

TAXONOMIC REVISION OF THE GENUS
***Calanthe* R. Br. (ORCHIDACEAE) IN NEPAL**



A DISSERTATION SUBMITTED TO THE
DEPARTMENT OF BOTANY
AMRIT CAMPUS
INSTITUTE OF SCIENCE AND TECHNOLOGY
TRIBHUVAN UNIVERSITY
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BOTANY

BY

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MARCH, 2023

DECLARATION

I declare that this Dissertation entitled “**Taxonomic Revision of the Genus *Calanthe* R. Br. (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 and cosupervised by Dr. Tirtha Raj Pandey, Research Officer, National Herbarium and Plant Laboratories, Godawari. 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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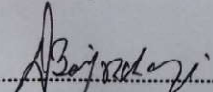
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RECOMMENDATION

This is to recommend that **Rina Duwal** has carried out the research entitled “**Taxonomic Revision of the Genus *Calanthe* R. Br. (Orchidaceae) in Nepal**” for the partial fulfillment of requirements for the Master’s Degree in **Botany** under our supervision. To our 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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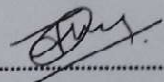
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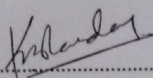
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LETTER OF APPROVAL

The M. Sc. dissertation entitled "Taxonomic Revision of the Genus *Calanthe* R. Br. (Orchidaceae) in Nepal" submitted by Rina Duwal 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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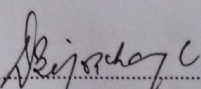

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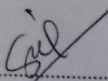

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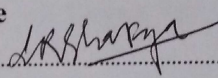

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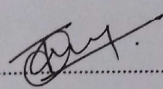

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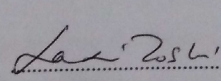

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ABSTRACT

Calanthe is the terrestrial orchid with a distinguishing character of a plicate, linear to broad leaves, 8 pollinia in 2 groups, and the genus mostly occurs in moist and humid dense forest floors. The genus was closely related to previously known genus *Phaius* and after the merge of these two genera in 2020 by Chase *et al.* the nomenclatural stability is maintained. This study is based on all the species of these taxa that are naturally distributed in Nepal.

This taxonomic revisionary study is based on the herbarium specimens 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, E, K and TI. This study confirms the presence of 15 species of *Calanthe* in Nepal namely; *C. alpina*, *C. arcuata*, *C. brevicornu*, *C. chloroleuca*, *C. davidii*, *C. densiflora*, *C. griffithii*, *C. mannii*, *C. masuca*, *C. plantaginea*, *C. puberula*, *C. tankervilleae*, *C. tricarinata*, *C. trulliformis* and *C. woodfordii*. Among these 15 species, 2 species are later added from previously known genus '*Phaius*'; *C. tankervilleae* and *C. woodfordii*.

The synonyms, type specimens, description, ecology, altitudinal range, flowering season, specimens 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.

Additionally, the cladistic analysis is also interpreted to find out the phylogenetic relationship between the species. The cladogram showed that *C. chloroleuca* and *C. plantaginea* are closely related species. Similarly, the study also portrayed the closest relationship between *C. tankervilleae* and *C. woodfordii*.

The genus *Calanthe* is found to be distributed in all 3 regions of Nepal with the altitudinal range from 200 m to 3300 m in 31 districts of Nepal. The peak flowering season of this genus is May to August and more than half of species of *Calanthe* in Nepal have flowering time in these months.

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ABBREVIATIONS AND ACRONYMS

<p>& <i>Ann. Ch. Fl. Pl. Nep.</i> <i>Ann. Roy. Bot. Gard.</i> <i>Calcutta</i> °E °N BM ca. cm E <i>Enum. Fl. Pl. Nep.</i> <i>et al</i> <i>Fl. Brit. Ind.</i> <i>Fl. China</i> <i>Fol. Orchid.</i> ft <i>Gen. Sp. Orchid. Pl.</i> <i>Hand. Fl. Pl. Nep.</i> <i>Hand. Orchid. Nep</i> K K-LINDL KATH L LINN-HS m P <i>Pl. Nep.</i> <i>Pl. Vas. Gen.</i> <i>Prodr. Fl. Nepal.</i> R. Br. TI TUCH</p>	<p>and Annotated Checklist of Flowering Plants of Nepal Annals of the Royal Botanic Garden, Calcutta Longitude latitude Natural History Museum, London, U. K. approximately Centimeter Royal Botanic Garden Edinburgh An Enumeration of Flowering Plants of Nepal and others Flora of British India Flora of China Folia Orchidaceae feet The Genera and Species of Orchidaceous Plants Handbook of Flowering Plants of Nepal A Handbook of the Orchids of Nepal Kew Royal Botanic Gardens, London, U. K. The Lindley Herbarium National Herbarium and Plant Laboratories, Lalitpur, Nepal Naturalis Biodiversity Centre, formerly Leiden University, Leiden, Neitherland The Linnean collections, Smith Herbarium, London, U. K. meter Herbier Museum Paris, Paris, France Plants of Nepal Plantarum Vascularium Genera Prodromous Florae Nepalensis Robert Brown The University of Tokyo, Japan Tribhuvan University Central Herbarium, Kathmandu, Nepal</p>
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1. INTRODUCTION

