in *C.*

aloifolium, *C. crassifolium*, *C. cyperifolium*, *C. devonianum*, *C.* × *gammieanum* and *C. lancifolium*. The lip is fused at the base to the base of the column for about 2-5 mm in *C. elegans*, *C. erythraeum*, *C. hookerianum* and *C. iridioides* (Table 6) (Figure 5).

4.1.2.8 Column

The size of the column varies from 10-40 mm in all the species of this genus. The smallest column is found in *C. crassifolium* which is 10 mm whereas the largest column is found in *C. hookerianum* which is 40 mm and the rest of the species has the column that ranges from 12-35 mm. The columns are usually long, slender, curved, narrowly winged and rarely pubescent (Table 6).

Table 6: Comparative study of lip and column in *Cymbidium* Sw.

S.N.	Botanical Names	Lip lobe	Lip shape and size	Callus in disk	Column (mm)
1	*C. aloifolium*	Lobed	Oblong (14 × 8 mm)	2	10-12
2	*C. crassifolium*	Lobed	Subovate (12 × 8 mm)	2	10
3	*C. cyperifolium*	Lobed	Oblong (17× 12 mm)	2	14
4	*C. devonianum*	Unlobed	Obcordate (14 × 10 mm)	2	12
5	*C. elegans*	Lobed	Oblanceolate-triangular (34 × 13 mm)	2	30
6	*C. erythraeum*	Lobed	Elliptic-ovate (20 × 16 mm)	2	30
7	*C.* × *gammieanum*	Lobed	Oblong (32 × 15 mm)	2	35
8	*C. hookerianum*	Lobed	Elliptic (40 × 32 mm)	2	40
9	*C. iridioides*	Lobed	Elliptic (45 × 20 mm)	2	35
10	*C. lancifolium*	Lobed	Ovate-oblong (18 × 9 mm)	2	15

4.1.2.9 Pollinia

The pollinia are usually 2 and deeply cleft and 4 in 2 unequal pairs in the section Maxillarianthe and Geocymbidium.

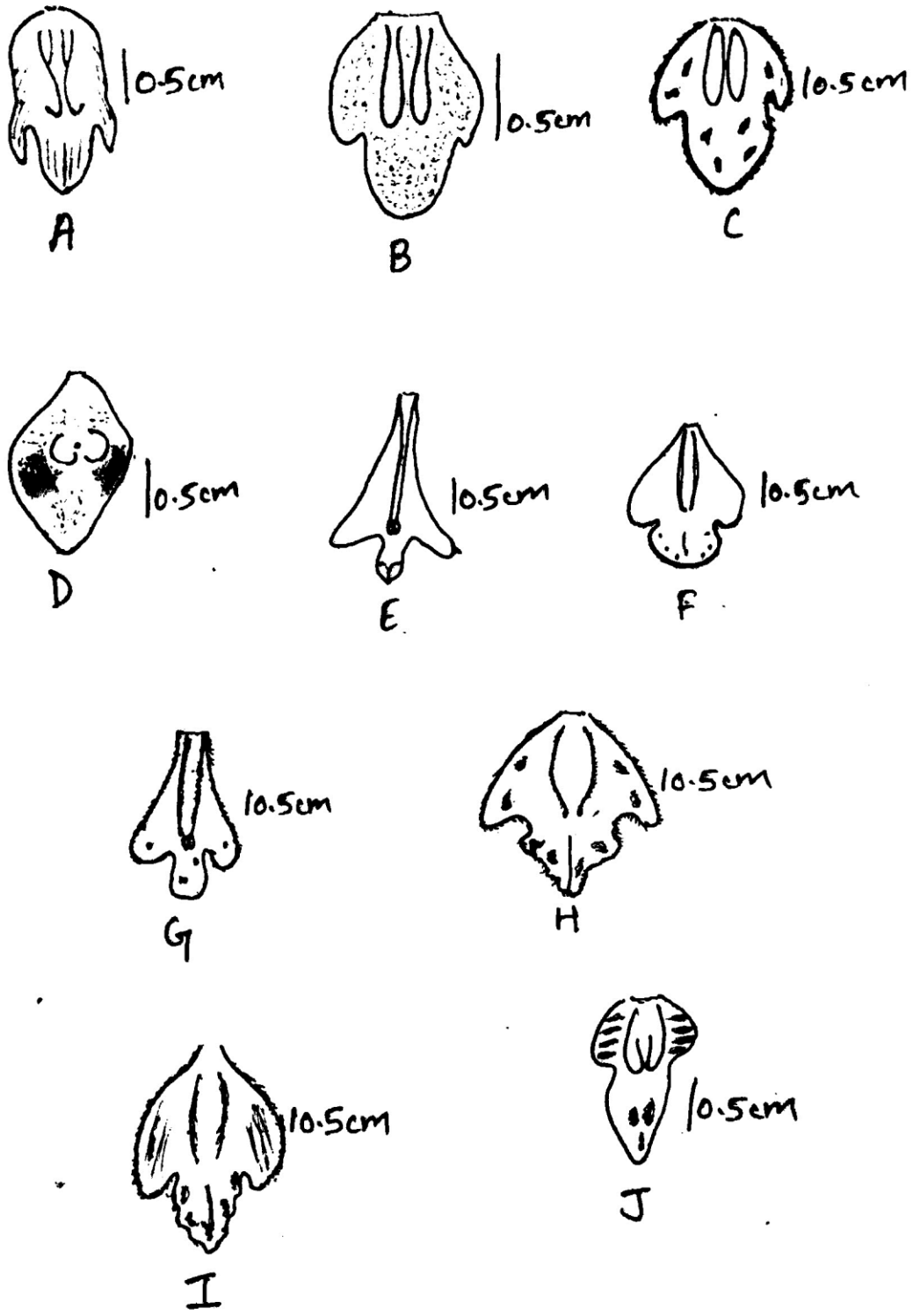


Figure 5: Lip of *Cymbidium* species (A-J). A. *C. aloifolium*, B. *C. crassifolium*, C. *C. cyperifolium*, D. *C. devonianum*, E. *C. elegans*, F. *C. erythraeum*, G. *C.* × *gammieanum*, H. *C. hookerianum*, I. *C. iridioides*, J. *C. lancifolium*.

4.2 Taxonomic treatment

4.2.1 *Cymbidium* Sw., *Nov. Act. Reg. Soc. Sci. Upsal.* 6: 70 (1799).

Jensoa Raf., *Fl. Tellur.* 4: 38 (1836).

Cyperorchis Bl., *Rumphia.* 4: 47 (1848); *Mus. Bot. Lugd.* 1: 48 (1849); *Orchid. Arch. Ind.* 1: 92 (1858).

Iridorchis Bl., *Orchid. Arch. Ind.* 1: 91 t.26 (1858).

Type Specimen: *Epidendrum aloifolium* L. (= *Cymbidium aloifolium* (L.) Sw.).

Plant terrestrial, epiphytic or lithophytic, usually autotrophic. Rhizome rarely present, subterranean, fleshy, branched. Pseudobulb small to elongate, ovoid, ellipsoid, fusiform, rarely absent, often bilaterally compressed, enclosed in leaf bases. Leaves few to many, distichous, usually linear, oblong, elliptic, rarely lanceolate, acute to strongly bilobed at the apex, often articulate towards base. Inflorescence simple raceme, lax or dense, usually arising from base of pseudobulb or rarely from axils of leaves, erect, arching or pendulous; rachis many flowered; peduncle sheathed; floral bract persistent. Flowers large or medium sized, variedly coloured. Sepals and petals free, sub-similar, spreading or erect, or with petals porrect and covering the column; lip usually 3-lobed or unlobed, free or adnate to the base of column; lateral lobes erect, often clasping the column; mid-lobe often recurved; callus usually with 2, rarely 3 glabrous or pubescent ridges. Column long; pollinia 2 and deeply cleft or 4 and in 2 unequal pairs, triangular, ovoid, attached by short caudicle to a broad viscidium.

Distribution: NW Himalaya to Japan and South through Indo-China and Malaysia to the Philippines, New Guinea and Australia.

About 85 species in the world; 10 species in Nepal.

4.2.2 Synopsis of the classification of the genus *Cymbidium* Sw.

Order : Asparagales

Family : Orchidaceae

Subfamily : Epidendroideae

Tribe : Cymbidieae

Genus : *Cymbidium* Sw.

Section I. **Cymbidium**

1. *C. aloifolium* (L.) Sw.

2. *C. crassifolium* Herb.

Section II. **Maxillarianthe** Schltr.

3. *C. cyperifolium* Lindl.

Section III. **Bigibbarium** Schltr.

4. *C. devonianum* Paxton

Section IV. **Cyperorchis** P. F. Hunt

5. *C. elegans* Lindl.

Section V. **Iridorchis** (Bl.) P. F. Hunt

6. *C. erythraeum* Lindl.

7. *C. hookerianum* Reichb.

8. *C. iridioides* D. Don.

Section VI. **Geocymbidium** Schltr.

9. *C. lancifolium* Hook.

Natural Hybrid

10. *C.* × *gammieanum* King & Pantl.

4.2.3 Keys to the sections of the genus *Cymbidium* Sw.

1a. Lip unlobed …… **III Biggibarium**

b. Lip 3-lobed……..……..... 2

2a. Leaves leathery ……..…... **I Cymbidium**

b. Leaves papery ……... 3

3a. Pseudobulb cylindric, not flattened ……..……. 4

b. Pseudobulb ovoid or ellipsoid, bilaterally flattened ……. 5

4a. Sepals linear-lanceolate; petals ovate; lip oblong ……. **II Maxillarianthe**

b. Sepals oblanceolate; petals elliptic; lip ovate-oblong ……..... **VI Geocymbidium**

5a. Flowers greenish or yellowish green with reddish brown spots …….. **IV Iridorchis**

b. Flowers white or pale yellow tinged pink ……. **V Cyperorchis**

4.2.4 Key to the species of genus *Cymbidium* Sw.

1a. Lip unlobed ……...…… **4. *C. devonianum***

b. Lip 3-lobed ……..……..... 2

2a. Leaves leathery ……..…...……...…. 3

b. Leaves papery ……..……. 4

3a. Lip with maroon longitudinal stripes on mid-lobe, lateral lobe of lip acute …… ……...…….... **1. *C. aloifolium***

b. Lip with central maroon to purple brown longitudinal stripes, lateral lobe of lip obtuse ……...…… **2. *C. crassifolium***

4a. Pseudobulb cylindric, not flattened ……..……...……...5

b. Pseudobulb ovoid or ellipsoid, bilaterally flattened ……. 6

5a. Sepals linear-lanceolate; petals ovate; lip oblong ……. **3. *C. cyperifolium***

b. Sepals oblanceolate; petals elliptic; lip ovate-oblong …….... **9. *C. lancifolium***

6a. Flowers greenish or yellowish green with reddish brown spots and stripes … 7

b. Flowers white or pale yellow tinged pink ……...…. 9

7a. Flowers less than 5cm across, dorsal sepal less than 12mm wide …… ……...…….…..... **6. *C. erythraeum***

b. Flowers more than 5cm across, dorsal sepal more than 12mm wide …...…… 8

8a. Sepals and petals clear green; mid-lobe of the lip longer than the lateral lobes …….…….…… **7. *C. hookerianum***

b. Sepals and petals yellowish green with red-brown stripes; mid-lobe of the lip shorter than lateral lobes …… **8. *C. iridioides***

9a. Flower yellowish, creamy yellow lip with red purplish spots ….... **5. *C. elegans***

b. Flower dirty yellow, flushed with brown lines, lip yellow …… **10. *C.* × *gammieanum***

4.2.5 Description of the species

Section I. Cymbidium

The species in this section are distinguished by their thick, coriaceous leaves with obtuse to emarginated bilobed apices, and pendulous scapes with well-spaced flowers. The flowers are cream or pale yellow with red brown markings.

Key to the species in section Cymbidium

1a. Lip with maroon longitudinal stripes on mid-lobe, lateral lobe of lip acute ……... **1. *C. aloifolium***

b. Lip with central maroon to purple brown longitudinal stripes, lateral lobe of lip obtuse ……... **2. *C. crassifolium***

1. *Cymbidium aloifolium* (L.) Sw., *Nova Acta Regiae Soc. Sci. Upsal.* 6: 73 (1799); Roxb. *Fl. India.* 3: 458 (1832); Lindl., *Gen. Sp. Orchid. Pl.* 3: 165 (1833); Reichb., F. in *Walp. Ann*. 6: 624 (1861); Hook. f., *Fl. Brit. Ind.* 6: 10 (1890); King & Pantl. in *Ann. Roy. Bot. Gard. Cal.* 8: 189, t. 252 (1898); Duthie, in *Ann. Roy. Bot. Gard. Cal.* 9: 136 (1906); Hara *et al., Enum. Fl. Pl. Nep.* 1: 37 (1978); Press *et al. Ann. Ch. Fl. Pl.*

Nep.:212 (2000); Pearce & Cribb *Fl. Bhutan.* 3: 257 (2002); Chen *et al. Fl. China.* 25: 260-280 (2009); Rajbhandari & Dahal in Rajbhandari & Baral, *Cat. Nep. Fl. Pl.* 1: 51 (2010) (Plate 38); Shrestha *et al. Pl. Nep.*:85 (2022).

Epidendrum aloifolium L., *Sp. Pl.* 2: 953 (1753).

Cymbidium pendulum (Roxb.) Sw., *Nova Acta Regiae Soc. Sci. Upsal.* 6: 73 (1799).

Cymbidium simulans Rolfe, *Orchid Rev.* 25: 175 (1917).

Type Specimen: Phillippines, *Cuming s.n.* (Holotype, K).

Plant 20-50 cm, epiphytic, autotrophic. Pseudobulb ovoid, bilaterally flattened, enclosed in leaf bases, 3-7 × 1-4 cm. Leaves 2-8, 18-62 × 1-2.5 cm, sessile, leathery, linear, entire, obtuse to emarginated and unequally bilobed at the apex, arching, articulate 10-14cm from base. Inflorescence 20-100 cm long, arising from base of the pseudobulb, pendulous; rachis 20-26 flowered; peduncle with 3-6 sheaths; floral bract 2-3 × 1-1.5 mm, ovate, acute, much shorter than the stalked ovary. Flower 3 cm across; pedicel and ovary 10-15 mm; sepals and petals pale yellow with broad, central, brownish purple stripes; lip white-cream, maroon veined on lateral lobe and longitudinal in mid lobe. Dorsal sepal 16-20 × 3 mm, oblong, obtuse; lateral sepals 17-20 × 3 mm, similar, oblique, spreading. Petals 18 × 4 mm, elliptic, obtuse to acute. Lip 14 × 8 mm when spread, 3-lobed, oblong, adnate at the base of the column, slightly saccate base; lateral lobes ovate-lanceolate, 3 × 1 mm, glabrous margin, acute; mid-lobe ovate, 5 × 6 mm, glabrous margin, obtuse; disk with 2 hairy calli. Column 10-12 mm long, arching, winged at apex; pollinia 2, triangular.

Distribution: Nepal, W Himalaya, E Himalaya, Assam-Burma, S Asia and SE Asia.

Altitudinal Range: 1500-2400 m.

Ecology: On trees in forests and thickets.

Flowering time: April – May.

Note: This species has been first described as *Epidendrum aloifolium* by Linnaeus in his *Species Plantarum*. Roxburgh described *Epidendrum pendulum* in his *Plants of the Coast of Coromandel* in 1795 that now serve as the type. Later it was transferred to the genus *Cymbidium* by Swartz. Lindley (1833) considered it as the distinct species from *C. aloifolium* and *C. bicolor* but J. D. Hooker (1890), considered them conspecific and

treated *E. pendulum* under the synonym of *C. aloifolium*. *C. aloifolium* is closely allied to *C. bicolor* but it can be distinguished by its vegetative and floral characters. In *C. aloifolium* leaves are usually 4-5 per pseudobulbs, apex emarginated, flowers are yellow with broad central purple strip and the callus is strongly sigmoid and usually broken whereas in *C. bicolor* leaves are usually 5-7 per pseudobulbs with obtuse apex, flowers maroon brown with yellow cream margin and the callus is weakly sigmoid and almost straight.

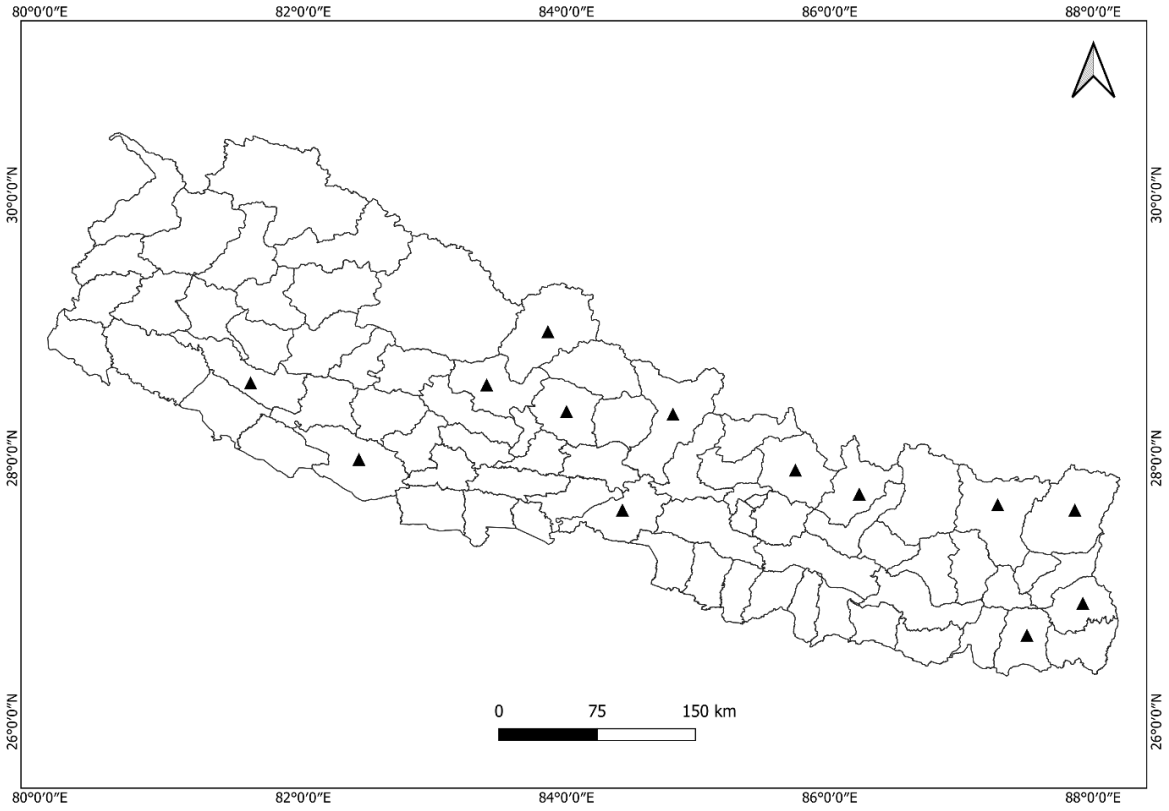
Specimen Examined:

Western Nepal: *Karnali Province*: **Surkhet**, Ghatte khola, 500m, 29/06/1979, K. R. Rajbhandari & B. Roy 2667 (KATH 002380!, KATH002381!, KATH002382!); Solighopte, 700m, 21/02/1991, N. P. Manandhar & N. Acharya 127-91 (KATH!). *Lumbini Province*, **Dang**, Garhwa, 250m, 28/08/1982, N. P. Manandhar & N. K. Bhattarai 8504 (KATH!).

Central Nepal: *Bagmati Province*, **Chitwan**, Sauraha, 160m, 18/01/1996, M. Mikage *et al.* 9614157 (KATH026404!); 27-34˚E 84-30˚N, 18/01/1996, M. Mikage *et al*. 9614157 (TI); **Dolakha**, Near Torikhet, Tambakosi Valley, 950m, 13/07/1977, K. R. Rajbhandari & B. Roy 1257 (KATH002386!, KATH002387!, KATH002388!); **Sindhupalchok**, Bhansar-Bahrabise, 500-630m, 03/07/1973, D. P. Joshi & B. Roy 1257 (KATH!). *Gandaki Province*, **Gorkha**, Maukauna, 580m, 04/06/1973, Shakya & Bhattacharya 2494 (KATH!); Arughat, 580m, 11/06/1983, P. R. Shakya *et al.* 7809 (KATH002383!, KATH002384!, KATH002385!); **Kaski**, Panchase, 1200m, 27/06/2018, P. Bhandari P1637 (KATH038025!); **Mustang**, Narayangar, 190m, 10/09/1988, M. Suzuki, T. Maeda, N. Naruhashi, R. Watanabe, M. N. Subedi, M. Minaki, S. Noshiro & H. Ikeda 8830892 (KATH!); **Myagdi**, Ranabang, 1000m, 27/05/1992, N. P. Manandhar & S. K. Acharya 407-92 (KATH!).