1.1 Background

Orchidaceae is the flowering plant family that is cosmopolitan, distributed in almost all kind of habitat except glaciers. It is widely distributed in the tropical and subtropical regions of the world and is regarded as one of the largest, most diverse and distinctive family of flowering plants (Dressler 1981, 1993). Orchidaceae is the second largest flowering plant family with 28,237 species after Asteraceae with 32,581 species in the world (Shrestha 2020). The word 'Orchid' was first time used by Linnaeus as Orchis in 1742 in his Book '*Genera Plantarum*' in which he described only nine orchid genera known at that time. The members of orchidaceae family are known as orchids. The word 'Orchid' is derived from the ancient greek word 'Orchis' which means testicle and the word is drawn similar with the underground bulb (Teoh 2005).

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 (Adhikari *et al.* 2016). Terrestrial orchid life-cycles are complex and dependent on pollinators and mycorrhizal associates (Shefferson *et al.* 2020).

The diagnostic characters of family orchidaceae have been listed in different points by many scientists till the 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 only in the case of the 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 conditions, seed can germinate only when symbiotic fungi are present.

One of the petals in most orchid is highly modified to form lip or labellum which is attractively colored and most of them forms scent to attract the agent for pollination however, many orchids does not have a lip, for example *Thelymitra* from Australia have similar petals (Chase & Christenhusz 2017). The lip is marked by unusual form, veining patterns and usually a series of keels and protuberances called callus, these overall shape of lip and callus is highly adapted for insect attraction with resulting pollination (Withner

1959). The stamen and pistil are fused in a single structure called column and the flowers mostly resupinate.

According to Acharya *et al.* (2011) 239 taxa of orchids are present in Western Himalaya, 372 species in Central Himalaya and 490 species of orchids are present in Eastern Himalaya. In Nepal, Orchidaceae is the largest flowering plant family with 480 species belonging to 112 genera followed by Poaceae with 450 species and Asteraceae with 437 species (Shrestha 2020) comprising 7.1% of total Nepal's angiosperms (Rokaya *et al.* 2013) among which 18 species are known to be endemic (Rajbhandari 2014) and distributed between 60 and 5200 m above sea level in range of habitats from tropical low land to high Himalayan of Nepal (Rokaya *et al.* 2013; Rajbhandari & Rai, 2017; Shrestha *et al.* 2018; Bhandari *et al.* 2020).

1.2 Genus *Calanthe* R. Br.

The genus *Calanthe* was described by Robert Brown in 1821. The generic name is derived from the Greek words 'kalos' (beautiful) and 'anthe' (flower). *Calanthe* R. Br. is the largest genus of the tribe Collabieae (Subfamily Epidendroideae). The major distinguishing characters of the *Calanthe* are plicate leaves, anther-1, 8 waxy pollinia in 2 groups, lip joined to half or whole length of the column (Clayton & Cribb 2013). Most of the *Calanthe* species are terrestrial and deciduous, they lose their leaves before the flower spikes develop and after flowering they take a short rest (Manda 1937). The genus *Calanthe* (*C. dominii*) is the first hybrid orchid to flower successfully, the cross was made between *C. masuca* and *C. furcata* by J. Dominy in 1853 (Curtis 1910).

Calanthe is widespread orchid predominantly occurring in tropical, subtropical and temperate regions of Asia, Australia, Madagascar, New Guinea, South west Pacific Island, tropical Africa, Central and South America (Chen *et al.* 2009a; Clayton & Cribb 2013). The centre of diversity of this genus is found to be South East Asia while the Malay Archipelago and New Guinea are the secondary centres of diversity of genus *Calanthe* (Clayton & Cribb 2013).

Total of 216 species of *Calanthe* are present worldwide (Chase *et al.* 2015). The highest endemism of *Calanthe* occurs in New Guinea which is followed by Borneo, Sumatra and subtropical China (Clayton & Cribb 2013). The online database; The World Flora Online (WFO) includes 449 species of *Calanthe* with 250 accepted name of *Calanthe*

(www.worldfloraonline.org; retrieved on 23 March 2023). Total of 15 species (*Calanthe* + *Phaius*) of *Calanthe* are present in Nepal (Rajbhandari 2015; Rajbhandari & Rai 2017; Shrestha *et al.* 2018) with the altitudinal distribution ranging from 200 m – 3300 m (Rokaya *et al.* 2013). And the number of species of this genus increased to 18 according to Shrestha *et al.* (2022).