Eastern Nepal: *Koshi Province*, **Ilam**, Near Godak, 2900ft, 09/06/1978, P. Pradhan & R. Niraula 489 (KATH002392!); 26-53˚E 87-57˚N, 08/12/1963, H. Hara *et al*. 10002501 (TI); 26-50˚E 87-57˚N, 09/12/1963, H. Hara *et al*. 10002503 (TI); **Morang**, Raja-Rani, 570m, 04/06/1974, P. Pradhan et al. 32/74 (KATH!); Kanepokhari, 260m, 03/06/1974, P. Pradhan et al. 4/74 (KATH!); **Sankhuwasabha**, Tumlingtar, 470m, 05/07/1988, M. Suzuki *et al.* 8820169 (KATH026339!); 04/06/1981, J. Stainton 8324 (E00296618); 27-16˚E 87-13˚N, 05/07/1988, M. Suzuki *et al*. 8820169 (TI); Mane

Bhanzyang, 840m, 06/06/1994, P. R. Shakya & K. K. Dangol 10002 (KATH!); Below Khandbari, 750m, 09/06/1977, P. R. Shakya 4596 (KATH002389!, KATH002390!, KATH002391!); **Taplejung**, 27-22˚E 87-53˚N, 24/11/1963, H. Hara *et al*. 10002502 (TI).



Map 2: Distribution of *C. aloifolium* (L.) Sw. in Nepal.

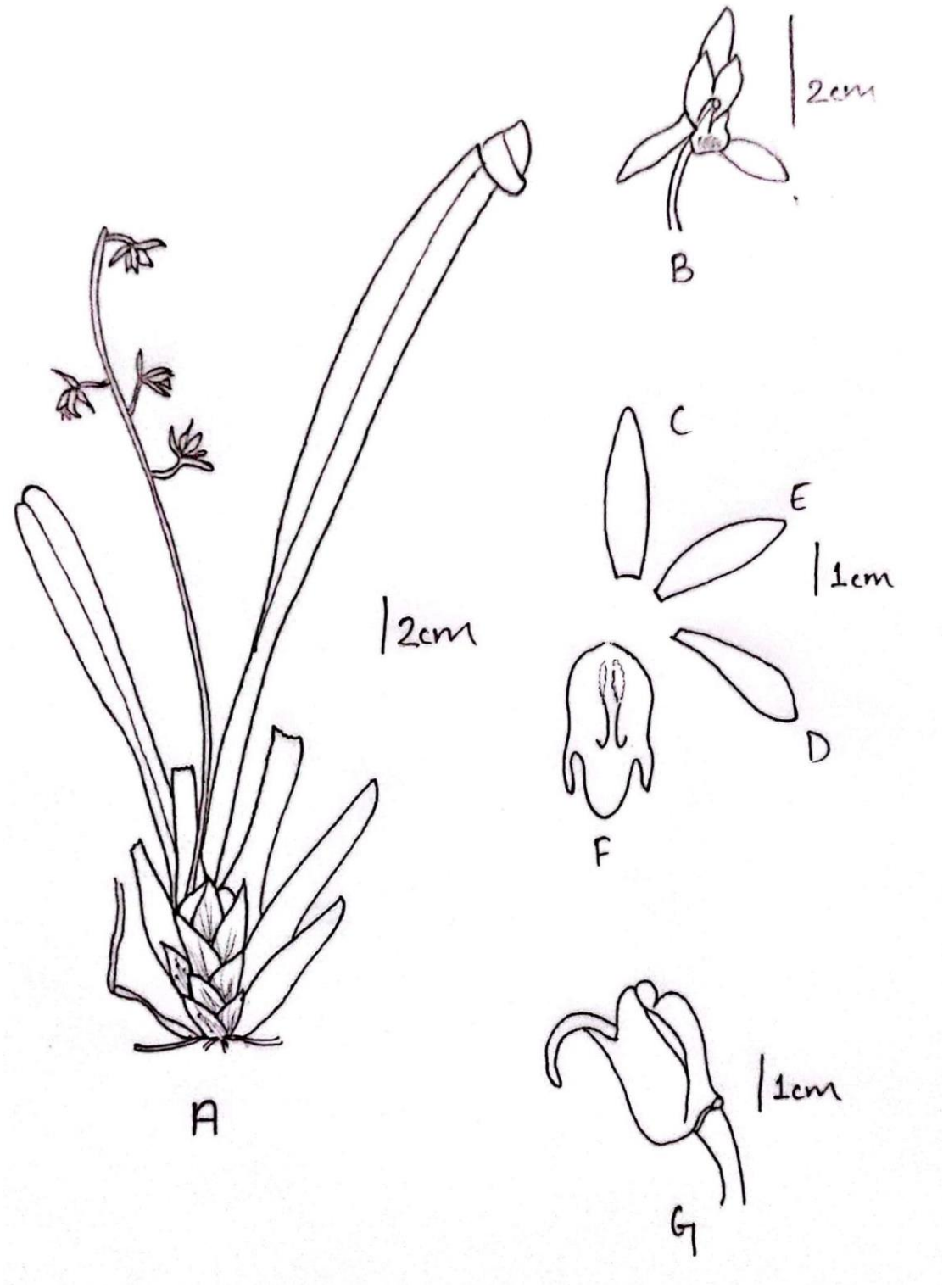


Figure 6: *Cymbidium aloifolium* (L.) Sw. A. Habit sketch. B. Single flower. C. Dorsal sepal. D. Lateral sepal. E. Petal. F. Lip. G. Lip and column (P. R. Shakya 4596, KATH002390).

2. *Cymbidium crassifolium* Herb., *Proc. Hort. Soc. London.* 1838: 42 (1838); Lindl., *Gen. Sp. Orchid. Pl.* 3: 165 (1833); Hook. f., *Fl. Brit. Ind.* 6: 10 (1890); Hara *et al., Enum. Fl. Pl. Nep.* 1: 37 (1978); Press *et al. Ann. Ch. Fl. Pl. Nep.*:212 (2000); Pearce & Cribb *Fl. Bhutan.* 3: 257 (2002); Chen *et al. Fl. China.* 25: 260-280 (2009); Rajbhandari & Dahal in Rajbhandari & Baral, *Cat. Nep. Fl. Pl.* 1: 51 (2010) (Plate 38); Shrestha *et al. Pl. Nep.*:86 (2022).

Cymbidium bicolor Lindl. subsp. *obtusum* Du Puy & Cribb., *Gen. Cymbidium* 70 (1988).

Cymbidium mannii Rchb. F., *Flora* 55: 274 (1872).

Type Specimen: Thailand, Uttaradit, *Menzies & Du Puy* 120 (Holotype, K).

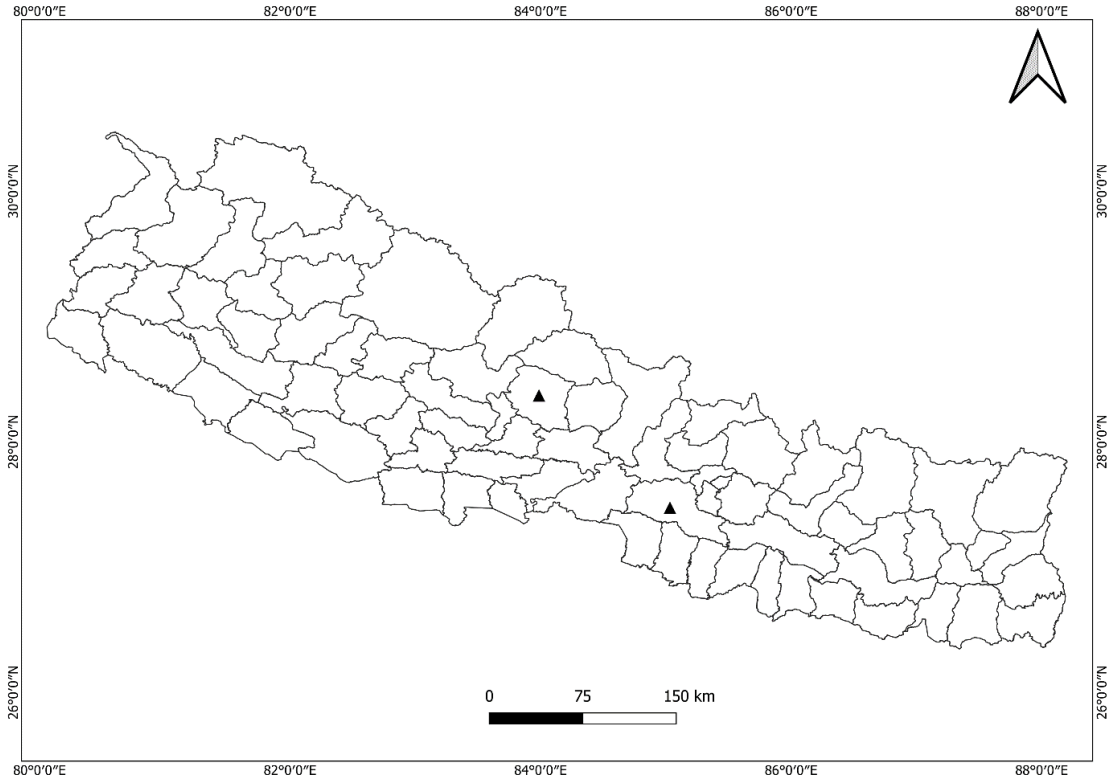
Plant 40-50 cm, epiphytic, autotrophic. Pseudobulb ovoid, bilaterally flattened, enclosed in leaf bases, 2.5-5 × 2-3 cm. Leaves 4-7, 22-70 × 1-3 cm, leathery, linear, obtuse. Inflorescence 17-28 cm long, arising from within the sheaths at base of the pseudobulb, pendulous; rachis 10-26 flowered; peduncle with 2-4 sheaths; floral bract 1-3 × 1-1.5 mm, triangular. Flowers 3-4 cm across; pedicel and ovary 10 mm; sepals and petals pale yellow-cream with central maroon-brown stripes; lip white-cream mottled with maroon to purple-brown except at base and margins. Dorsal sepal 16× 3 mm, oblong, obtuse; lateral sepals 15 × 3 mm, similar. Petals 15 × 2 mm, elliptic, obtuse. Lip 12× 8 mm, 3-lobed, subovate, saccate at base; lateral lobes ovate, 1 × 1 mm, glabrous margin, obtuse; mid-lobe ovate, 5 × 5 mm, recurved, glabrous margin; callus 2-ridged, minutely papillose-pubescent. Column 10 mm long, curved, winged at apex; pollinia 2.

Distribution: Nepal, W Himalaya, E Himalaya, Assam-Burma, S Asia, E Asia and SE Asia.

Altitudinal Range: 800-1900 m.

Ecology: Trees in forests and thickets.

Flowering time: March-April.



Map 3: Distribution of *C. crassifolium* Herb. in Nepal.

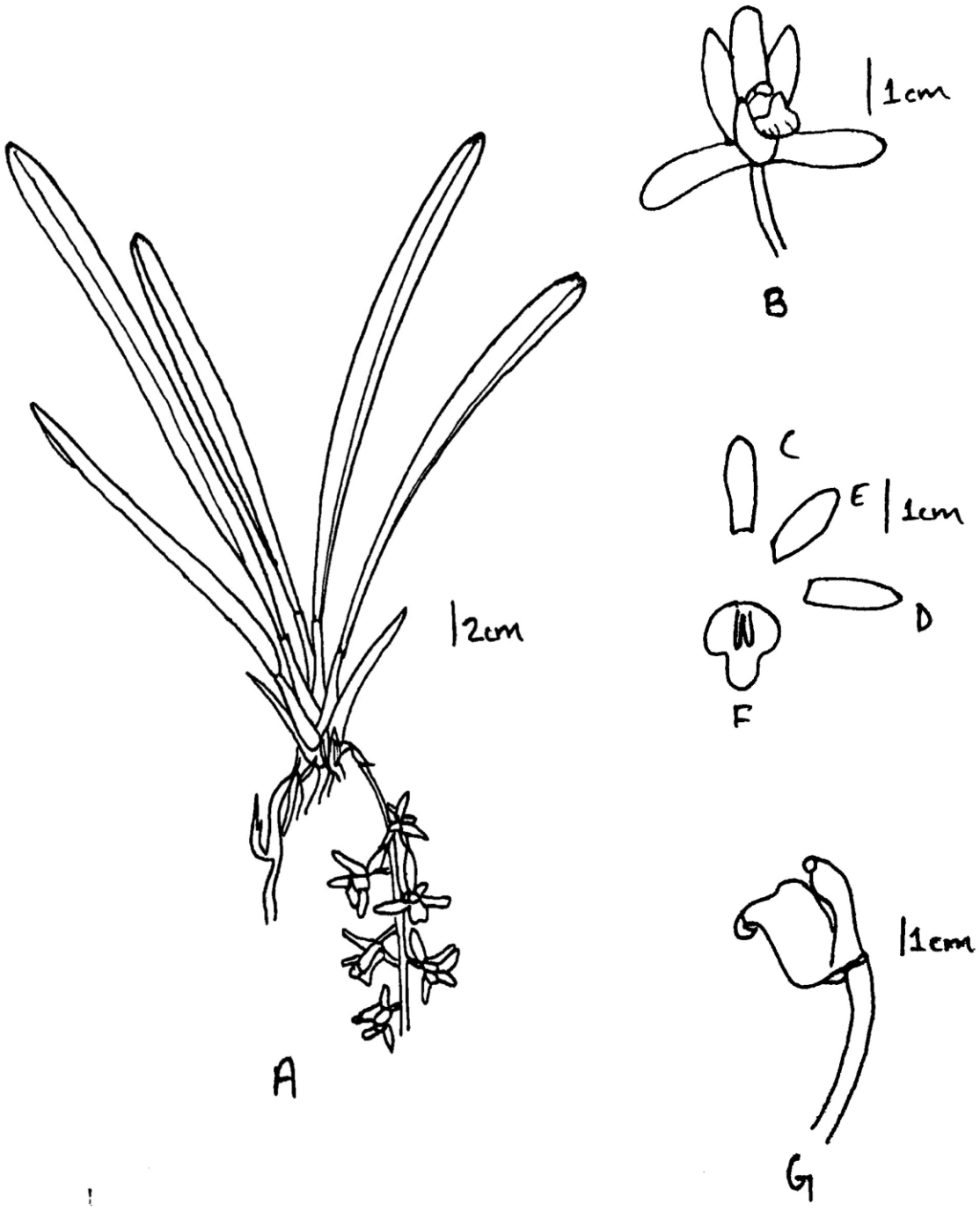


Figure 7: *Cymbidium crassifolium* Herb. A. Habit sketch. B. Single flower. C. Dorsal sepal. D. Lateral sepal. E. Petal. F. Lip. G. Lip and column (Illustration without collecting live specimen).

Section II. Maxillarianthe Schltr. in *Feddes Repert. Spec. Nov. Reg. Veg.* 20: 101 (1924).

The species in this section is characterized by having about 6-13 leaves on each shoot with fragrant flower.

3. *Cymbidium cyperifolium* Wall. ex Lindl., *Gen. Sp. Orchid. Pl.* 163 (1833); Hook. f. *Fl. Brit. Ind.* 6: 13 (1890); King & Pantl., in *Ann. Roy. Bot. Gard. Cal.* 8: 186, t. 248 (1898); Hara *et al., Enum. Fl. Pl. Nep.* 1: 37 (1978); Press *et al. Ann. Ch. Fl. Pl. Nep.*:212 (2000); Pearce & Cribb *Fl. Bhutan.* 3: 257 (2002); Chen *et al. Fl. China.* 25: 260-280 (2009); Rajbhandari & Dahal in Rajbhandari & Baral, *Cat. Nep. Fl. Pl.* 1: 51 (2010); Shrestha *et al. Pl. Nep.*:85 (2022).

Limodorum longifolium Roxb., *Fl. Ind.* 3: 468 (1832).

Type Specimens: Bangladesh, Sylhet, *De Silva F. & Bruce, H.* 7353 (Holotype, K-LINDL, Isotype, K-W, K).

Plant 30-40 cm, terrestrial or lithophytic, autotrophic. Pseudobulb small, cylindric, 3 × 1.5 cm, enclosed in leaf bases. Leaves 6, 42-65 × 0.4-0.5 cm, sessile, papery, distichous, linear, acute apex, articulate 5-6 cm from base. Inflorescence 36 cm long, arising from near the base of pseudobulb, erect; rachis 3-8 flowered; peduncle with 7 sheaths at the base; floral bract 20 × 2 mm, lanceolate, acuminate. Flowers fragrant, 4 cm across; pedicel and ovary 20-30 mm; sepals and petals yellowish green, lined in red-brown; lip pale yellow with reddish purple striations. Dorsal sepal 22 × 3 mm, linear to linear lanceolate, acute; lateral sepals 25 × 4 mm, spreading. Petals 15 × 5 mm, ovate, acute. Lip 17× 12 mm, 3-lobed, oblong, adnate at the base of the column; lateral lobes semi-elliptic, 5 × 5 mm, ciliate margin and inner surface, rounded; mid-lobe ovate, 11 × 12 mm, ciliate margin, straight, obtuse; callus 2-ridged, converging at the base of mid-lobe. Column 14 mm long, curved, narrowly winged; pollinia 4 in 2 pairs.

Distribution: Nepal, W Himalaya, E Himalaya and E Asia.

Altitudinal Range: 1600-1700 m.

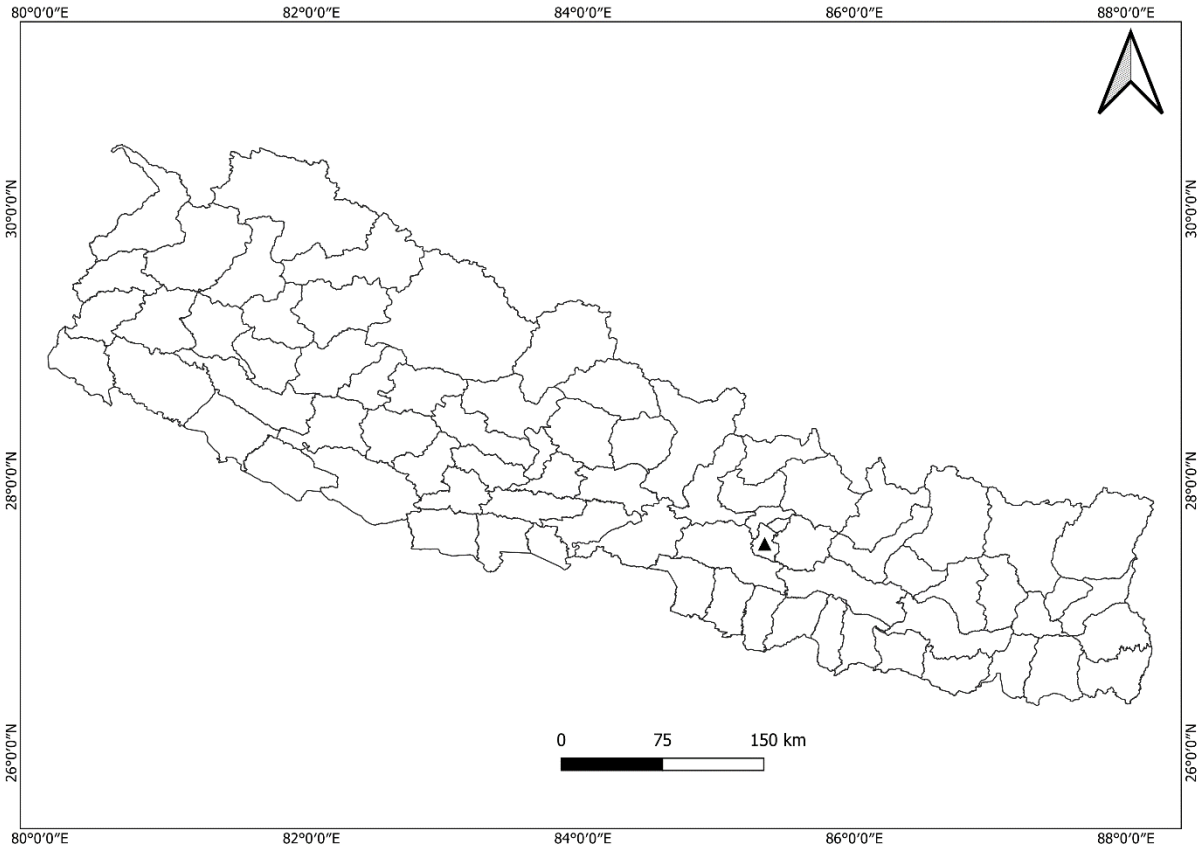
Ecology: Forest, rocky places.

Flowering: June-July.

Note: The above description is based on the single herbarium specimen deposited in KATH. King & Pantling (1898) mentioned that the flowers are green, becoming yellowish with age; the ovary and its stalk are dull purple, and the lip has streaks and blotches of the same colour. The rachis of the raceme is also purplish.

Specimen Examined:

Central Nepal: *Bagmati Province*, **Lalitpur**, Godavari, 5500ft (1676m), 03/1975, P. Pradhan G/2 (KATH002393!).



Map 4: Distribution of *C. cyperifolium* Wall. ex Lindl. in Nepal.

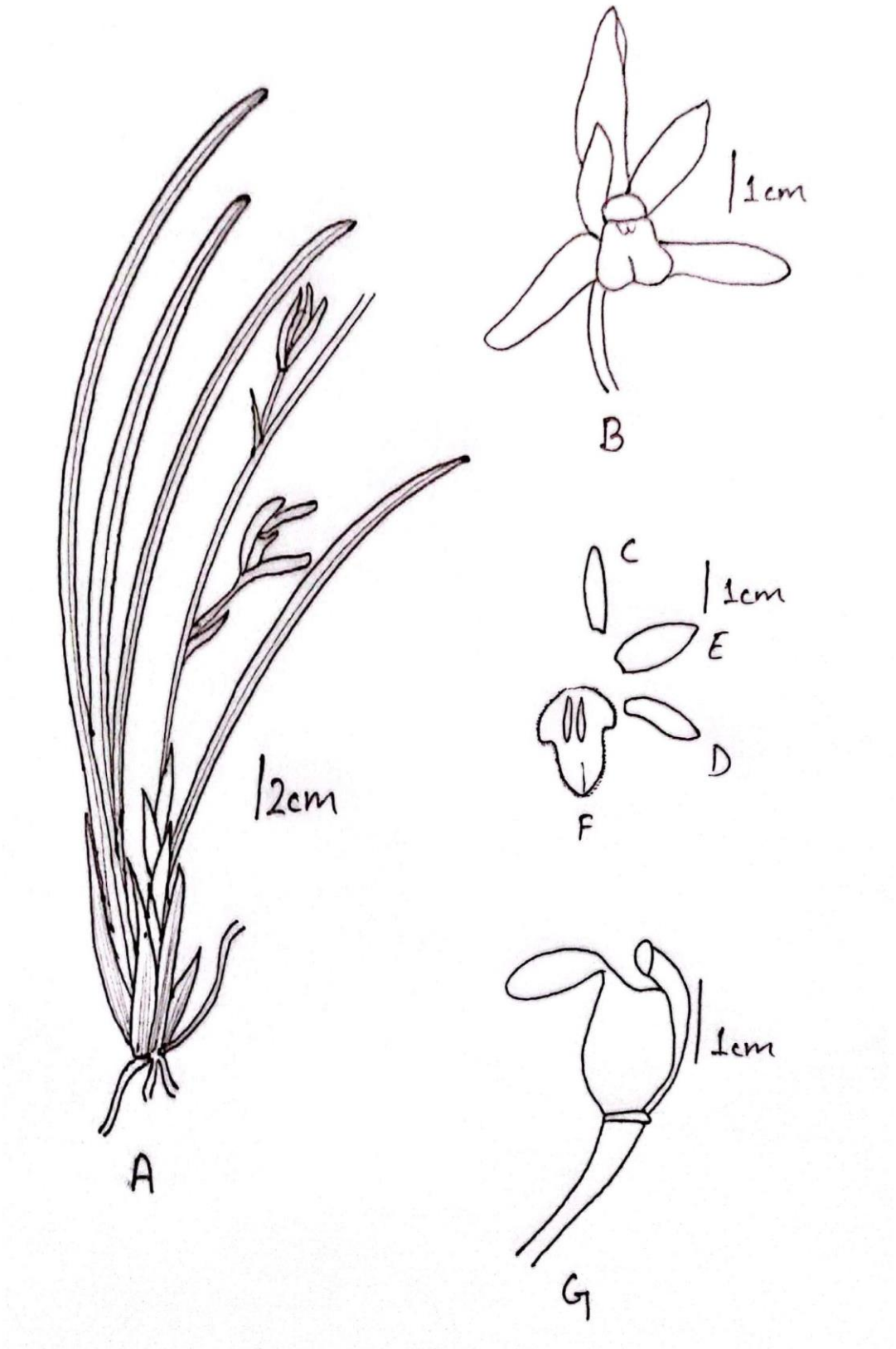


Figure 8: *Cymbidium cyperifolium* Wall. ex Lindl. A. Habit sketch. B. Single flower. C. Dorsal sepal. D. Lateral sepal. E. Petal. F. Lip. G. Lip and column. (P. Pradhan G/2, KATH002393).

Section III. Bigibbarium Schltr. in *Feddes Repert. Spec. Nov. Reg. Veg.* 20: 105 (1924).

Schlechter (1924) established this section which contains a single, highly distinctive species. It is characterised by its unusual leaves which are narrowed to a slender petiole from an unusually broad, elliptic lamina. The petals are elliptic-lanceolate in shape, and the almost entire lip has two large, deep purple spots at the base.

4. *Cymbidium devonianum* Paxton, *Paxton's Mag. Bot.* 10: 97 (1843); Hook. f. *Fl. Brit. Ind.* 6: 10 (1890); King & Pantl., in *Ann. Roy. Bot. Gard. Cal.* 8: 90. t.253 (1898); Tuyama, in *Fl. East. Himalaya* pt.1: 430 (1966); pt.2: 183 (1971); Hara *et al.*, *Enum. Fl. Pl. Nep.* 1: 37 (1978); Press *et al. Ann. Ch. Fl. Pl. Nep.*:212 (2000); Pearce & Cribb *Fl. Bhutan.* 3: 257 (2002); Chen *et al. Fl. China.* 25: 260-280 (2009); Rajbhandari & Dahal in Rajbhandari & Baral, *Cat. Nep. Fl. Pl.* 1: 51 (2010) (Plate 38); Shrestha *et al. Pl. Nep.:*86 (2022).

Cymbidium sikkimense Hook. f., *Fl. Brit. Ind*. 6(1): 9 (1890).

Type Specimen: India, Sikkim, Lachen Valley, *Hooker* s.n. (Holotype, K).

Plant 20-40 cm, epiphytic or lithophytic, autotrophic. Pseudobulb small, cylindric, enclosed by persistent leaf bases, 2-4 × 1-2 cm. Leaves 2-4, 15-28 × 2.5-5 cm, leathery, elliptic, smooth, with prominent mid-vein, obtuse to subacute, margin entire; leaf base petiolated, channeled, ca. 12-15 cm, articulate near middle. Inflorescence 20-30 cm long, arising from base of pseudobulb, pendulous; rachis 10-20 flowered; peduncle with 3-8 sheaths; floral bract 2-3 × 1.5-3 mm, ovate, acute. Flowers 2.5 cm across; pedicel and ovary 15 mm; sepals and petals pale yellow to green, mottled with purple brown; lip purple with dark maroon blotches on lateral lobes. Dorsal sepal 20-22 × 5 mm, elliptic, acuminate; lateral sepals 22-25 × 5 mm, similar, oblique, spreading. Petals 15-20 × 5 mm, elliptic-lanceolate, acute. Lip 14 × 10 mm, obcordate, adnate to the base of column, entire, obtuse; callus reduced to 2 small swelling at base. Column 12 mm long, winged at apex; pollinia 2, triangular.

Distribution: Nepal, E Himalaya, Assam-Burma, E Asia and SE Asia.

Altitudinal Range: 1500-2400 m.

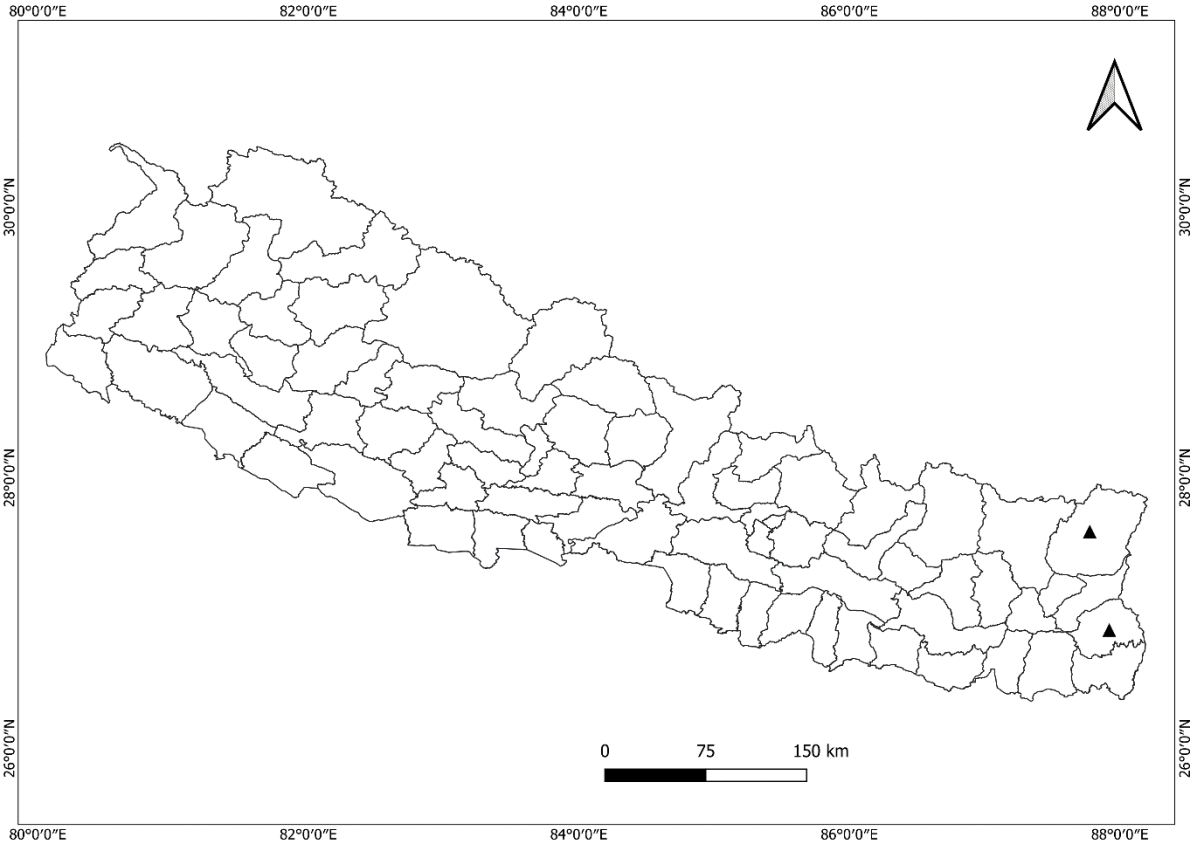
Ecology: Mossy rocks and moss covered trees.

Flowering: April-June.

Note: There is some variation in the flower colour of *C. devonianum*, especially in the amount of red-brown on the sepals and petals. Those in the original description by Paxton (1843) are nearly white and lip in this case has dark maroon blotches.

Specimen Examined:

Eastern Nepal: *Koshi Province*, **Ilam**, Hanspokhari, 5200ft, 06/06/1978, P. Pradhan & R. Niraula 450 (KATH002394!, KATH002395!, KATH002396!, KATH002397!); **Taplejung**, 27-31˚E 87-48˚N, 08/11/1963, H. Kanai *et al*. 6305481 (TI).



Map 5: Distribution of *C. devonianum* Paxton. in Nepal.

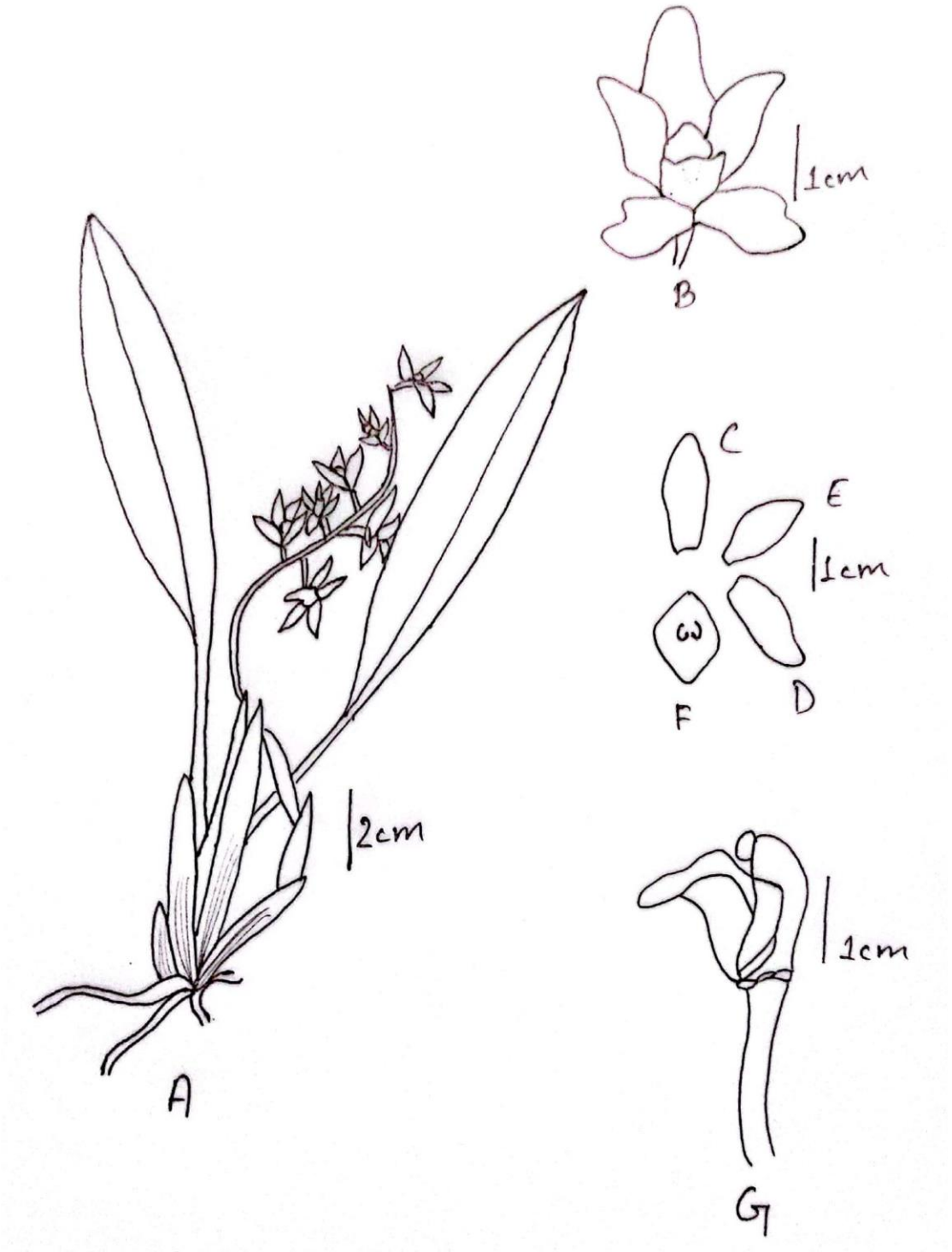


Figure 9: *Cymbidium devonianum* Paxton. A. Habit sketch. B. Single flower. C. Dorsal sepal. D. Lateral sepal. E. Petal. F. Lip. G. Lip and column. (P. Pradhan & R. Niraula 450, KATH002397).

Section IV. Cyperorchis (Bl.) P. F. Hunt in *Kew Bull.* 24: 94 (1970); Seth & Cribb in *Arditti (ed.), Orchid. Biol. Rev. Persp.* 3: 303 (1984).

Cyperorchis in the narrow sense of Blume (1848) and Hunt (1970) is given sectional status within subgenus *Cyperorchis* following the treatment of Seth and Cribb (1984). This section is characterised by its basal scape with pendulous flowers which do not open widely.

5. *Cymbidium elegans* Lindl., *Gen. Sp. Orchid. Pl.* 163 (1833); Hara *et al., Enum. Fl. Pl. Nep.* 1: 37 (1978); Press *et al. Ann. Ch. Fl. Pl. Nep.*:212 (2000); Pearce & Cribb *Fl. Bhutan.* 3: 257 (2002); Chen *et al. Fl. China.* 25: 260-280 (2009); Rajbhandari & Dahal in Rajbhandari & Baral, *Cat. Nep. Fl. Pl.* 1: 51 (2010) (Plate 38); Shrestha *et al. Pl. Nep.:*86 (2022).

Cymbidium longifolium D. Don, *Prodr. Fl. Nep.* 36 (1825)

Type Specimen: Nepal, Gossaingsthan, *Wallich, N.* Cat. no. 7354 (Holotype, K-LINDL, Isotype, K-W).

Plant 20-60 cm, epiphytic or lithophytic, autotrophic. Pseudobulb ovoid, bilaterally flattened, enclosed in persistent leaf bases, 4-5 × 2-2.5 cm. Leaves 4-8, 30-74 × 1-1.5 cm, sessile, papery, distichous, linear, acute and minutely 2-lobed at apex, articulate 13-14 cm from base. Inflorescence 63cm long, arising from base of pseudobulb, pendulous; rachis pendent, with 15-25 closely spaced flowers; peduncle with 5 sheaths; floral bract 4-5 × 1.5-2 mm, ovate, acuminate. Flowers about 2 cm across, pendulous cluster, bell shaped, not opening widely; pedicel and ovary 15-20 mm; sepals and petals pale yellow, tinged pale pink; lip cream-yellow, with red purplish spots; callus orange yellow; column pale green. Dorsal sepal 34-36 × 6 mm, obovate, acute, covering the column; lateral sepals 35-40 × 8 mm, similar, not spreading. Petals 32 × 3 mm, oblanceolate, obtuse. Lip 34 × 13 mm, 3-lobed, oblanceolate-triangular, elongate, base fused to base of column for 2-3 mm; lateral lobes triangular, 11 × 5 mm, glabrous margin, apex acute; mid-lobe oblong, 9 × 9 mm, glabrous margin, apex slightly bilobed and incurved; callus 2-ridged, hairy. Column 30 mm long, puberulent toward base, narrowly winged; pollinia 2, clavate.

Distribution: Nepal, E Himalaya, Tibetan Plateau, Assam-Burma and E Asia.

Altitudinal Range: 1500-2800 m.

Ecology: Trees in forests, cliffs.

Flowering: September-November.

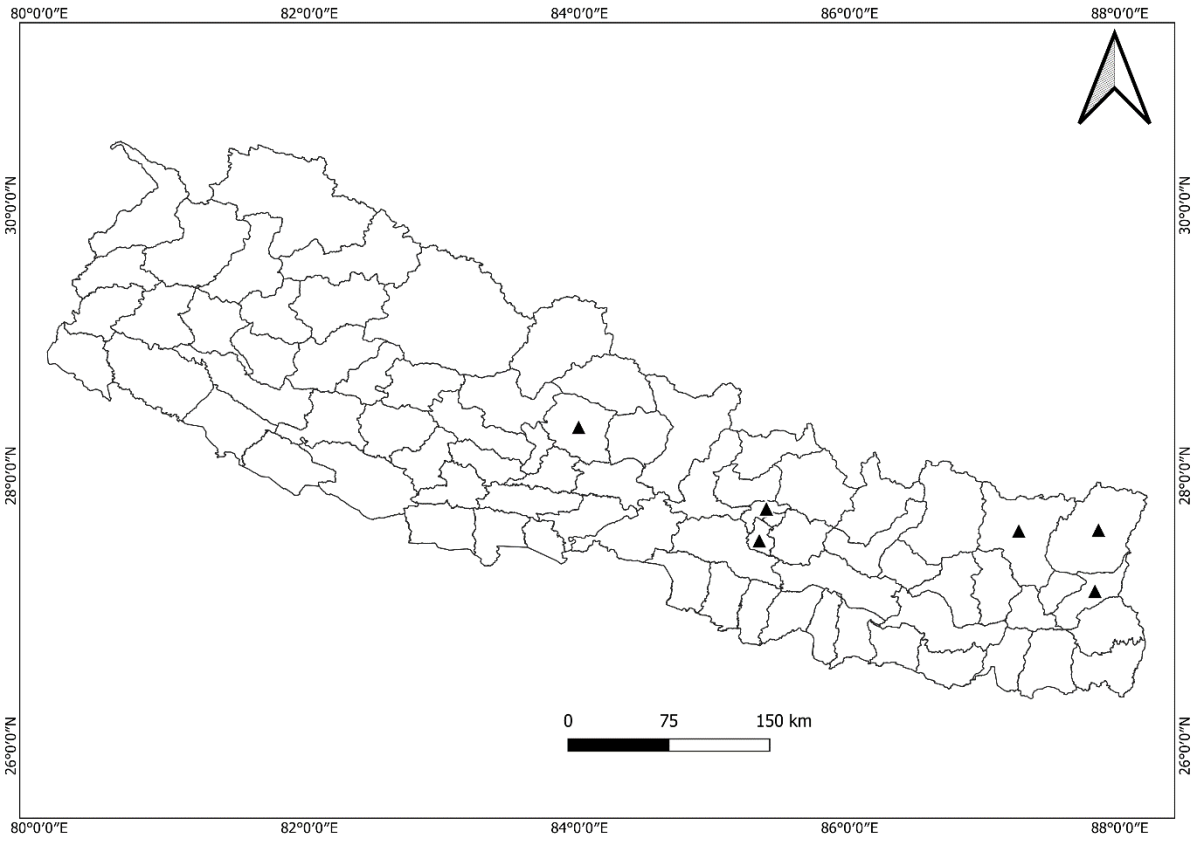
Note: Hara *et al*. (1978) used the name *C. longifolium* but unfortunately this name was used by Lindley (1833) for another species, to which Hara *et al*. have applied the name *C. erythraeum*.