1.3 Systematic position of the genus *Calanthe* R. Br.

Lindley (1830-1840) described all the then known 19 species of *Calanthe* and placed the genus under the tribe Vandeeae, one of the seven tribes recognized by him. Later Lindley in 1852-1855 categorised the then known 38 species of *Calanthe* into two sections namely; ‘Ghiesbreghtia’ and ‘Eucalanthe’ on the basis of absence or short spur and long spur respectively. Bentham (1881) defined the genus on the basis of pseudobulb and floral characteristics, he kept the genus *Calanthe* in subtribe Coelogynae under the tribe Epidendreae. Hooker (1890) following the classification of Bentham (1881) for the intergeneric classification explained 34 *Calanthe* species and separated them into three sections based on the position and attachment of lip and column.

King & Pantling (1898) transferred the genus *Calanthe* to tribe Vandeeae from Epidendreae along with two other genus *Crytochilus* and *Oreorchis* saying the fact that ‘the gland terminating the caudicle is, in all three, unmistakably derived from the stigma’. Dressler & Dodson (1960) placed the genus in subtribe Blettiinae under the tribe Epidendreae on the basis of the number and nature of pollinia.

Dressler (1981, 1993) placed *Calanthe* in the tribe Arethusae and subtribe Blettiinae. Rao (2010) described 16 species of *Calanthe* from Arunachal Pradesh, India and he had placed the genus into subtribe Blettiinae under the tribe Bletieae by dividing *Calanthe* into 2 subgenera (*Preptanthe* and *Calanthe*) and 7 sections. Among the 7 sections, two additional sections were recognized in the subgenus *Calanthe*; *Monophylla* and *Vernae*. Chase *et al.* (2015) placed the genus *Calanthe* in the tribe Collabieae in the updated classification of Orchidaceae. The present study follows the classification by Chase *et al.* (2015).

1.4 Generic delimitation of *Calanthe* R. Br.

The generic name *Calanthe* was first time used by Robert Brown in 1821 while describing a species of *Lissochilus* in the book ‘*The Botanical Register*’ by Edwards (1821). He said that *Calanthe* agrees with *Bletia* in having eight pollen masses, but differs from it in the claw of the lip being connected with the column. In the ninth volume of ‘*The Botanical Register*’ by Edwards (1823), the species *C. veratrifolia* was described. A species from Madagascar, *Alismorkis sylvatica* (= *C. sylvatica*) is the first latin binomial name provided to this genus by a French botanist Louis Marie Aubert du Petit Thouars in 1809 and he renamed this species as *Centrosia sylvatica* in 1822 (Clayton & Cribb 2013).

The genus *Calanthe* has previously many complexes regarding the allied genera and clades in classification. *Calanthe* is very near to *Phaius* having very little morphological differences; the apex of column is more or less united with the lip in *Calanthe* while in *Phaius*, the apex of the column is free from the lip and the species *Calanthe delavayi* is the link between the two genera which have characteristics of both genus (Xiang *et al.* 2014). *Calanthe delavayi* shows the character of *Phaius* having the lip that is not completely fused to and also clasps the column making it unclear whether it is to consider *Calanthe* or *Phaius*. The morphological data only is not enough for the taxonomic classification. On the basis of genetic information, the origin of *Calanthe* is polyphyletic and its relatives are *Phaius* and *Cephalantheropsis* (Xiang *et al.* 2014; Zhai *et al.* 2014).

Even after several of relevant studies in terms of molecular phylogenetics (Yukawa & Ishida 2008, Yukawa 2013, Yukawa & Cribb 2014, Xiang *et al.* 2014, Zhai *et al.* 2014) the problems of *Calanthe* and related genera is so muddled that the specialists find it confusing and unworkable. Chase *et al.* (2020) proposed the rejection of name *Phaius* in favour of the name *Calanthe* and made necessary combinations, they expanded *Calanthe* to merge and include the species of *Phaius* along with *Cephalantheropsis* and *Gastrorhiza* in the genus *Calanthe*.

1.5 Statement of the problem

The first generic material for this genus was published by Lindley in 1830-1840 the book ‘*The Genera and Species of Orchidaceous Plants*’. Regarding the monograph, ‘*The Genus Calanthe*’ is the only monograph published till date. It was published by Clayton

& Cribb in 2013. The first taxonomic revision in this genus (published material) was performed by Rathore (1983) in India.

The *Calanthe* group is a well defined group of terrestrial orchid species in a tribe Collabieae under the subfamily Epidendroideae which comprises three genera as *Calanthe* R. Br., *Phaius* Lour. and *Cephalantheropsis* Guillaumin that have similar morphological characteristics (Kurzweil 2010, Kurzweil & Ormerod 2019, Zhai *et al.* 2014, Buddhachat *et al.* 2022) however, due to limited and confusing delimitation characters, the taxonomy of the *Calanthe* group has not been sufficiently resolved and the phylogenetic analysis revealed a paraphyletic relationship in the *Calanthe* group (Nanjala *et al.* 2022) while in case of the genus it is shown that the genus is polyphyletic in origin (Xiang *et al.* 2014, Yukawa & Cribb 2014, Zhai *et al.* 2014). The genus *Calanthe* was closely related to genus *Phaius*. There was always the unresolved problems and confusion regarding these two closely related genera. Different phylogenetic analysis and molecular study were also performed by the scientists and researcher to shut out the problems. Therefore, to make the nomenclatural stability Chase *et al.* (2020) provide new names by merging these two genera and made necessary combinations to broaden generic concept of *Calanthe* and hence the genus *Phaius* has now come under the genus *Calanthe*.

After this expansion of the genus, the taxonomic revision for this genus was mandatory in Nepal. Infact there was no any taxonomic revision performed in this genus in Nepal before this historical date for *Calanthe*. The main aim of this study is to give the additional diagnostic characters regarding the morphology, flowering, distribution and phylogenetic relationship of the species of *Calanthe* in Nepal.

1.6 Objectives

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

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

1.7 Limitations of study

The attempt to collect the fresh specimens from the field at respective flowering season was done as planned. But the collection of all the species of *Calanthe* present in Nepal was impossible during the study. The herbarium specimens deposited are the major source to study for the remaining uncollected species.

The presence of *C. biloba* in Nepal was mentioned in Hara *et al.* (1978) but the authentic herbarium specimen of this species from Nepal could not be traced in any herbaria. In this study, *C. biloba* is excluded.

The micromorphological study could not be performed in this study as 3 species (*C. davidii*, *C. masuca* and *C. woodfordii*) are examined virtually from the international herbaria. Similarly all remaining 12 species could not be collected during the study time. Therefore, this study priorly has focused on the morphological study.

The herbarium specimens of *C. davidii*, *C. masuca* and *C. woodfordii* were lacking in Nepalese herbarium, KATH and TUCH so, they were studied virtually from the available images in the international herbarium.

Most of the herbarium specimens deposited in enquired herbaria (KATH, TUCH, BM, E, K and TI) lacks the pseudobulb, so different other literatures and floras were studied as a reference for the taxonomic information of that part.

2. LITERATURE REVIEW

2.1 *Calanthe* R. Br. 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. Suwal (1969) mentioned 2 species of *Calanthe* from Phulchoki and Godawari; *C. masuca* and *C. tricarinata* along with the short description and its flowering season. Malla (1973) reported *C. masuca* from Nagarjun with the short information about the ecology and flower. Malla *et al.* (1976) recorded *C. puberula* from Langtang with a very short description. Hara *et al.* (1978) enumerated 315 species of orchids from Nepal under 90 genera and excluding *C. biloba* among 12 species described, 11 species of them are now present in Nepal; *C. alpina*, *C. brevicornu*, *C. flavus* (*C. woodfordii*), *C. mannii*, *C. masuca*, *C. pachystalix* (*C. davidii*), *C. plantaginea*, *C. puberula*, *C. tankervilleae*, *C. tricarinata* and *C. trulliformis*.

Banerji (1978) mentioned 4 species of *Calanthe* from Nepal along with short description and key; *C. chloroleuca*, *C. masuca*, *C. plantaginea* and *C. tricarinata*. Later Banerji & Pradhan (1984) described 10 herbarium specimens of *Calanthe* deposited at KATH; *C. alpina*, *C. brevicornu*, *C. chloroleuca*, *C. flavus* (*C. woodfordii*), *C. mannii*, *C. plantaginea*, *C. puberula*, *C. tankervilleae*, *C. tricarinata* and *C. trulliformis*. The book also has described about *C. masuca* and *C. pachystalix* (*C. davidii*) in short without including them in the key. Malla *et al.* (1986) reported 6 species of *Calanthe* from Kathmandu valley; *C. brevicornu*, *C. mannii*, *C. masuca*, *C. plantaginea*, *C. puberula* and *C. tricarinata*.

Press *et al.* (2000) listed 12 species of *Calanthe* from Nepal; *C. alpina*, *C. brevicornu*, *C. flavus* (*C. woodfordii*), *C. mannii*, *C. masuca*, *C. pachystalix* (*C. davidii*), *C. plantaginea*, *C. puberula*, *C. tankervilleae*, *C. tricarinata* and *C. trulliformis* (excluding *C. biloba*). An updated online version of Press *et al.* (2000) mentioned 15 species of *Calanthe* from Nepal; (*C. alpina*, *C. brevicornu*, *C. chloroleuca*, *C. densiflora*, *C. flavus* (*C. woodfordii*), *C. griffithii*, *C. mannii*, *C. masuca*, *C. pachystalix* (*C. davidii*), *C. plantaginea*, *C. puberula*, *C. tankervilleae*, *C. tricarinata* and *C. trulliformis*) excluding *C. biloba*. Rajbhandari & Bhattarai (2001), mentioned 6 species of *Calanthe*; *C. brevicornu*, *C. mannii*, *C. masuca*, *C. pachystalix* (*C. davidii*), *C. plantaginea* and *C. tricarinata*.