Voucher specimen: Kaski, Panchase, 2260 m, 28˚13'30"N 83˚48'9"E, 09/06/2023, Amita Twayana, Anil Twana & Rishav Chaudhary A001 (ASCOL).

Specimen Examined:

Central Nepal: *Bagmati Province,* **Kathmandu**, Sundarijal-Chisapani, 2187m, 09/11/2012, K. R. Rajbhandari *et al.* 20121115 (KATH!); **Lalitpur**, Tinpane bhanjyang, 2133m, 18/11/1977, P. Praadhan, 380 (KATH018600!, KATH018601!, KATH018602!); *Gandaki Province*, **Kaski**, Panchase Forest, 2400m, 08/01/2015, P. Bhandari 1262P (KATH!).

Eastern Nepal: *Koshi Province*, **Panchthar**, 27-17˚E 87-57˚N, 26/11/1963, H. Kanai *et al*. 6307335 (TI); 27-17˚E 87-57˚N, 27/11/1963, H. Kanai *et al*. 6307337 (TI); 27-14˚E 87-57˚N, 28/11/1963, H. Kanai *et al*. 10002515 (TI); **Sankhuwasaba**, Tashigawn, 1950m, 11/12/1998, D. Karkee 741 (TUCH!), 27-14˚E 87-30˚N, 29/10/1963, H. Hara *et al*. 6307329 (TI); 27-18˚E 87-35˚N, 30/10/1963, H. Hara *et al*. 6307338 (TI); **Taplejung**, 27-27˚E 87-54˚N, 19/11/1963, H. Hara *et al*. 6307330 (TI); 27-31˚E 87-48˚N, 08/11/1963, H. Kanai *et al*. 6307331 (TI); 27-27˚E 87-54˚N, 19/11/1963, H. Hara *et al*. 6307336 (TI).



Map 6: Distribution of *C. elegans* Lindl. in Nepal.

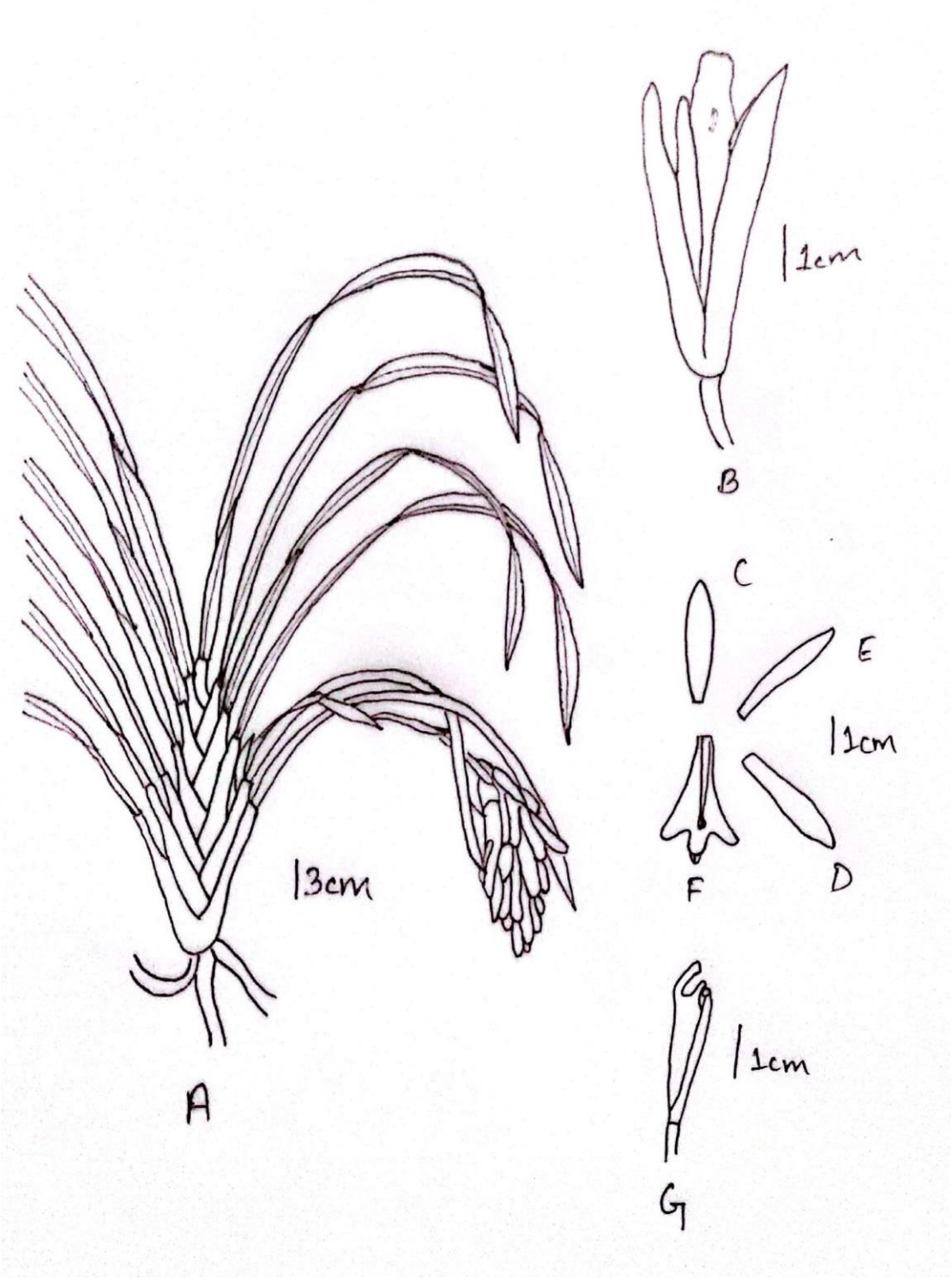


Figure 10: *Cymbidium elegans* Lindl. A. Habit sketch. B. Single flower. C. Dorsal sepal. D. Lateral sepal. E. Petal. F. Lip. G. Lip and column. (Amita Twayana *et al*. A001, ASCOL).

Section V. Iridorchis (Bl.) P. F. Hunt in *Kew Bull.* 24: 94 (1970).

Iridorchis Bl. was reduced to sectional status within the genus *Cyperorchis* by Schlechter (1924), and was later transferred to the genus *Cymbidium* by P. Hunt (1970). Seth and Cribb (1984) placed it back again in subgenus *Cyperorchis*.

The vegetative plant in this species is robust, with long, linear, distichous, acute leaves and large, bilaterally compressed pseudobulbs which are produced annually and flower from the base. The flowers are large (about 4-7 cm in diameter), and open widely except for the dorsal sepal which is usually porrect and covers the column.

Key to the species in Section Iridorchis

1a. Flowers less than 5cm across, dorsal sepal less than 12mm wide ……..….. **6. *C. erythraeum***

b. Flowers more than 5cm across, dorsal sepal more than 12mm wide …...…… 2

2a. Sepals and petals clear green; mid-lobe of the lip longer than the lateral lobes ……..…… **7. *C. hookerianum***

b. Sepals and petals yellowish green with red-brown stripes; mid-lobe of the lip shorter than lateral lobes …… **8. *C. iridioides***

6. *Cymbidium erythraeum* Lindl., *J. Proc. Linn. Soc., Bot.* 3: 30 (1859); Hara *et al.*, *Enum. Fl. Pl. Nep.* 1: 37 (1978); Press *et al*. *Ann. Ch. Fl. Pl. Nep.*:212 (2000); Pearce & Cribb *Fl. Bhutan.* 3: 257 (2002); Chen *et al. Fl. China.* 25: 260-280 (2009); Rajbhandari & Dahal in Rajbhandari & Baral, *Cat. Nep. Fl. Pl.* 1: 51 (2010) (Plate 38); Shrestha *et al. Pl. Nep.*:86 (2022).

Cymbidium longifolium sensu *Lindl., Gen. Sp. Orchid. Pl.* 163 (1833), non D. Don.

Type Specimen: India, Sikkim, *Hooker* 229 (Holotype, K-LINDL).

Plant 47-60 cm, epiphytic or lithophytic, autotrophic. Pseudobulb ovoid, bilaterally compressed, enclosed in leaf bases, 4-5 × 2.5-5 cm. Leaves 6-11, 23-64 × 0.5-1.5 cm, sessile, papery, distichous, linear, acuminate, articulate 6-7 cm from base. Inflorescence 60 cm long, arising from base of pseudobulb, arching; rachis 5-14 flowered; peduncle with 7 sheaths; floral bract 7 × 1.5 mm, triangular, acute. Flowers 4-5 cm across; pedicel and ovary 20-30 mm; sepals and petals greenish with reddish brown longitudinal

stripes; lip white with red veined on lateral lobes and central longitudinal dash on mid-lobe. Dorsal sepal 11-37 × 7-12 mm, oblanceolate, acute, porrect; lateral sepals similar to dorsal sepal. Petals 36-44 × 5-8 mm, oblong, acute, spreading. Lip 20 × 16 mm, 3-lobed, elliptic-ovate, base fused to the base of the column for 2-3 mm; lateral lobes subovate, 5 × 2 mm, erect, ciliate at apex, obtuse; mid-lobe cordate-reniform, 8 × 10 mm, margin ciliate, obtuse; callus 2-ridged, tapering to the base of the lip, slightly swollen towards apices, densely pubescent. Column 30 mm long, winged, sparsely pubescent; pollinia 2, obliquely triangular.

Distribution: Nepal, W Himalaya, E Himalaya, Tibetan Plateau, Assam-Burma and E Asia.

Altitudinal Range: 1500-2400 m.

Ecology: On trees, rocks and steep banks in open forest.

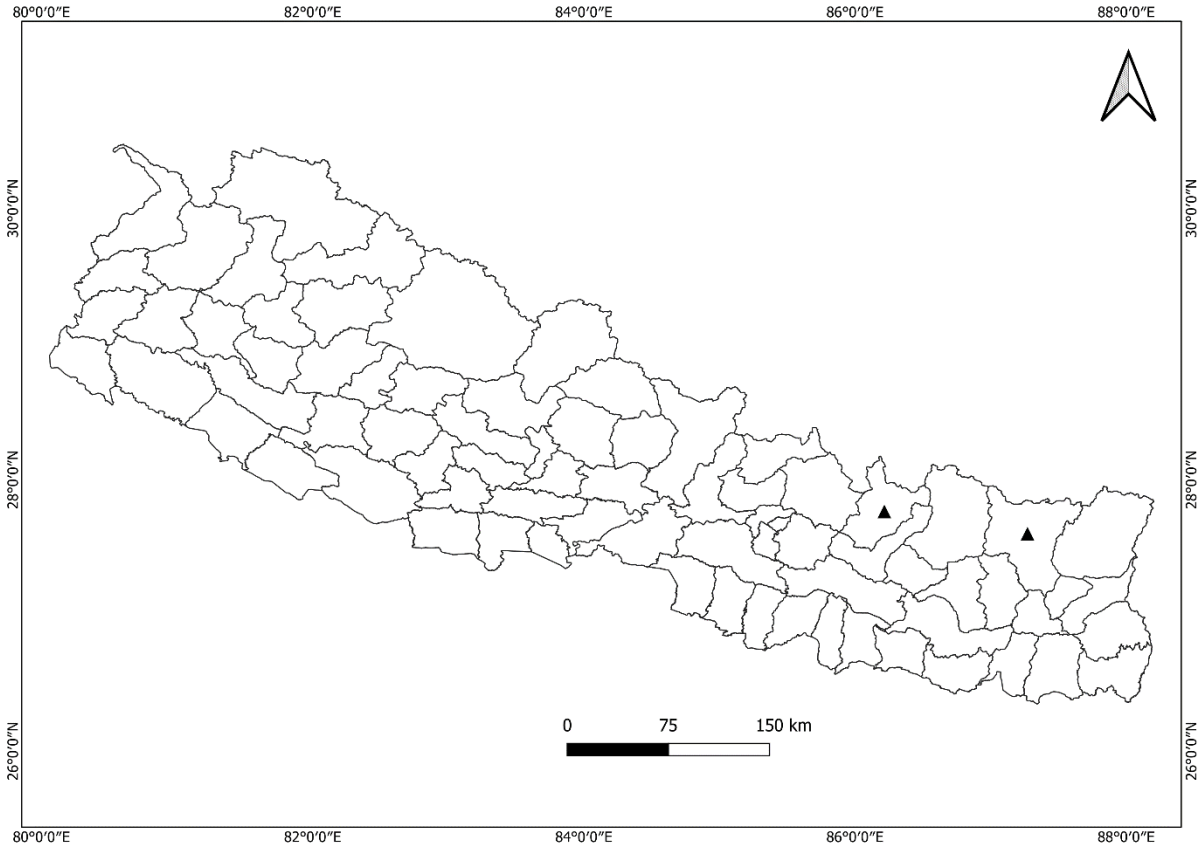
Flowering: September-November.

Note: Lindley misapplied the name *C. longifolium* in 1833 and the names have been incorrectly used since. Hara *et al*. (1978) and Hara (1985) stated that the type specimen of *C. longifolium* collected by Wallich from Nepal is referable to the species commonly known as *C. elegans*. King & Pantling (1898), Kataki (1986), Deva & Naithani (1986) reported *C. longifolium* is actually *C. erythraeum*. This species is allied to *C. iridioides* but differ in having smaller flowers. The lip of *C. erythraeum* is white with few red veined whereas the lip of *C. iridioides* is yellowish with more reddish spots.

Specimen Examined:

Central Nepal: *Bagmati Province*, **Dolakha**, Jungu, 2271m, 15/10/2017, S. Karki & A. P. Dhital J26 (KATH086702!).

Eastern Nepal: *Koshi Province*, **Sankhuwasabha**, Arun Valley, 1940m, 20/09/1991, D. G. Long et al. 104 (KATH002398!, E00114941); Below Dandakharca, 2000m, 29/05/2011, M. L. Pathak & L. R. Tharu 20110549 (KATH!).



Map 7: Distribution of *C. erythraeum* Lindl. in Nepal.

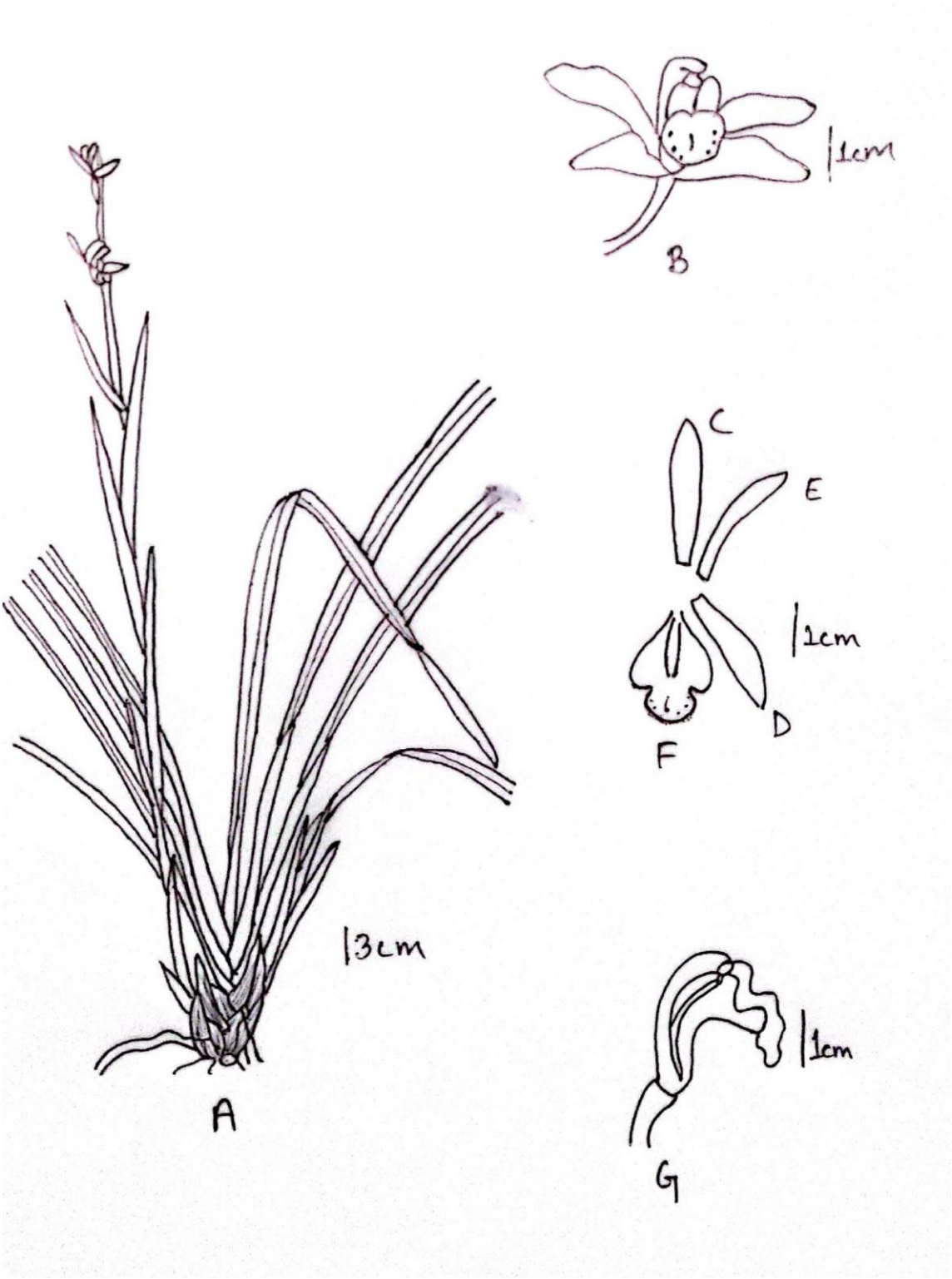


Figure 11: *Cymbidium erythraeum* Lindl. A. Habit sketch. B. Single flower. C. Dorsal sepal. D. Lateral sepal. E. Petal. F. Lip. G. Lip and column. (S. Karki & A. P. Dhital J26, KATH086702).

7. *Cymbidium hookerianum* Reichb. f. in *Gard. Chron.* 1866: 7 (1866); Bateman in Curtis, *Bot. Mag.* 92: t. 5574 (1866); Hara *et al., Enum. Fl. Pl. Nep.* 1: 37 (1978); Press *et al. Ann. Ch. Fl. Pl. Nep.*:212 (2000); Pearce & Cribb *Fl. Bhutan.* 3: 257 (2002); Chen *et al. Fl. China.* 25: 260-280 (2009); Rajbhandari & Dahal in Rajbhandari & Baral, *Cat. Nep. Fl. Pl.* 1: 51 (2010) (Plate 38); Shrestha *et al. Pl. Nep.:*86 (2022).

Cymbidium grandiflorum Griff., *Ic. Asiat.* 3: t.321 (1851).

Cyperorchis grandiflora (Griff.) Schltr. In *Feddes Repert. Spec. Nov. Regni. Veg.* 20: 107 (1924).

Type Specimens: India, Khasia, cult. *Veitch s.n.* (Holotype, W!); Bhutan, Pimi, *Griffith* 5270 (Holotype, K).