Rajbhandari & Dahal (2004) reported 14 species of *Calanthe* from Nepal; *C. alpina*, *C. brevicornu*, *C. chloroleuca*, *C. griffithii*, *C. flavus* (*C. woodfordii*), *C. mannii*, *C. pachystalix* (*C. davidii*), *C. plantaginea*, *C. puberula*, *C. tankervilleae*, *C. tricarinata* and *C. trulliformis* (excluding *C. biloba* and *C. sylvatica*). Rajbhandari (2005) made a new addition of *Calanthe densiflora* Lindl. to the Flora of Nepal. Raskoti (2009) reported 10 species of *Calanthe* from Nepal; *C. chloroleuca*, *C. flavus* (*C. woodfordii*), *C. mannii*, *C. pachystalix* (*C. davidii*), *C. plantaginea*, *C. puberula*, *C. masuca*, *C. tankervilleae*, *C. tricarinata* and *C. trulliformis*. Rokaya *et al.* (2013) reported 437 species of orchids under 104 genera and 15 species of *Calanthe* from Nepal; *C. alpina*, *C. brevicornu*, *C. chloroleuca*, *C. davidii*, *C. densiflora*, *C. flavus* (*C. woodfordii*), *C. griffithii*, *C. mannii*, *C. plantaginea*, *C. puberula*, *C. masuca*, *C. tankervilleae*, *C. tricarinata* and *C. trulliformis* (excluding *C. biloba* now). The species *C. masuca* was kept as a synonym of *C. sylvatica* in this checklist.

Shakya & Bajracharya (2013) reported 2 species of *Calanthe*; *C. plantaginea* and *C. puberula* from Shivapuri National Park. Rajbhandari (2014) mentioned that Nepalese species of *Calanthe* have ornamental value; *C. brevicornu*, *C. plantaginea* and *C. masuca* and medicinal value; *C. plantaginea* (rhizome as tonic), *C. puberula* (rhizome as antipyretic), *C. masuca* (pseudobulb to stop bleeding) and *C. tricarinata* (leaves aphrodisiac). Rajbhandari (2015) listed 15 Nepalese *Calanthe*; *C. alpina*, *C. brevicornu*, *C. chloroleuca*, *C. davidii*, *C. densiflora*, *C. griffithii*, *C. flavus* (*C. woodfordii*), *C. mannii*, *C. plantaginea*, *C. puberula*, *C. masuca*, *C. tankervilleae*, *C. tricarinata* and *C. trulliformis* (*C. biloba* now excluded and *C. masuca* was written as synonym of *C. sylvatica* in this book).

Pant *et al.* (2016) studied the orchid diversity along with their medicinal value in two community forest of Makwanpur district and reported 63 species of orchid from the area in which 3 species belong to the genus *Calanthe*; *C. plantaginea* (dry powder of rhizome with milk used as tonic and aphrodisiac), *C. puberula* (rhizome is used as antipyretic) and *C. tricarinata* (leaves and pseudobulb are used as aphrodisiac and leaf paste applied on sores and eczema). Rajbhandari *et al.* (2016) reported 48 species of orchids and among them one is *Calanthe tricarinata* from Kailali, West Nepal. Rajbhandari & Rai (2017) listed 15 Nepalese *Calanthe*; *C. alpina*, *C. brevicornu*, *C. chloroleuca*, *C. davidii*, *C.*

densiflora, *C. griffithii*, *C. flavus* (*C. woodfordii*), *C. mannii*, *C. plantaginea*, *C. puberula*, *C. masuca*, *C. tankervilleae*, *C. tricarinata* and *C. trulliformis*.

Bhandari *et al.* (2018) reported 49 genera and 125 species of orchids including 2 species of *Calanthe* from Panchase protected forest; *C. plantaginea* and *C. puberula*. Shrestha *et al.* (2018) reported 15 species of *Calanthe* from Nepal; *C. alpina*, *C. brevicornu*, *C. chloroleuca*, *C. davidii*, *C. densiflora*, *C. flavus* (*C. woodfordii*), *C. griffithii*, *C. mannii*, *C. plantaginea*, *C. puberula*, *C. masuca*, *C. tankervilleae*, *C. tricarinata* and *C. trulliformis* (*C. biloba* excluded now). Bhandari *et al.* (2020) carried out a study in Panchase forest of mid hills of Central Nepal and reported 52 genera of orchids with 4 *Calanthe* species in the area; *C. mannii*, *C. plantaginea*, *C. puberula* and *C. tricarinata*. Rajbhandari *et al.* (2020) reported 10 species of *Calanthe* from Province No. 1, East Nepal; *C. alpina*, *C. brevicornu*, *C. chloroleuca*, *C. griffithii*, *C. mannii*, *C. puberula*, *C. tankervilleae*, *C. tricarinata* and *C. trulliformis* (excluding *C. biloba*). Shrestha *et al.* (2022) reported 18 species of *Calanthe* from Nepal; *C. alpina*, *C. arcuata*, *C. brevicornu*, *C. chloroleuca*, *C. davidii*, *C. densiflora*, *C. griffithii*, *C. mannii*, *C. masuca*, *C. plantaginea*, *C. puberula*, *C. tankervilleae*, *C. tricarinata*, *C. trulliformis* and *C. woodfordii* (excluding *C. biloba*, *C. himalaicum* and *C. metoensis*).

2.2 *Calanthe* R. Br. in international literatures

Lindley (1830-1840) described about 19 species of *Calanthe* and among them 7 species are present in Nepal; *C. brevicornu*, *C. densiflora*, *C. maculatus* (*C. woodfordii*), *C. masuca*, *C. plantaginea*, *C. puberula* and *C. tricarinata*. Lindley (1852-1855) again described 38 species of *Calanthe* under two sections; 'Ghiesebreghtia' and 'Eucalanthe'. And among these species, 9 are present in Nepal; *C. alpina*, *C. brevicornu*, *C. chloroleuca*, *C. densiflora*, *C. griffithii*, *C. masuca*, *C. plantaginea*, *C. puberula* and *C. tricarinata*.

Hooker (1890) has described 34 *Calanthe* species from India and 11 of them are present in Nepal. He separated *Calanthe* into three sections; section I: lip at the top of the short stout column opposite to the stigmatic cavity (*C. alpina*, *C. brevicornu*, *C. chloroleuca*, *C. griffithii*, *C. mannii*, *C. masuca*, *C. pachystalix* (*C. davidii*), *C. plantaginea*, *C. puberula* and *C. tricarinata* are the species common to Nepal), section II: lip inserted at the base of the column which is not embraced by its side lobes (*C. densiflora* is common

in Nepal) and section III: lip inserted at the top of the broad short column, its side lobes convolute and embracing the column (no species from this section is common to Nepal).

King & Pantling (1898) described 21 species of *Calanthe* from Sikkim Himalaya along with the taxonomic indented key and illustration and 10 species of them are present in Nepal; *C. alpina*, *C. brevicornu*, *C. chloroleuca*, *C. densiflora*, *C. maculatus* (*C. woodfordii*), *C. mannii*, *C. masuca*, *C. puberula*, *C. tricarinata* and *C. trulliformis*. Duthie (1906) described about 7 species of *Calanthe* from North Western Himalaya and 6 of them are present in Nepal; *C. brevicornu*, *C. mannii*, *C. pachystalix* (*C. davidii*), *C. plantaginea*, *C. puberula* and *C. tricarinata*. Seidenfaden & Smitinand (1958-1965) studied the orchids of Thailand and reported 14 species of *Calanthe* and three of them are present in Nepal; *C. flavus* (*C. woodfordii*), *C. masuca* and *C. tankervilleae*.

Hara (1966) mentioned about *C. chloroleuca* in the Flora of Eastern Himalaya. Hara (1971) in the study of Flora of Eastern Himalaya, second report described 6 species of *Calanthe* which are present in Nepal; *C. brevicornu*, *C. chloroleuca*, *C. mannii*, *C. plantaginea*, *C. tankervilleae* and *C. tricarinata*. Ohashi (1975) described 5 species of *Calanthe* which are present in Nepal; *C. brevicornu*, *C. mannii*, *C. puberula*, *C. tricarinata* and *C. trulliformis*. Pradhan (1979) listed 19 species of *Calanthe* from India and 11 of them are present in Nepal; *C. alpina*, *C. brevicornu*, *C. chloroleuca*, *C. densiflora*, *C. mannii*, *C. masuca*, *C. pachystalix* (*C. davidii*), *C. plantaginea*, *C. puberula*, *C. tricarinata* and *C. trulliformis*.

Deva & Naithani (1986) recorded 9 species of *Calanthe* along with the illustration, description, bracketed key and distribution from the North West Himalaya and 8 species of them are present in Nepal; *C. alpina*, *C. brevicornu*, *C. mannii*, *C. pachystalix* (*C. davidii*), *C. plantaginea*, *C. puberula*, *C. tankervilleae* and *C. tricarinata*. Chowdhery (1998) described 22 species of *Calanthe* from Arunachal Pradesh along with the taxonomic indented key, description and illustrations. Among them 13 species are present in Nepal; *C. alpina*, *C. brevicornu*, *C. chloroleuca*, *C. densiflora*, *C. flavus* (*C. woodfordii*), *C. griffithii*, *C. mannii*, *C. masuca*, *C. plantaginea*, *C. puberula*, *C. tankervilleae*, *C. tricarinata* and *C. trulliformis* (*C. flavus* and *C. woodfordii* given as two different species).

Pearce & Cribb (2002) described 25 species of *Calanthe* from Bhutan among which 12 species are found in Nepal; *C. alpina*, *C. brevicornu*, *C. chloroleuca*, *C. densiflora*, *C. flavus* (*C. woodfordii*), *C. griffithii*, *C. mannii*, *C. plantaginea*, *C. puberula*, *C. tankervilleae*, *C. tricarinata* and *C. trulliformis*.