Plant 45-55 cm, epiphytic or lithophytic, autotrophic. Pseudobulb elliptic-ovoid, bilaterally compressed, enclosed in leaf bases, 5 × 5 cm. Leaves 5, 32-48 × 2 cm, sessile, papery, linear, acute, articulate 11-15 cm from base. Inflorescence 50 cm long, arising from near base of pseudobulb, arching; rachis 7-15 flowered; peduncle with 4-7 sheaths; floral bract 3-5 × 1-1.5 mm, ovate-triangular, acute. Flowers 5-7 cm across; pedicel and ovary 25 mm; sepals and petals greenish; lip white with red-brown spots and stripes. Dorsal sepal 50 × 20 mm, oblong, acute, porrect; lateral sepals 55 × 17 mm, similar, spreading. Petals 50 × 12 mm, oblong, acute. Lip 40 × 32 mm, 3-lobed, sub-elliptic, base fused to column base for 4-4.5 mm; lateral lobes ovate-triangular, 5 × 5 mm, margin ciliate, acute; mid-lobe ovate, 15 × 12 mm, margin ciliate, recurved, erose; callus 2-ridged, pubescent. Column 40 mm long, curved forward, winged, pubescent ventrally; pollinia 2, subtriangular.

Distribution: Nepal, E Himalaya, Tibetan Plateau, Assam-Burma, E Asia and SE Asia.

Altitudinal Range: 1600-2600 m.

Ecology: Trees in dense forests, rocks along valleys.

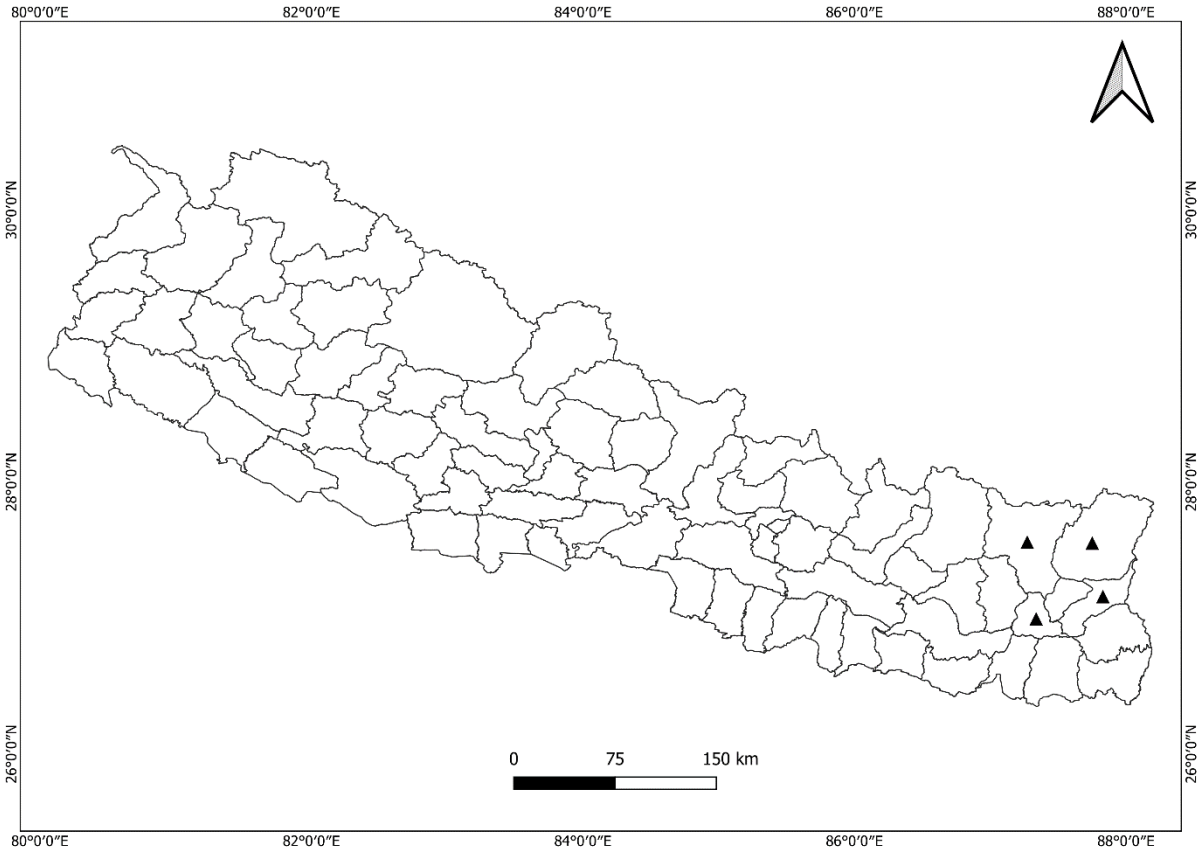
Flowering: January-April.

Note: Griffith (1851) described *C. grandiflorum* based on a specimen collected from Bhutan. But Swartz (1799) already used this name for a species, now shifted to *Pogonia*. The flower colour mentioned on the herbarium specimen is greenish with

white lip having red-brown spots and stripes while King & Pantling (1898) mentioned apple green sepals and petals with pale tint margin; the lip and column are ochraceous yellow speckled with purple.

Specimen Examined:

Eastern Nepal: *Koshi Province*, **Dhankuta**, Guranse to Basantapur, 2200m, 30/01/1982, K. R. Rajbhandari *et al.* 6109 (KATH002399!, KATH002400!, KATH002401!); 27-03˚E 87-21˚N, 24/10/1963, H. Hara *et al* 6307328 (TI); **Panchthar**, 27-17˚E 87-57˚N, 27/11/1963, H. Hara *et al*. 10002512 (TI); 27-14˚E 87-57˚N, 28/11/1963, H. Kanai *et al*. 10002514 (TI); **Sankhuwasaba**, Milke Dara, 14/05/1981, J. Stainton 8283 (E00296617); **Taplejung**, 27-41˚E 87-47˚N, 11/11/1963, H. Kanai *et al*. 6307327 (TI).



Map 8: Distribution of *C. hookerianum* Reichb. in Nepal.

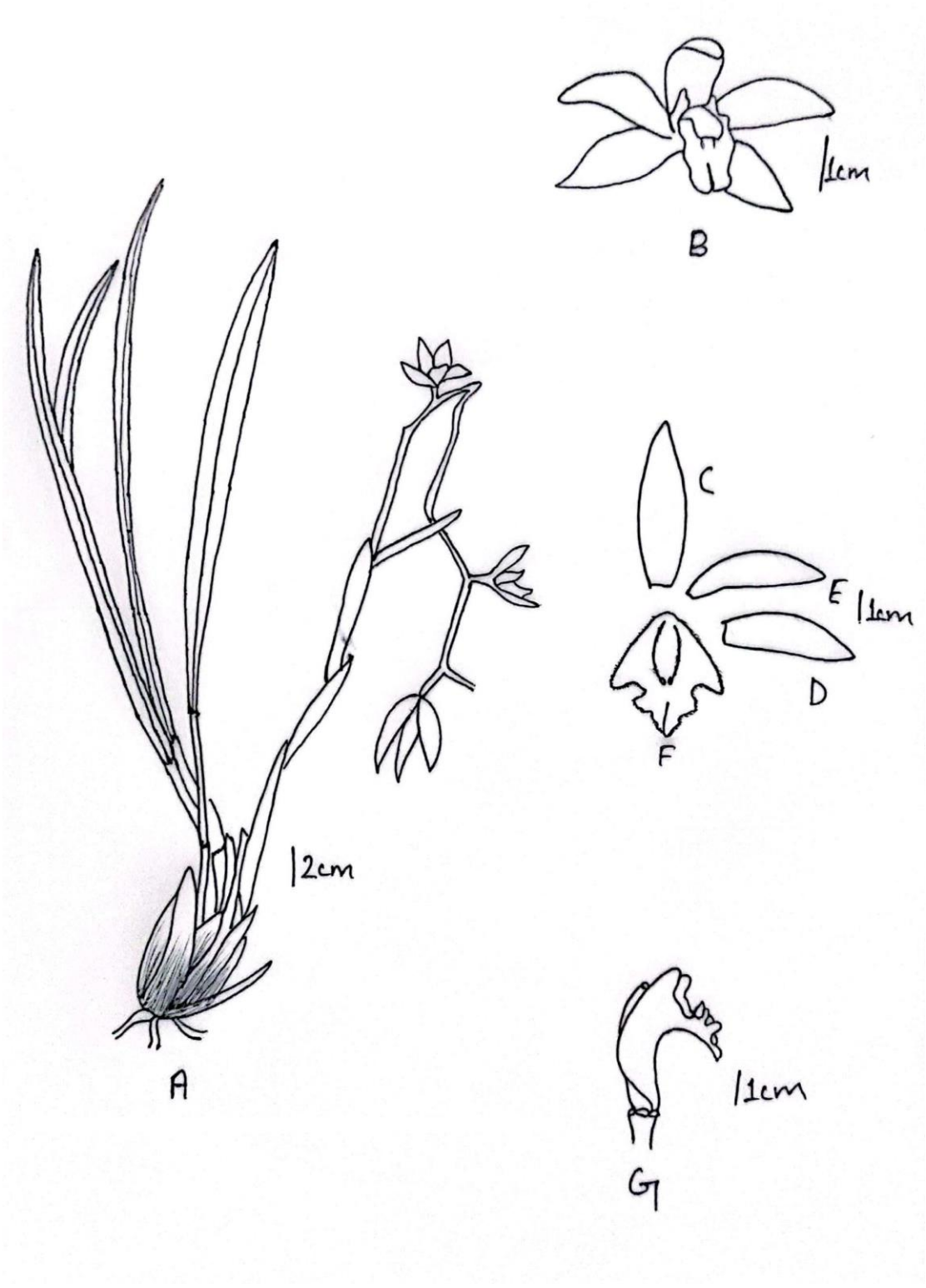


Figure 12: *Cymbidium hookerianum* Reichb. A. Habit sketch. B. Single flower. C. Dorsal sepal. D. Lateral sepal. E. Petal. F. Lip. G. Lip and column. (K. R. Rajbhandari *et al.* 6109, KATH002401).

8. *Cymbidium iridioides* D. Don, *Prodr. Fl. Nepal.* 36 (1825); Hook. f., *Fl. Brit. Ind.* 6: 14 (1890); Hara *et al.*, *Enum. Fl. Pl. Nep.* 1: 37 (1978); Press *et al. Ann. Ch. Fl. Pl. Nep.*:212 (2000); Pearce & Cribb *Fl. Bhutan.* 3: 257 (2002); Chen *et al. Fl. China.* 25: 260-280 (2009); Rajbhandari & Dahal in Rajbhandari & Baral, *Cat. Nep. Fl. Pl.* 1: 51 (2010) (Plate 38); Shrestha *et al. Pl. Nep.*:86 (2022).

Cymbidium giganteum Wall. ex Lindl., *Gen. Sp. Orchid. Pl.* 163 (1833), non Sw. (1799).

Iridorchis gigantea (Wall. ex Lindl.) Bl., *Coll. Orchid.* 91 (1858).

Cyperorchis gigantea (Wall. ex Lindl.) Schltr. In *Feddes Repert. Spec. Nov. Regni. Veg.* 20: 107 (1924).

Type Specimens: Nepal, *Wallich s.n.* (Holotype, BM); Nepal, Sheopore, coll. *Wallich Wall.* Cat. 7355 (Lectotype, K-LINDL, K-W).

Plant 40-60 cm, epiphytic or lithophytic, autotrophic. Pseudobulb ovoid, bilaterally compressed, enclosed in leaf bases, 3-4 × 2.5 cm. Leaves 6, 32-50 × 1-2 cm, sessile, papery, linear, acute, articulate 10-12 cm from base. Inflorescence 60 cm long, arising from base of pseudobulb, sub-erect; rachis 5-10 flowered; peduncle with 5-6 sheaths; floral bract 4-6 × 1.5 mm, triangular, acute. Flowers 5-6 cm across; pedicel and ovary 25-40 mm; sepals and petals yellowish green, with reddish brown streaks; lip yellowish, with reddish spots. Dorsal sepal 55 × 20 mm, lanceolate, acute, porrect; lateral sepals 60 × 17 mm, similar, spreading. Petals 55 × 12 mm, oblong, acute. Lip 45 × 20 mm, 3-lobed, sub-elliptic, base fused to the base of column for 4-5 mm; lateral lobes ovate, 25 × 10 mm, margins ciliate, obtuse; mid-lobe ovate, 10× 5 mm, obtuse, sparsely hairy; callus 2-ridged, pubescent-ciliate. Column 35 mm long, winged; pollinia 2, subtriangular.

Distribution: Nepal, W Himalaya, E Himalaya, Tibetan-Plateau, Assam-Burma, E Asia and SE Asia.

Altitudinal Range: 1500-2800 m.

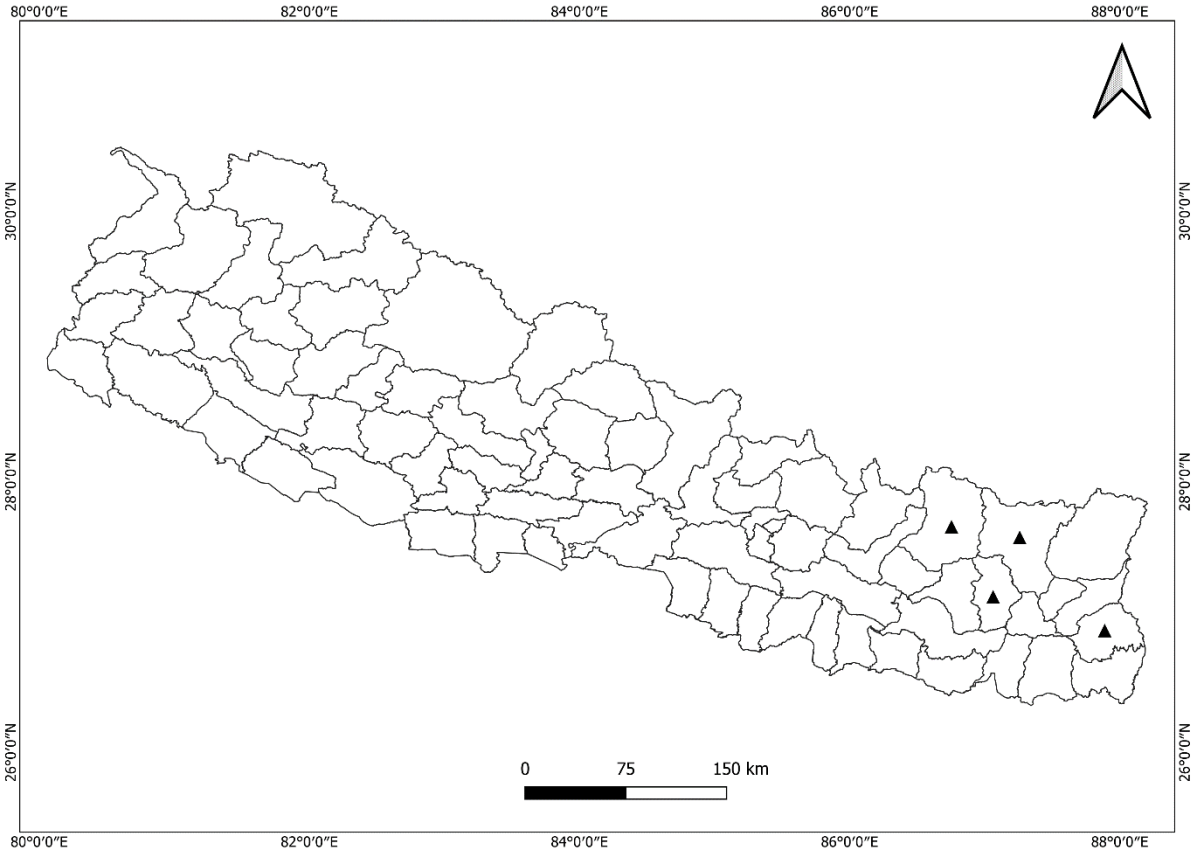
Ecology: Trees or rocks in dense forest.

Flowering: June-July.

Note: In 1832, Lindley published the name *C. giganteum* based on a specimen in Wallich Herbarium. He placed *C. iridioides* under its synonymy with a question mark. This species is allied with *C. erythraeum* but differs from latter in having longer and more hairs on side lobe and mid lobe of lip. It is also much allied to *C. hookerianum* in habit and leaves but differs in the size and colour of the flowers.

Specimen Examined:

Eastern Nepal: *Koshi Province*, **Bhojpur**, Suntaley to Dingla, 6500ft (1981m), 20/04/1965, Banerjee et al. 3232 (KATH!); **Ilam**, Hanspokhari, 1550m, 21/11/1978, P. Pradhan *et al*. 905 (KATH!); **Sankhuwasabha**, Above Nundhaki, 2400m, 28/04/1991, P. R. Shakya 9643 (KATH002402!, KATH002403!, KATH002404!); Mai patale, 2400m, 14/04/1977, P. R. Shakya 4039 (KATH018538!, KATH018539!); Above Gupte, 2610m, 29/04/1977, P. R. Shakya 4163 (KATH019212!, KATH019213!); **Solukhumbu**, Shete, 8700ft (2651m), 05/04/1958, 13651(KATH!).



Map 9: Distribution of *C. iridioides* D. Don. in Nepal.

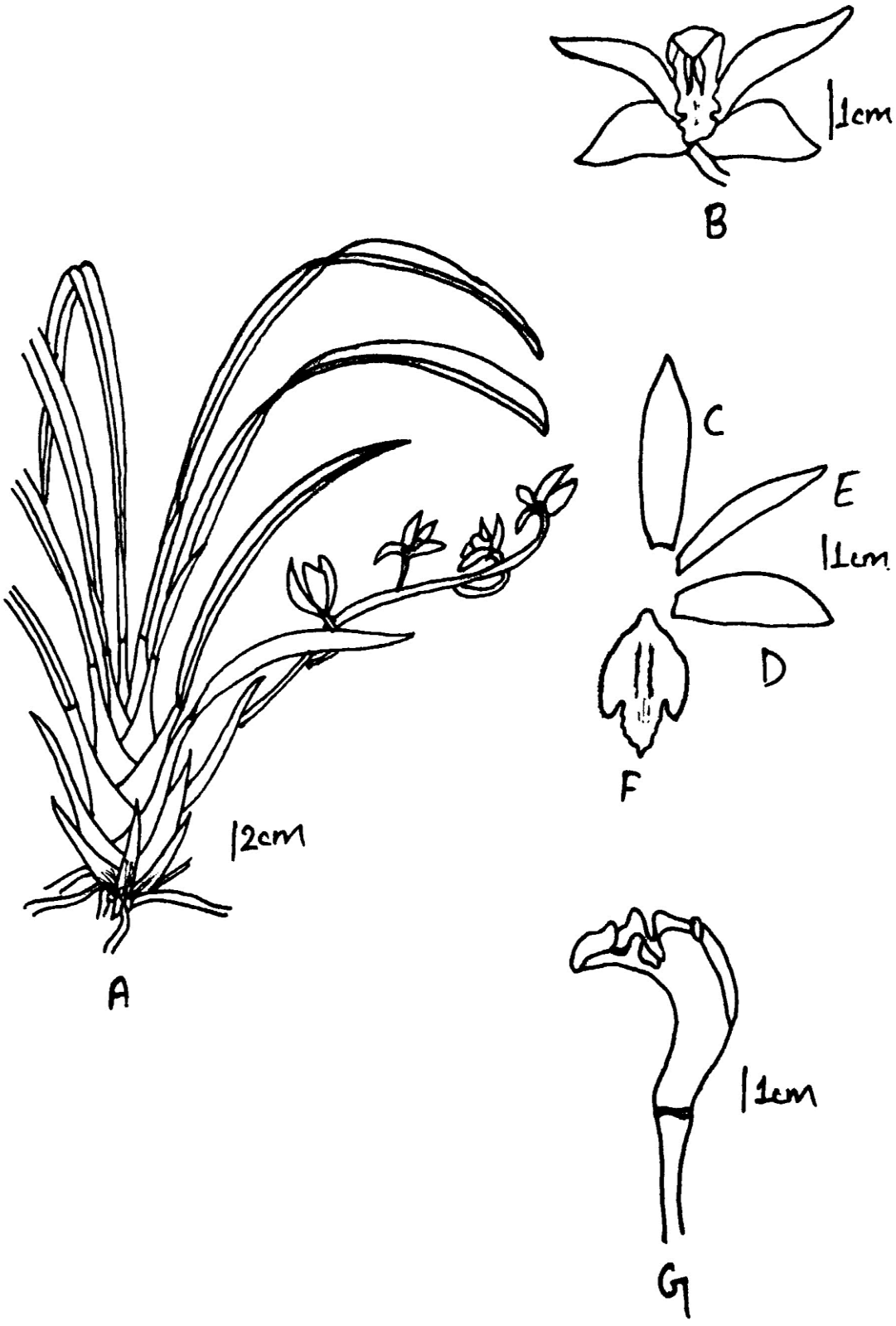


Figure 13: *Cymbidium iridioides* D. Don. A. Habit sketch. B. Single flower. C. Dorsal sepal. D. Lateral sepal. E. Petal. F. Lip. G. Lip and column. (P. R. Shakya 9643, KATH002402).