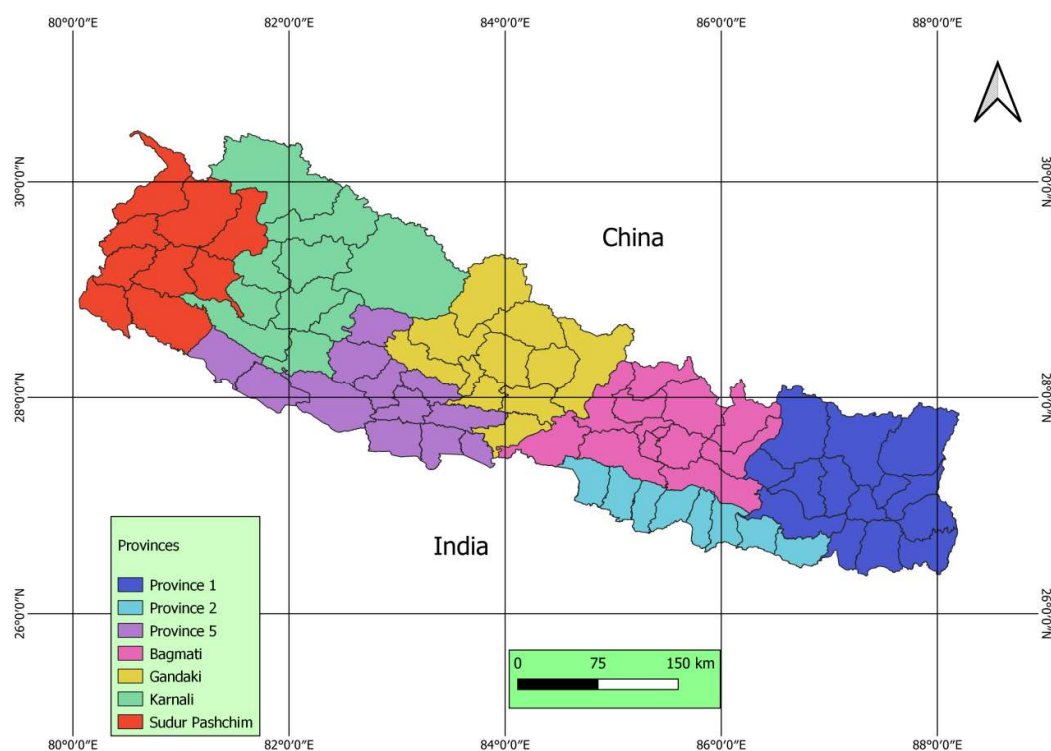
Chen *et al.* (2009a) described 51 species of *Calanthe* from China with its 21 endemic species and 10 of them are common to Nepal; *C. alpina*, *C. arcuata*, *C. brevicornu*, *C. davidii*, *C. densiflora*, *C. griffithii*, *C. mannii*, *C. plantaginea*, *C. puberula* and *C. tricarinata*. The taxonomic indented key, detail description and illustration was given. Chen *et al.* (2009b) described 9 species of *Phaius* (*Calanthe*) from China and 2 of them are common in Nepal; *C. tankervilleae* and *C. woodfordii*.

(Note: The reviewed literatures containing *C. tankervilleae* and *C. woodfordii* have these species in the section of genus *Phaius* in the respective literatures except Shrestha *et al.* (2022). And the total number of species given in those literatures indicates species of both *Calanthe* and *Phaius*).

3. MATERIALS AND METHODS

3.1 Study Area

The study area (Map 1) of this study is Nepal as this study is based on the herbarium specimens. Nepal is small 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 of the country. The total geographical area of Nepal is 147, 516 km² and it has a 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 the provinces.

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

3.2 Protologues and preparation of character matrix

The protologues for all the species were studied in both handbooks and media through the online library like Biodiversity Heritage Library (BHL), websites like TROPICOS was used for the reference. The original literatures, Floras or books were also used from library (ASCOL and KATH). The necessary protologues were converted into English using Stearn (1983), google and with help of converter website Botanicus.

The taxonomic characters were also studied from different articles and Floras and compared with the protologues and the literature based character matrices were made accordingly.

3.3 Selection of Characters

Orchids are typically classified on the basis of their lip. But generally all the morphological characters play equal 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 character matrix prepared. The morphological and floral parts like pseudobulb, pseudostem, leaf, scape, inflorescence, sterile bract, floral bract, pedicel and ovary, sepals, petals, lip, spur, column and pollinia were used to study. The number, shape, size, texture, colour, arrangement and origin of all parts are studied in both fresh and herbarium specimen.

3.4 Collection of fresh plant Specimens

With the help of the literatures and the record of Nepalese herbarium specimens deposited at both national and international herbaria, the flowering season of all species were noted. The fresh plant specimens of 4 species were collected from the field. The field notes along with the photographs in the habitat were taken instantly at the location. The measurements of all the necessary parts and other important characters such as presence of colour, fragrance of flowers were noted which was followed by the illustration of a whole plant and the flower. The fresh specimens were then pressed and dried following the techniques provided by Rajbhandari & Rajbhandary (2015). The herbarium were made and then deposited in the ASCOL herbarium.

3.5 Study of fresh plant specimens

All the morphological characters were studied in detail. The collected specimens of 4 species were studied with the help of 5× hand lens. The flowers were dissected carefully and studied under stereo microscope.