Section VI. Geocymbidium Schltr. in *Feddes Repert. Spec. Nov. Reg. Veg.* 20: 101 (1924).

The single species in this section is highly distinctive vegetatively, and is characterised by having elongated, narrowly fusiform pseudobulbs which have about 2-3 apical leaves, and a lateral scape. The leaves have an oblanceolate lamina, which narrows towards the base to a slender petiole.

9. *Cymbidium lancifolium* Hook., *Exot. Fl.* 1: t. 51 (1823); Lindl., *Gen. Sp. Orch. Pl.* pt.3: 164 (1833); in *Journ. Linn. Soc.* 30 (1859); Hook. f., *Fl. Brit. Ind.* 6: 9 (1890); King & Pantl., in *Ann. Roy. Bot. Gard. Cal.* 8: 185. t.247 (1898); Holtt., *Fl. Malaya*. 1: 518 ed.2 (1957); Seidenf. & Smitin., *Orch. Thailand.* 3: 512 (1961).

Type Specimen: Nepal, *Wallich s.n.*, cult. Shepherd (Holotype, K).

Plant 14-25 cm, terrestrial or lithophytic, autotrophic. Pseudobulb cylindric, fusiform, fleshy, 3 × 2 cm. Leaves 3, 8-15 × 2-3 cm, papery, lanceolate, acute, petiolate, petiole ca. 3-5 cm. Inflorescence 13 cm long, lateral, arising from middle of the pseudobulb, erect; rachis 3-4 flowered; peduncle with 3-5 sheaths; floral bract 15 × 1-2 mm, lanceolate, acute. Flowers 3 cm across; pedicel and ovary 25 mm; sepals and petals apple green, with purplish stripes; lip white, with red spots and purplish markings. Dorsal sepal 22-25 × 2 mm, oblanceolate, acute; lateral sepals 22 × 2 mm, similar, spreading. Petals 23 × 5 mm, elliptic, acute. Lip 18 × 9 mm, 3-lobed, ovate-oblong, adnate to the base of the column; lateral lobes rounded, 3 × 2 mm, erect, glabrous margin, obtuse; mid-lobe ovate, 12 × 9 mm, glabrous margin, recurved, acute; callus 2-ridged. Column 15 mm long, slender, curved, winged; pollinia 4 in 2 pairs.

Distribution: Nepal, W Himalaya, E Himalaya, Tibetan Plateau, Assam-Burma, S Asia, E Asia and SE Asia.

Altitudinal Range: 1300-2400 m.

Ecology: On slopes in shady places and broad leaved forest, humus-rich rocks.

Flowering time: April-August.

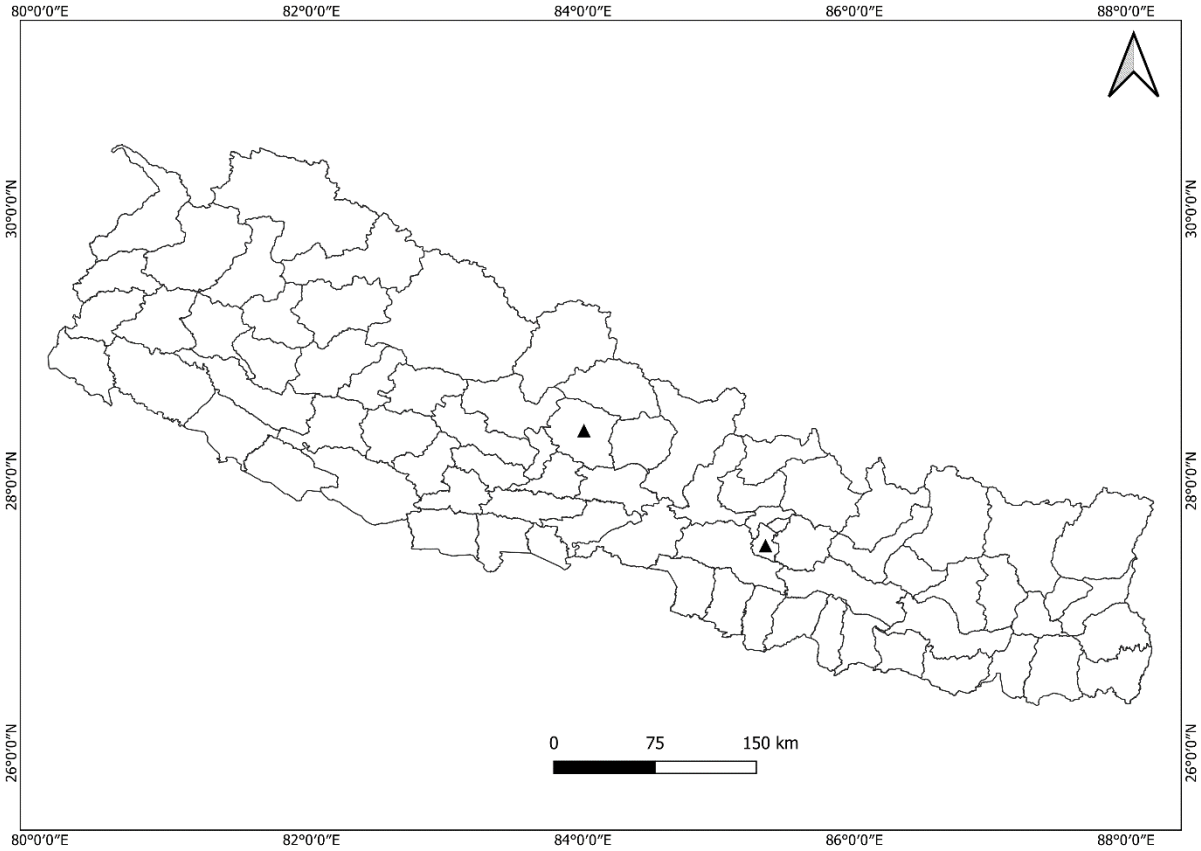
Note: Hooker based his original description on a cultivated plant which had been collected by Nathaniel Wallich in Nepal. On the examination of fresh plant material,

the sepals and petals are white with purplish midvein and the lip is white with purplish markings.

Voucher Specimen: Kathmandu, Samakhusi, 1308 m, 27˚43'28"N 85˚18'52"E, 23/06/2023, Amita Twayana A002 (ASCOL) (cultivated).

Specimen Examined:

Central Nepal: *Bagmati Province*, **Lalitpur**, Phulchoki, 7500ft [2290m], 07/07/1979, P. Pradhan *et al.* 824 (KATH002405!, KATH002406!); Godavari, 15/07/1989, S. Dahal 1 (KATH!); Bajrabarahi, 1320m, 25/2001, M. Ghimire 122 (TUCH!). *Gandaki Province*, **Kaski**, Bhadaure-Panchase, 1900m, 15/07/2002, A. Subedi *et al*. 94 (TUCH!).



Map 10: Distribution of *C. lancifolium* Hook. in Nepal.

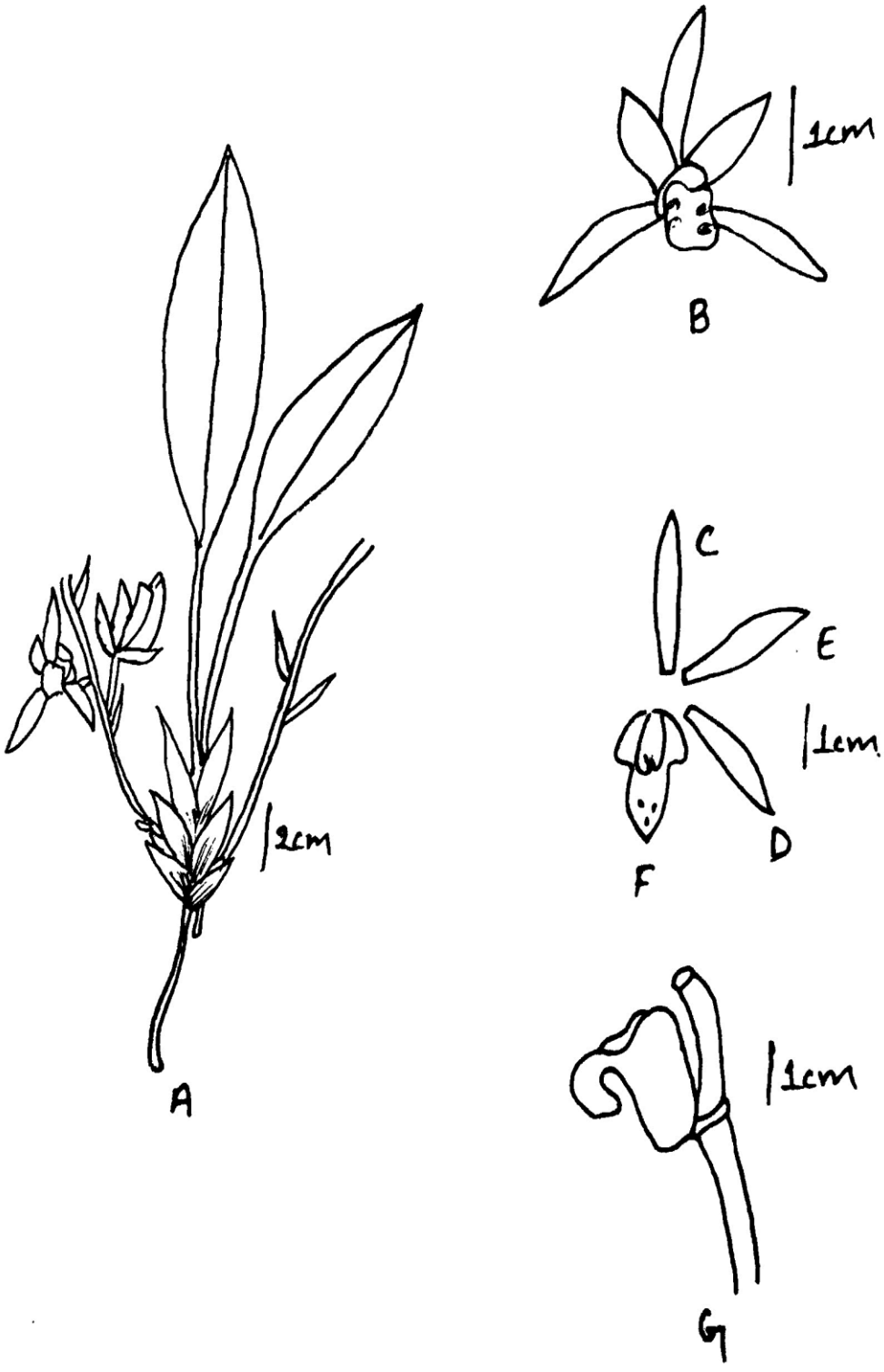


Figure 14: *Cymbidium lancifolium* Hook. A. Habit sketch. B. Single flower. C. Dorsal sepal. D. Lateral sepal. E. Petal. F. Lip. G. Lip and column. (P. Pradhan *et al.* 824, KATH002406).

Natural Hybrid

10. *Cymbidium* × *gammieanum* King & Pantl., *J. Asiat. Soc. Bengal. Pt. 2, Nat. His.* 64: 339 (1896) *et* in *Ann. Roy. Bot. Gard. Cal.* 8: 193, t. 257 (1898).

Cyperorchis × *gammieana* (King & Pantl) Schltr., *Repert. Spec. Nov. Regni Veg.* 20: 107 (1924).

Type Specimen: India, Sikkim, *Pantling* 299 (Holotype, CAL).

Plant 30-40 cm, epiphytic. Pseudobulb ovoid, enclosed in leaf sheaths, 3 × 2 cm. Leaves 10, 28-36 × 1cm, sessile, papery, distichous, linear, slightly narrowed to the base, acuminate, articulate 8-11cm from base. Inflorescence 40 cm long, arising from base of pseudobulb, raceme pendulous, laxly or densely flowered; rachis 15-20 flowered; peduncle with 5 sheaths; floral bract 5 × 1.5 mm, obovate, acute. Flowers 7 cm long; pedicel and ovary 15 mm; sepals and petals yellow flushed with brown lines; lip yellow with brown spots. Dorsal sepal 40 × 10 mm, linear-lanceolate, obtuse; lateral sepals 30 × 5 mm, similar. Petals 28 × 5 mm, linear-oblong, slightly shorter than sepals, acute. Lip 32 × 15 mm, 3-lobed, oblong, adnate at the base of the column; lateral lobes ovate-triangular, 4 × 3 mm, erect, ciliate margin, obtuse; mid-lobe sub-orbicular, 6 × 5 mm, glabrous margin, obtuse; calli 2, pubescent, parallel, ending abruptly at the base of mid-lobe with ciliolate sinus. Column 35 mm long, slender, winged; pollinia 2.

Distribution: Nepal and E Himalaya.

Altitudinal Range: 1500-2200 m.

Ecology: On trees in forest.

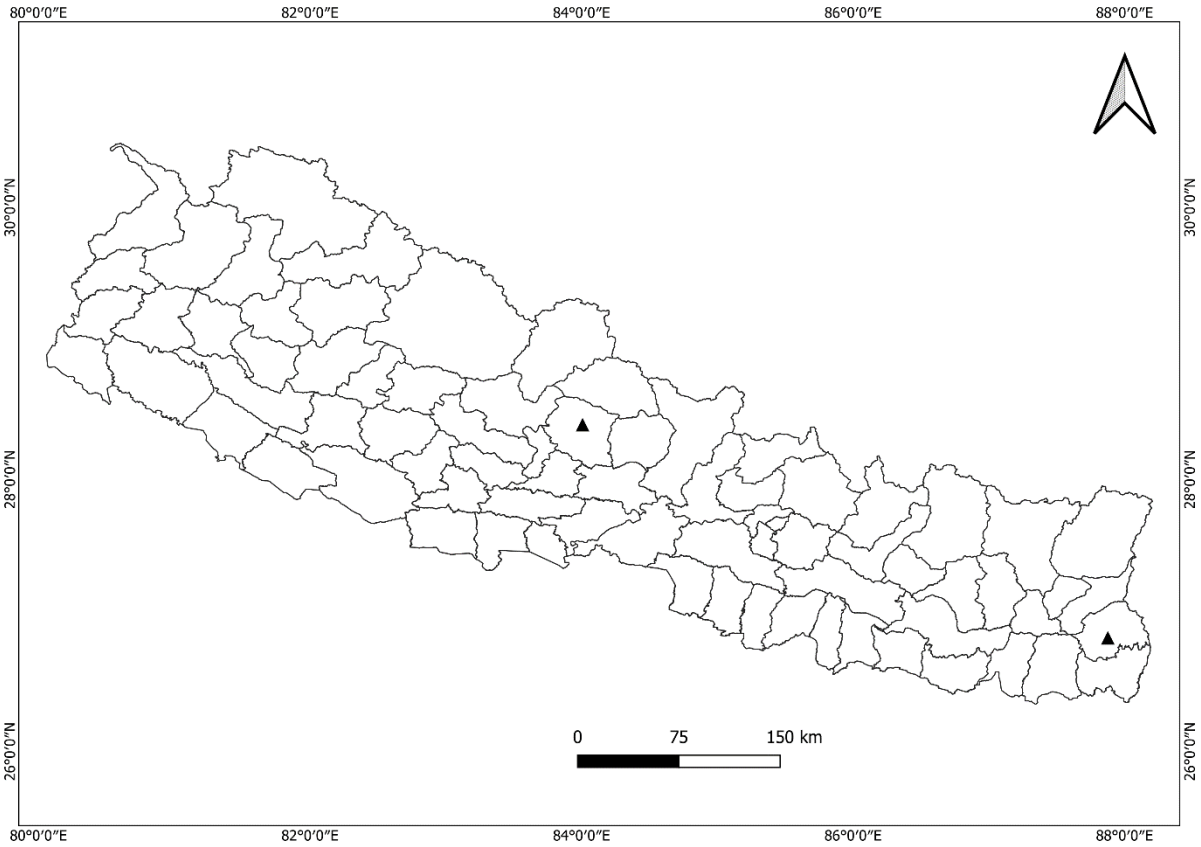
Flowering: September-November.

Note: King & Pantling (1898) suggest that it may be a hybrid between *C. iridioides* D. Don and *C. elegans* Lindl. as its flowers combine characters of both the species. Vij & Shekhar (1987) identified this as a natural hybrid between *C. elegans* and *C. iridioides* based on cytological investigations. Du Puy & Cribb (1988a) identified it as a natural hybrid between *C. elegans* and *C. erythraeum*.

Specimen Examined:

Central Nepal: *Gandaki Province*, **Kaski**, Panchase danda, 2200m, 09/11/2002, A. Subedi *et al*. 1023 (TUCH!).

Eastern Nepal: *Koshi Province*, **Ilam**, 1800m, 1995, S. B. Desar & S. K. Tamang 95/1 (KATH038897!, KATH038898!, KATH038899!).



Map 11: Distribution of *C.* × *gammieanum* King & Pantl. in Nepal.

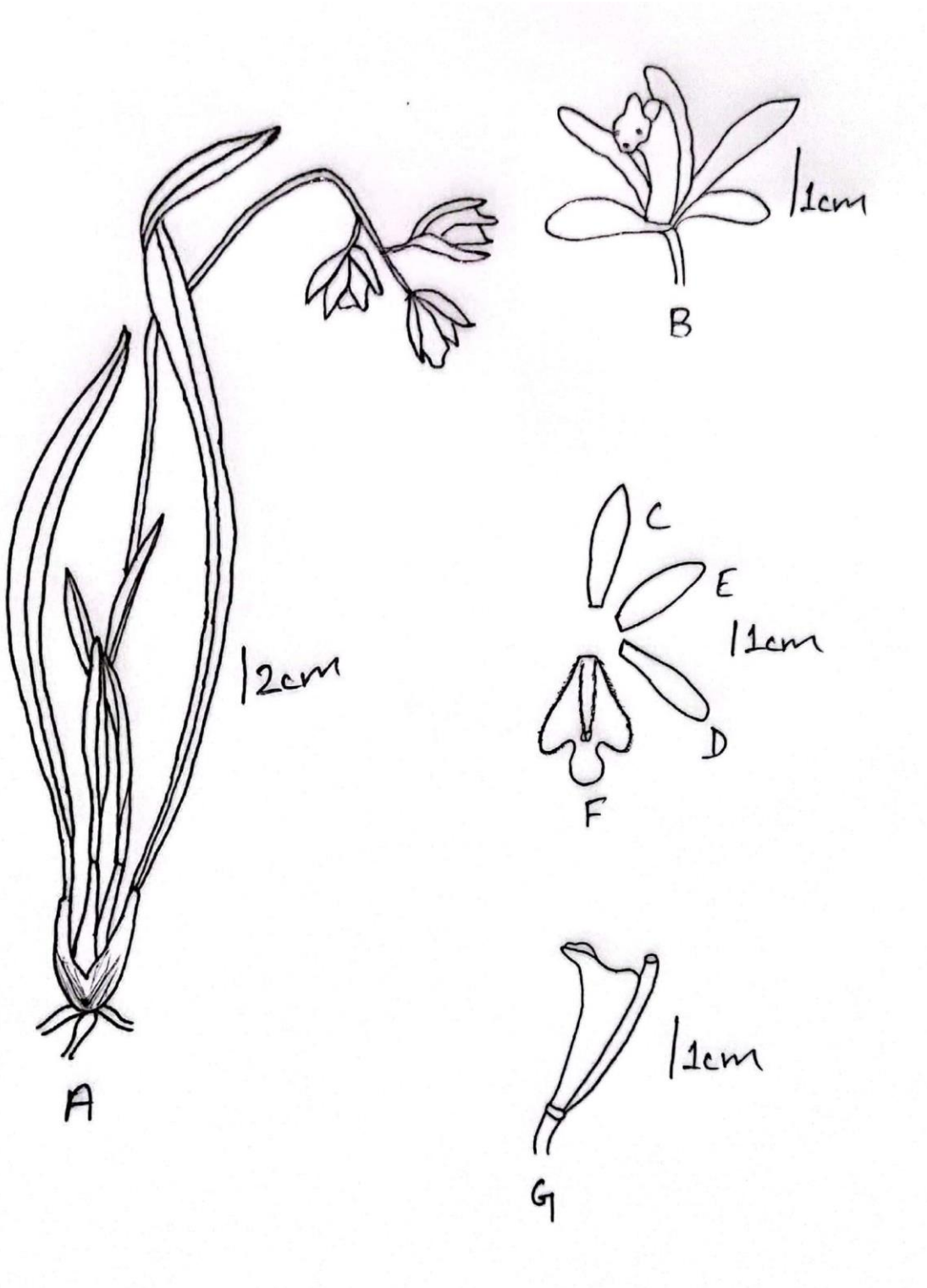


Figure 15: *Cymbidium* × *gammieanum* King & Pantl. A. Habit sketch. B. Single flower. C. Dorsal sepal. D. Lateral sepal. E. Petal. F. Lip. G. Lip and column. (S. B. Desar & S. K. Tamang 95/1, KATH038898).

4.2.6 Doubtfully recorded species

1. *Cymbidium cyperifolium* var. *szechuanicum* (Y. S. Wu & S. C. Chen) S. C. Chen & Z. J. Liu, *Acta Phytotax. Sin.* 41(1): 83. (2003).

Note: This subspecies was mentioned in Rokaya *et al.* (2013) from Central and Eastern Nepal, though the exact location is not traced out and Shrestha *et al.* (2018). There is no authentic herbarium specimen deposited in KATH.

2. *Cymbidium dayanum* Rchb.f., *Edward's Bot. Reg.* 33: t.67. (1847).

Note: This species was first collected by Wallich from Kalmouda, Nepal. Rokaya *et al.* (2013), Shrestha *et al.* (2018) and Chen *et al.* (2009) also reported its presence in Nepal. But there is no any herbarium specimen available in KATH.

3. *Cymbidium eburneum* Lindl., *Edward's Bot. Reg.* 33: t.67. (1847).

Note: Specimen of this species is not available in KATH but it has been reported by Hara *et al.* (1978), Press *et al.* (2000), Raskoti (2009), Rokaya *et al.* (2013) and Shrestha *et al.* (2018).

4. *Cymbidium macrorhizon* Lindl. *Gen. Sp. Orchid. Pl.* 162. (1833).

Note: This species was reported by Shrestha *et al.* (2018) and the photocopy of the illustration done by King & Pantling (1898) had been recorded in KATH. However, the exact location has not been traced down in Nepal.

5. *Cymbidium micranthum* Z. J. Liu & S. C. Chen, *J. Wuhan. Bot. Res.* 22(6): 500. (2004).

Note: This species was reported by Rokaya *et al.* (2013) and Shrestha *et al.* (2018). There is also the record of collection from Nepal by Wallich but there is no authentic herbarium specimen.

4.3 Micro-morphological study of the genus *Cymbidium* Sw.

Micro-morphological characters on leaf epidermal features had been used widely in taxonomic and phylogenetic studies as they provide valuable information (Patal 1979). Williams (1979) reported that *Cymbidium* and the related genera in the tribe Cymbidieae generally have two subsidiary cells. Singh (1981) examined the development of the stomatal complex in *C. iridioides* and found the mature stomata to

be of perigenous type and classified as anomocytic in nature though the guard cells were surrounded by 3-6 neighboring cells. Kaushik (1983) proposed a division of the Orchidaceae according to the morphological type of stomatal complex in a survey of Himalayan orchids. *Cymbidium* was placed in the Paracyticeae, characterized by having paracytic stomata. Du Puy & Cribb (1988) reported that the stomata may be anomocytic or paracytic. Stern (20214) pointed out the stomata are prominently tetracytic. In section Cymbidium, the stomatal covers were elliptical characterized by slit-shaped pores. In subgenus *Jensoa*, pores were circular.

The stomatal complex of 10 species of *Cymbidium* had examined with compound microscope to assess the leaf surface characters that had been used to revise systematics of the genus. The stomatal distribution on the leaf surface, stomatal size with guard cells, stomatal frequency, stomatal index, shape of stomata, shape and type of epidermal cells on the abaxial surface of leaves was found to be variable in different species of *Cymbidium*.

The epidermal cells on abaxial surface are rectangular to polygonal and regular to irregular in shape. The epidermal cells were mostly parenchymatous. Shape of stomata in *Cymbidium* varied from elliptical to circular. Elliptic type of stomata had found in more number than circular type. In species like *C. aloifolium*, *C. crassifolium*, *C. elegans*, *C. erythraeum*, *C.* × *gammieanum*, *C. hookerianum*, *C. iridioides* and *C. lancifolium* the stomata were elliptical type and *C. cyperifolium* and *C. devonianum* had circular type.

The largest stoma was found in *C. cyperifolium* with the area of 7.67 μm^2 and the smallest in *C. crassifolium* with the area of 2.30 μm^2. The stomatal frequency varied from 15.38 mm^2 – 215.38 mm^2. The highest stomatal frequency was found in *C. elegans* and *C. iridioides* with 215.38 mm^2 and the lowest in *C. crassifolium* with 15.38 mm^2. The stomatal index was found highest in *C. iridioides* with 38.88 and the lowest in *C. crassifolium* with 1.78 (Table 7).

Table 7: Micromorphological characters of leaf surface in species of *Cymbidium* Sw.

Abbreviation used: Rect. = Rectangular, poly. = polygonal, paren. = parenchymatous

Name of the species	Stomatal size with Guard cells (µm)	Average no. of stomata (S)	Average no. of epidermal cells (E)	Stomatal Frequency (SF) SF=S/A	Stomatal Index % (SI) SI=S×100/(E+S)	Shape of stomata	Shape of epidermal cells	Type of epidermal cells
C. aloifolium	2.68 × 1.64	2	50	30.76	3.84	Elliptic	Rect. to poly.	Paren.
C. crassifolium	2.21 × 1.04	1	55	15.38	1.78	Elliptic	Rect. to poly.	Paren.
C. cyperifolium	2.77 × 2.77	8	20	123.07	28.57	Circular	Rect. to poly.	Paren.
C. devonianum	2.77 × 1.77	10	35	153.84	22.22	Circular	Rect. to poly.	Paren.
C. elegans	2.86 × 2.51	14	50	215.38	21.87	Elliptic	Rect. to poly.	Paren.
C. erythraeum	2.68 × 1.9	8	40	123.07	17.77	Elliptic	Rect. to poly.	Paren.
C. × gammieanum	3.12 × 1.9	10	25	153.84	28.57	Elliptic	Rect. to poly.	Paren.
C. hookerianum	3.12 × 2.25	13	30	200	30.23	Elliptic	Rect. to poly.	Paren.
C. iridioides	2.34 × 1.73	14	22	215.38	38.88	Elliptic	Rect. to poly.	Paren.
C. lancifolium	2.51 × 1.82	6	15	92.3	28.57	Elliptic	Rect. to poly.	Paren.

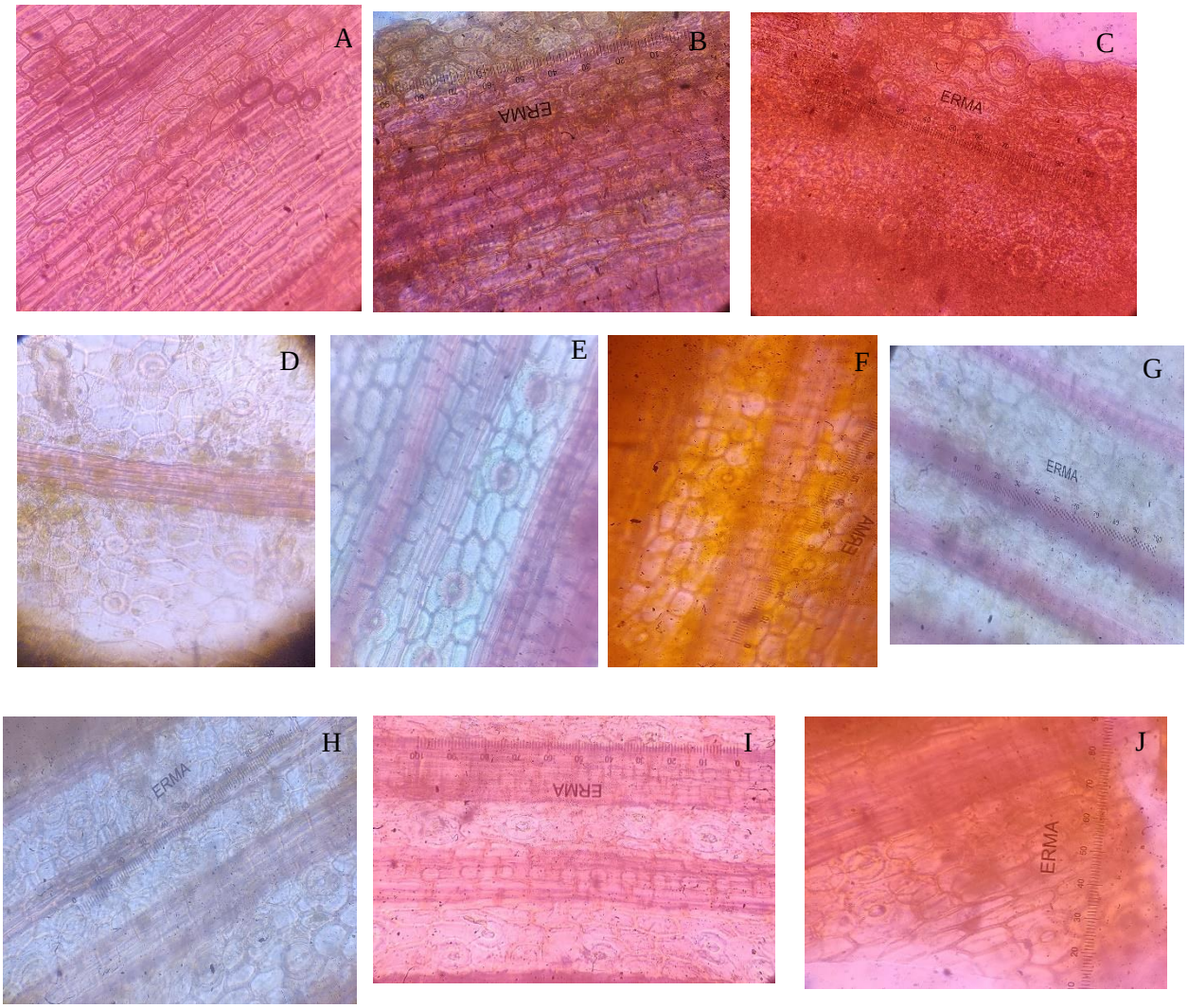


Plate 1: Stomatal variations in different species of *Cymbidium* Sw.

A. *C. aloifolium*; B. *C. crassifolium*; C. *C. cyperifolium*; D. *C. devonianum*; E. *C. elegans*; F. *C. erythraeum*; G. *C.* × *gammieanum*; H. *C. hookerianum*; I. *C. iridioides*; J. *C. lancifolium*.

The present study revealed the stomatal complex of *Cymbidium* which showed variation in types of epidermal cells, shape, size of stomata, stomatal frequency and stomatal index. All species of *Cymbidium* showed hypostomatic leaf surface. Stomata were found only on the abaxial surface because these plants are adapted to aerial habitats to minimize water loss through stomata (Stebbins & Khush, 1961).

4.4 Cladistic Analysis

Cladistic analysis is a parsimony-based search for hierarchial arrangements or patterns of terminal units (in most cases species) which results in an estimate of the relationship between the species and the delimitation of higher level taxa that is monophyletic groups (Ungricht *et al*. 1998). Cladograms represent a synapomorphy scheme which suggests the closeness of relationship due to recency of shared common ancestry and there are many possible phylogenetic trees compatible with one cladogram (Eldredge 1979).

For the study of phylogenetic relationship among the species, 16 characters were selected which are unordered and have equal weight. The two-state or multi-state coding was used for the respective character state and the data matrix was prepared accordingly using NONA. The nearest species *Eulophia dabia* is used as the outgroup in the study. The generated cladograms statistics include Consistency Index (CI) which provides a measure of character fit on the cladogram (amount of homoplasy) and the Retention Index (RI) which express the fraction of similarities on the cladogram interpreted as synapomorphy (Farris 1988). For the terminologies of cladistics study Simpson (2010) was used.

Table 8: Data matrix for cladistics analysis of *Cymbidium* species

	Characters															
Species	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Eulophia dabia	0	1	0	0	0	1	1	0	1	3	0	4	1	0	0	0
C. aloifolium	0	0	0	0	1	2	1	1	0	0	0	0	1	0	0	0
C. crassifolium	0	0	0	0	1	2	1	0	0	1	0	0	1	0	0	0
C. cyperifolium	1	0	0	1	1	0	1	1	1	2	1	1	1	1	1	1
C. devonianum	1	1	1	0	1	2	0	1	0	0	2	2	0	0	0	0
C. elegans	0	0	0	1	1	0	1	0	1	0	3	3	1	0	0	0
C. erythraeum	0	0	0	1	1	1	1	1	1	1	4	4	1	0	1	0
C. × gammieanum	0	0	0	1	1	1	1	0	0	0	1	4	1	1	0	0
C. hookerianum	2	0	0	1	1	0	1	1	1	0	0	4	1	1	1	0
C. iridioides	0	0	0	1	1	0	1	1	1	0	5	4	1	1	1	0
C. lancifolium	1	1	2	1	0	0	0	0	1	2	4	0	1	0	0	1

Characters and character state: Pseudobulb (0): ovoid = 0, cylindric = 1, elliptic-ovoid = 2. Petiole (1): sessile =0, petiolate =1. Leaf shape (2): linear =0, elliptic = 1, lanceolate = 2. Leaf texture (3): leathery = 0, papery = 1. Number of leaves (4): less than or equal to 3 = 0, more than 3 = 1. Leaf apex (5): acute = 0, acuminate = 1, obtuse = 2. Inflorescence (6): less than 30 cm = 0, more than 30 cm = 1. Peduncle sheaths (7): less than or equal to 5 = 0, more than 5 = 1. Pedicel and ovary (8): less than or equal to 15 mm = 0, more than 15 mm = 1. Floral bract (9): ovate = 0, triangular = 1, lanceolate = 2, ovate-lanceolate = 3. Sepal shape (10): oblong = 0, linear-lanceolate = 1, elliptic = 2, obovate = 3, oblanceolate = 4, obovate-oblong = 5. Petal shape (11): elliptic = 0, ovate = 1, elliptic-lanceolate = 2, oblanceolate = 3, oblong = 4. Lip (12): unlobed = 0, 3-lobed = 1. Margin of lateral lobe (13): glabrous = 0, ciliate = 1. Margin of mid-lobe (14): glabrous = 0, ciliate = 1. Pollinia (15): 2 = 0, 4 = 1.

From the cladistics analysis a single most parsimonious tree and other cladogram from Bootstrap method were generated with L = 90, CI = 31 and RI = 50. (Figure 16 and Figure 17).

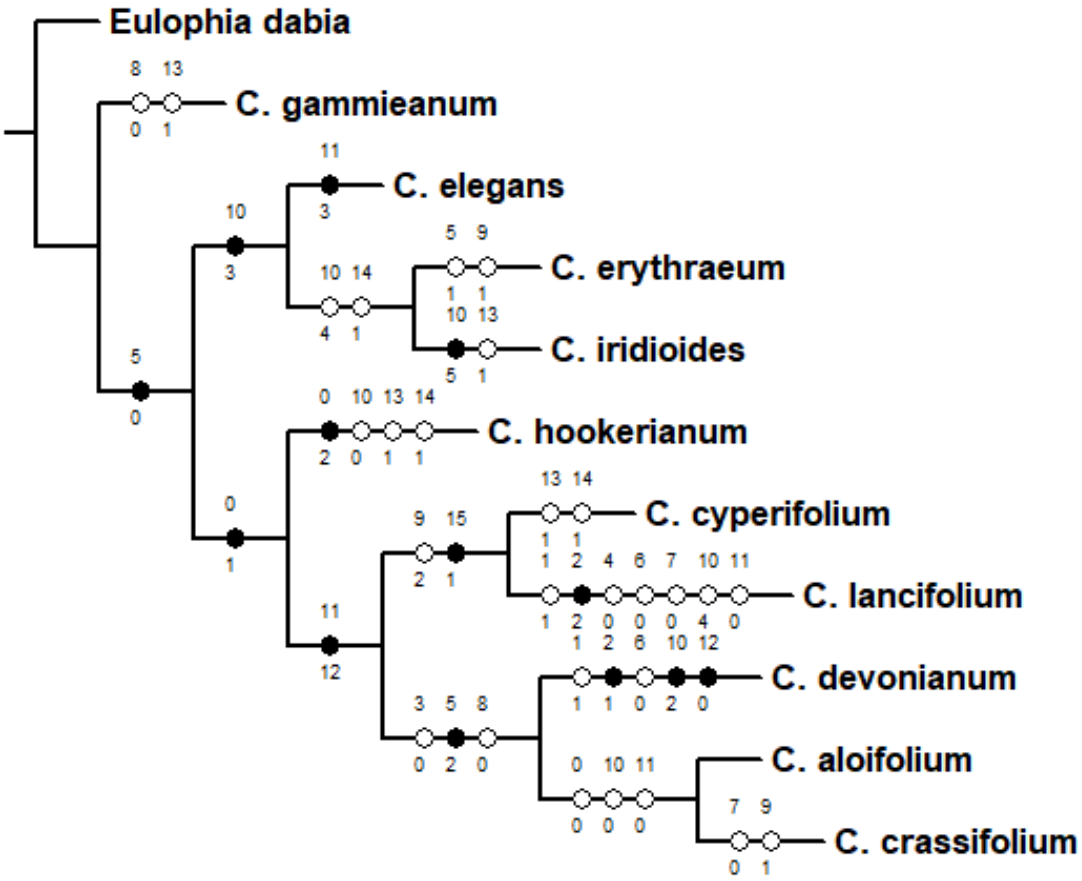


Figure 16: A singlemost parsimonious tree from Winclada analysis.

The legend white circle '○' shows homoplasies and the black circle '●' indicates nonhomoplasious changes among the species. The number in upper tier represents the character and the number in lower tier represents the character state.

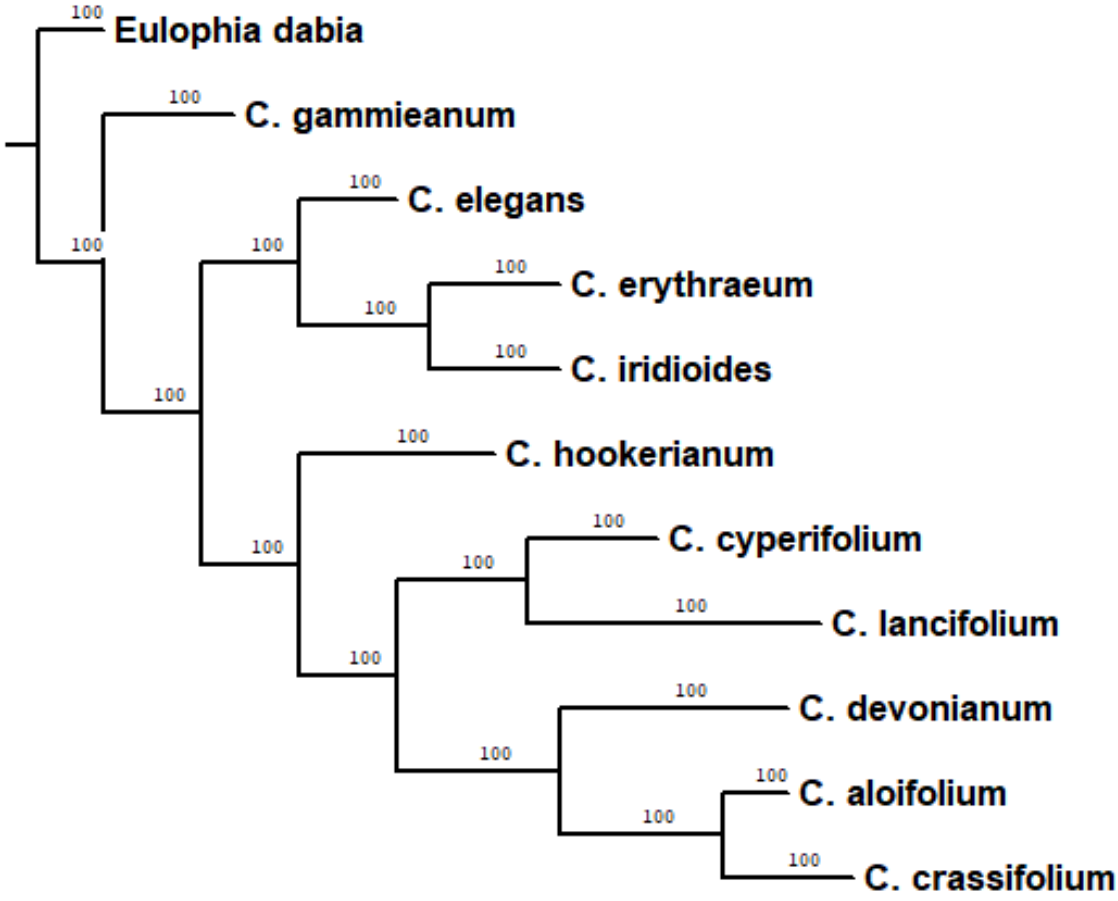


Figure 17: Cladogram by using Bootstrap method.

Cladogram of the 10 species of genus *Cymbidium* with outgroup *Eulophia dabia* shows 2 major clades (Figure 16). *C.* × *gammieanum* formed the first clade which is the natural hybrid. The second clade is formed by the remaining species.

The second clade is further divided into 2 subclades. The subclade 1 is subdivided into two sub-subclades, the first one formed by single species; *C. elegans* and the other formed by two species; *C. erythraeum* and *C. iridioides*. *C. elegans* formed the individual branch as the sepal is oblanceolate in shape and the others have oblong shape. *C. erythraeum* is paired with *C. iridioides* where *C. erythraeum* have oblanceolate sepal and obovate-oblong in *C. iridioides*. They show homoplasy in having ciliate margin of mid-lobe.

The subclade 2 is also further subdivided into two sub-subclades, the first one forming the individual branch by *C. hookerianum* and the other formed by remaining species which is further subdivided. *C. hookerianum* has elliptic-ovoid pseudobulb while the remaining one have the ovoid and cylindric pseudobulb.

The second sub-subclade is further divided into two branch. The first one is formed by *C. cyperifolium* paired with *C. lancifolium*. These two species show homoplasy in having lanceolate floral bract and nonhomoplasy in having 4 pollinia in 2 unequal pairs. The another branch is subdivided where the first sub-branch is fromed by *C. devonianum* and the another sub-branch consists of *C. aloifolium* paired with *C. crassifolium*. These species show homoplasy in having leathery leaves and pedicel and ovary less than or equal to 15 mm; also they show nonhomoplasy in having obtuse leaf apex. *C. devonianum* formed the single branch as it has petiolated leaves, elliptic sepal and unlobed lip while the others have sessile leaves, oblong sepal and 3-lobed lip. *C. aloifolium* and *C. crassifolium* show homoplasy in having ovoid pseudobulb, oblong sepal and elliptic petal.

4.5 Distribution

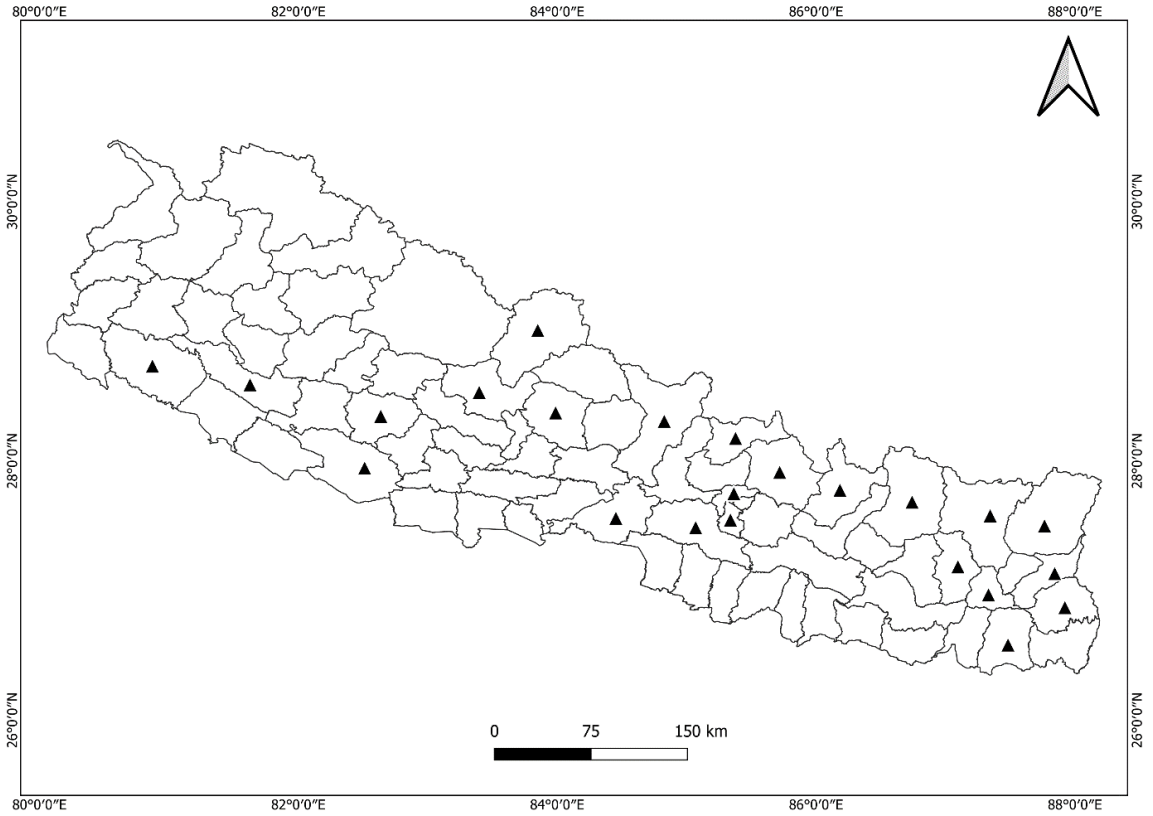
4.5.1 Horizontal Distribution

From the study of herbarium specimens as well as literature survey, 10 species are distributed in 23 districts of Nepal. Out of 10 species, *C. aloifolium*, *C. crassifolium*, *C. elegans* and *C. iridioides* are distributed in all three regions (West, Central and East) of Nepal. *C. cyperifolium* and *C. lancifolium* are distributed only in Central Nepal whereas *C. devonianum* and *C. hookerianum* are distributed only in Eastern Nepal. Similarly, *C. erythraeum* and *C. × gammieanum* are distributed in Central and Eastern Nepal.

Table 9: Horizontal Distribution of *Cymbidium* in Nepal

S.N.	Botanical Name	West	Central	East
1	*C. aloifolium*	$	$@*	$@
2	*C. crassifolium*	*	*	@
3	*C. cyperifolium*		$*	
4	*C. devonianum*			$@
5	*C. elegans*	*	$*	#@
6	*C. erythraeum*		$*	#@
7	*C. × gammieanum*		#*	$
8	*C. hookerianum*			$@
9	*C. iridioides*	*	*	$
10	*C. lancifolium*		$#*	

'$', '#' and '@' represents the distribution of species from herbarium record of KATH, TUCH and international herbaria (TI, BM and E) respectively. * represents the distribution of the species according to the literature survey.



Map 12: Distribution map showing the districts with *Cymbidium* Sw. in Nepal.

4.5.2 Vertical Distribution

According to the literature survey and study of herbarium specimen, it is found out that the species of this genus is usually distributed from sub-tropical to temperate region within the altitudinal range from 800 m to 2800 m in Nepal where majority at the range 1500 m to 2400 m.

Table 10: Horizontal Vs. Vertical Distribution of *Cymbidium*. in Nepal

S.N.	Botanical Name	Horizontal Distribution	Vertical Distribution
1	*C. aloifolium*	West, Central and East	1500-2400 m
2	*C. crassifolium*	West, Central and East	800-1900 m
3	*C. cyperifolium*	Central	1600-1700 m
4	*C. devonianum*	East	1500-2400 m
5	*C. elegans*	West, Central and East	1500-2800 m
6	*C. erythraeum*	Central and East	1500-2400 m
7	*C.* × *gammieanum*	Central and East	1500-2200 m
8	*C. hookerianum*	East	1600-2600 m
9	*C. iridioides*	West, Central and East	1500-2800 m
10	*C. lancifolium*	Central	1300-2400 m

4.6 Flowering season

Present study revealed that the flowering period of the genus *Cymbidium* is usually throughout the year. However, the flowering is not reported in December.

Table 11: Flowering period of *Cymbidium* in Nepal

S.N.	Botanical Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
1	*C. aloifolium*				■	■							
2	*C. crassifolium*			■	■								
3	*C. cyperifolium*						■	■					
4	*C. devonianum*				■	■	■						
5	*C. elegans*									■	■	■	
6	*C. erythraeum*									■	■	■	
7	*C.* × *gammieanum*									■	■	■	
8	*C. hookerianum*	■	■	■	■								
9	*C. iridioides*						■	■					
10	*C. lancifolium*				■	■	■	■	■				

5. DISCUSSION

The present study revealed that the genus *Cymbidium* have 10 species (excluding *C. eburneum*) in Nepal which encompasses the description of plant species with their type, synonymy, distribution, ecology and flowering.

In the case of life form, most of the species are epiphytic with few terrestrial and lithophytic. The species occur mostly on the tree trunks covered by mosses in the host species where the host species are mainly *Shorea robusta*, *Quercus semecarpifolia*, *Lyonia ovalifolia*, *Daphniphyllum himalense* and *Rhododendron arboreum*. The tallest species is *C. erythraeum* and *C. iridioides* reaching upto 60 cm and shortest species is *C. lancifolium* of 25 cm tall. Mostly the leaves are linear, narrow to broad, long, distichous, glabrous with elliptic (*C. devonianum*) and lanceolate (*C. lancifolium*).

The inflorescence in orchids is usually racemose and the flowers of orchids are always subtended by a floral bract which is usually inconspicuous (Dressler 1993). The flowers are arranged laxly to densely in the scape that usually develops from the base of the pseudobulb. Flower size ranges from small to large, semi-open to spreading, non-conspicuous to attractive and conspicuous. The members of section Iridorchis of subgenus *Cyperorchis* have large widely opening flowers except for the dorsal sepal which porrect over the column. Usually the flowers are open in *Cymbidium* but the members of section Cyperorchis are characterized by pendulous inflorescence and campanulate flowers which do not open fully. The lip of the *Cymbidium* is the most important part for the delimitation of the species. The lobes, colour, lip margin, callus and its attachment with the column are the taxonomically superior character for species delimitation in *Cymbidium*. The 3-lobed lip is present in *C. aloifolium, C. crassifolium, C. cyperifolium, C. elegans, C. erythtraeum, C. × gammieanum, C. hookerianum, C. iridioides* and *C. lancifolium*. The unlobed lip is present in *C. devonianum*. The callus or ridges are the extra structures present in the disk of lip in species of *Cymbidium* which are the another key factor for delimitation of species.

The shape of the stomata varied from elliptical to circular where in most of the species elliptical type was found. Various modifications of stomatal shape such as elliptical, circular, transversely elliptical and angular are known to exist within Orchidaceae (Rasmussen, 1987). In the present study, paracytic type of stomata were found among the species where the stomata are arranged in linear form in *C. elegans*, *C. erythraeum*,

C. × *gammieanum*, *C. hookerianum* and *C. iridioides* while scattered in *C. aloifolium*, *C. crassifolium*, *C. devonianum* and *C. lancifolium*.

The cladistics analysis of 10 species of genus *Cymbidium* was carried out with the outgroup *Eulophia dabia* and gave the phylogenetic relationship with 2 major clades using 16 different characters. The cladogram showed two major clades where the first clade comprises of the single natural hybrid species and the rest of the species formed the another clade. *C. erythraeum* and *C. iridioides* are closely related in having ciliate margin in the mid-lobe of the lip and *C. cyperifolium* and *C. lancifolium* are also closely associated as both possess 4 pollinia in 2 unequal pair. Furthermore, *C. aloifolium* and *C. crassifolium* are closely related species supported by leathery leaves with bilobed apex, ovoid pseudobulb, oblong sepal and elliptic petal. Du Puy and Cribb (2007) according to the DNA studies by Berg (2002) and Yukawa & Stern (2002), concluded that the subgenera of *Cymbidium* were not monophyletic, and they retained the sections but dispensed with subgenera. The delimitation of sections within *Cymbidium* were problematic, and most sections were found to be polyphyletic. Thus, the currently defined subgenera and sections of *Cymbidium* are not monophyletic (Zhang *et al*., 2021).

6. CONCLUSION AND RECOMMENDATIONS

The present study concluded that the genus *Cymbidium* is epiphytic, terrestrial, lithophytic which is characterized by the presence of bilaterally compressed ovoid and cylindric fusiform pseudobulbs enclosed by leaf sheaths, distichous, linear to elliptic-lanceolate leaves, showy and large flowers, distinct or obscured 3-lobed lip, pollinia 2 or 4 in two unequal pairs. The present study recognized 10 species within this genus in Nepal.

The species show similarity and dissimilarity in the morphological features. The variations found in these species are in pseudobulb, number of the leaves, floral bracts (shape and size), flower, lip (lateral and mid-lobe). The leaves are usually linear, distichous, elliptic in *C. devonianum* and lanceolate in *C. lancifolium*. Flower size ranges from small to large, semi-open to spreading, non-conspicuous to attractive and conspicuous. The important and the distinguishing character of this genus occurs in the lip. Lip is either lobed or unlobed among the species and the unlobed lip is present in *C. devonianum*. Callus ridge or lamellae at lip is usually paired and simple.

On studying the micromorphological character the shape of stomata in *Cymbidium* varied from elliptical to circular. In species like *C. aloifolium*, *C. crassifolium*, *C. elegans*, *C. erythraeum*, *C.* × *gammieanum*, *C. hookerianum*, *C. iridioides* and *C. lancifolium* the stomata were elliptical type and *C. cyperifolium* and *C. devonianum* had circular type. The largest stoma was found in *C. cyperifolium* with the area of 7.67 μm^2 and the smallest in *C. crassifolium* with the area of 2.30 μm^2. The highest stomatal frequency was found in *C. elegans* and *C. iridioides* with 215.38 mm^2 and the lowest in *C. crassifolium* with 15.38 mm^2. The stomatal index was found highest in *C. iridioides* with 38.88 and the lowest in *C. crassifolium* with 1.78.

The cladistics analysis of 10 species of genus *Cymbidium* was carried out with the outgroup *Eulophia dabia* and gave the phylogenetic relationship with 2 major clades using 16 different characters. The cladogram showed that the two major clades were formed. One comprising the natural hybrid and the another formed by the rest of the species. *C. aloifolium* and *C. crassifolium* are closely related species supported by leathery leaves with bilobed apex.

From the present study, it is also concluded that more collections and distribution of this genus has been made from Central region of Nepal followed by east and west respectively. In case of vertical distribution, it is found that the genus is present at the range from 800 – 2800 m in Nepal. The majority of the species are distributed in sub-tropical to temperate regions. In overall, the genus has been collected from 23 districts of Nepal.

The present study is based on the herbarium specimen examination in KATH and TUCH along with virtual examination of herbarium specimens from the international herbaria. Some of the recommendations are listed as follows:

1. This study is priorly based on the morphological characters with stomatal study of the genus *Cymbidium* and for the further study the molecular study can be performed to resolve the taxonomic limitations.
2. The plant material in the herbarium sheets should be traced out in such a way where any of the plant part is not lost and for the loosening part paper folder could be the best option that helps in further study.
3. The field note in most of the herbarium sheets lack the latitude and longitude of plant collected location. It is recommended to completely label the entire field note in the herbarium sheets.
4. Few collection is done from the Western region of Nepal, so it is recommended to explore the western Nepal equally with the Central and Eastern Nepal.

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(www.worldfloraonline.org)

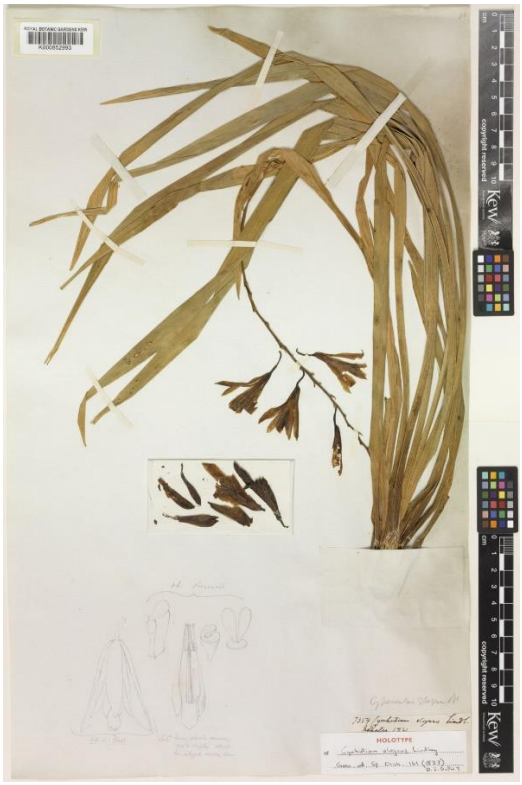
Annex: Type specimens of *Cymbidium* species

Holotype of *C. aloifolium* (L.) Sw. (K)

Holotype of *C. crassifolium* Herb. (K)

Syntype of *C. cyperifolium* Wall. ex Lindl. (K)

Holotype of *C. devonianum* Paxton. (K)



Holotype of *C. elegans* Lindl. (K)

Holotype of *C. erythraeum* Lindl. (K)

C. × *gammieanum* King & Pantl. (K)

Holotype of *C. hookerianum* Reichb. (W)

Iso-Lectotype of *C. iridioides* D. Don. (K)

C. lancifolium Hook. (K)

Annex 2: Photographs

C. devonianum Paxton.

C. elegans Lindl.

C. hookerianum Reichb.

C. lancifolium Hook.

नेपाल सरकार
वन तथा वातावरण मन्त्रालय
वन तथा भू-संरक्षण विभाग

फोन नं. ४-२२७५७४, ४-२२०३०३
फयाक्स: ४-२२७३७४

(कृपया पत्रोत्तरमा प्राप्त पत्र संख्या र मिति उल्लख गर्नुहोला।
बबरमहल, काठमाडौं, नेपाल

प्राप्त पत्र संख्या र मितिः-
पत्र संख्याः- ०८०।८१
च. नं.:- ६८३

मितिः २०८०/०९/१७
नेपाल संवत ११४४

विषयः अनुसन्धान अनुमति सम्वन्धमा ।

श्री अमिता त्वायना,
भक्तपुर, नेपाल ।

प्रस्तुत विषयमा Tribhuvan University, Amrit Campus, Kathmandu मा M. Sc. in Botany 4th semester मा अध्ययनरत तपाईले "Taxonomic Revision on Genus *Cymbidium* Swartz (Orchidaceae) of Nepal" को विषयमा अध्ययन अनुसन्धानका लागि अध्ययन अनुमति उपलब्ध गराइदिनु हुन भनि मिति २०८०/०८/१५ गते यस विभागमा दिनु भएको निवेदन साथ प्रपोजल प्राप्त भयो। सो सम्वन्धमा कारवाही हुँदा उक्त प्रपोजलमा उल्लेखित Methodology (Field Visit, plant specimen collection and Cladistic analysis) अनुसार तपसिलको शर्तहरुको अधिनमा रही डिभिजन वन कार्यालयसँग समन्वय गरि सन् २०२४, January देखि सन् २०२४, June सम्मका लागि अनुसन्धान गर्नु हुन निर्देशानुसार अनुरोध छ ।

शर्तहरु

१. अनुसन्धानकर्ताले वन ऐन २०७६ तथा वन नियमावली २०७९, राष्टिय निकुञ्ज तथा वन्यजन्तु संरक्षण ऐन, २०२९ र नियमावली २०३० तथा यस मातहतका नियमावलीहरुको पूर्ण पालना गर्नुपर्नेछ ।
२. अनुसन्धान कार्य डिभिजन वन कार्यालयसँगको समन्वयमा गर्नुपर्नेछ ।
३. सकलित नमुनाहरुको परिक्षण कार्य Amrit Campus, Kathmandu को प्रयोगशालामा गर्नुपर्नेछ ।
४. अनुसन्धानको क्रममा प्राप्त भएको जैविक विविधता संरक्षणसँग सम्वन्धित संवेदनशिल सूचनाहरु गोप्य राख्नु पर्नेछ । अनाधिकृत रुपमा त्यस्ता सूचनाहरु कसैलाई पनि उपलब्ध गराउन पाइने छैनं ।
५. अनुसन्धान कार्य समाप्त भए पश्चात एक प्रति रिपोर्ट/प्रतिवेदन (कागजी तथा विद्युतिय) यस विभागमा अनिवार्य रुपमा वुझाउनु पर्नेछ ।
६. तोकिएका शर्तहरुको पालना नगरिएमा विभागले कुनै पनि समयमा अनुसन्धान अनुमति रद्द गर्न सक्नेछ ।

(सवनम पाठक)
वन अधिकृत

वोधार्थ

श्री डिभिजन वन कार्यालय, कास्की। : आवश्यक सहयोग तथा अनुगमनको लागि अनुरोध छ ।