3.6 Study of herbarium specimens

The dried herbarium specimens were studied in both National Herbaria (KATH and TUCH) and the International Herbaria (BM, E, K and TI). The herbarium specimens were examined thoroughly through Radical stereo-microscope of RSM-4 model. Total of 142 specimens of 12 species were studied in KATH and 5 specimens of 4 species in TUCH. The virtual examination was done for the herbarium specimens through available images in international herbaria. In TI, 34 specimens of 6 species were studied. Similarly, 48 specimens of 7 species in BM, 25 specimens of 4 species in E and 6 specimens of 4 species in K were studied.

3.7 Identification and description

For the identification of the collected specimens, the prepared character matrix was used primarily. Also the monograph, different Floras (*Orchids of Sikkim Himalaya*, *Flora of Bhutan*, *Flora of China* and *Flora of British India*) and available literatures were used as reference for the identification of species. The selected morphological characters were studied in both fresh and herbarium specimens. They were examined for morphological description using the reference like Harris & Harris (1994), James Cullen (2006) and Chen *et al.* (2009c) for the botanical terminology. And the detail description for each species is prepared. The original author citations and synonyms for all species were used from Plants of World Online (POWO) and TROPICOS. The species are ordered alphabetically for the description.

3.8 Illustration

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

3.9 Construction of Identification key

With the help of the study from both fresh and herbarium specimen examination, the bracketed key was prepared to distinguish the species present in Nepal. The vegetative and reproductive structures both were used in making the identification key.

3.10 Cladistics

Cladistic analysis is a parsimony-based search for hierarchical 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 (Ungriht *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, 11 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 *Spathoglottis ixioides* is used as the outgroup in this 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 expresses the fraction of similarities on the cladogram interpreted as synapomorphy (Farris 1988). The singlemost parsimonious tree and Bootstrap method were performed to interpret the phylogenetic relationship among the species. For the terminologies of cladistic study Simpson (2010) was used.

3.11 Distribution Map

The distribution area were noted from all the herbarium specimens and in the case of International Herbaria only selected Herbaria were visited for distribution as the specific distribution area is not mentioned in herbarium specimens of some Herbaria. So, only TI and E were studied virtually in case of distribution. The distribution map for the species distribution in Nepal was made by using the program QGIS 3.16. The three different symbolic representations; ‘▲’ for national, ‘●’ for international herbaria ‘■’ for fresh specimen collections were used to denote the distribution of species distribution Map.

4. RESULTS

In this study, the morphological and phylogenetic relations of 15 species of *Calanthe* present in Nepal were studied. The 15 species of *Calanthe* that are present in Nepal are *C. alpina*, *C. arcuata*, *C. brevicornu*, *C. chloroleuca*, *C. davidii*, *C. densiflora*, *C. griffithii*, *C. mannii*, *C. masuca*, *C. plantaginea*, *C. puberula*, *C. tankervilleae*, *C. tricarinata*, *C. trulliformis* and *C. woodfordii*.

4.1 Morphological Treatment

All the morphological characters were studied in detail from both fresh plant and herbarium specimens deposited at KATH and TUCH. Similarly the virtual examination of herbarium specimen from international herbaria; BM, E, K and TI are done. The overall characters studied were described in two major topics: vegetative structures and reproductive structures.

4.1.1 Vegetative structures

Calanthe is terrestrial or rarely epiphytic orchid. The species present in Nepal are typically terrestrial in nature. The details of vegetative structures are studied in following titles.

4.1.1.1 Life form

There is no specific difference in the life forms of species present in Nepal. All the species are terrestrial herbs commonly found in the shady and moist area of forest floor at the altitudinal range from 200-3300 m, especially in dense *Tsuga*, *Pinus* and *Castanopsis* forest. Some of the species are also present in open grassy area. The genus is usually present in group than the individual presence. The genus is shade and moisture loving so they are commonly found near the water resources like forest watersheds area.

4.1.1.2 Pseudobulb

There is no mark distinction in the type of pseudobulb among the species. It is usually conic in most of the species, subconic in *C. griffithii*, narrowly cylindrical in *C. puberula* and it is inconspicuous in *C. densiflora*.

4.1.1.3 Pseudostem

The length of pseudostem vary among the species and they are present with the tubular sheaths. Usually the number of tubular sheaths vary from 3-5, their development is basal. The tubular sheaths are mostly membranous in lower ones but the upper sheaths are usually hard in all the species.

4.1.1.4 Leaves

Leaves are developed basally from the pseudobulb in all species except *Calanthe woodfordii* in which the leaves are cauline. The number of leaf varies from 2 to 5. Usually the leaves are petioled or have petiole like sheathing base. The mature leaf bears a distinct longer petiole than the new leaf.

There is high variation in the shape of leaf; linear, lanceolate, elliptic and ovate-lanceolate leaves are present among the species. The linear leaves are present in *C. arcuata*, *C. davidii* and *C. trulliformis*. The lanceolate leaves are present in *C. brevicornu*, *C. densiflora*, *C. griffithii*, *C. mannii*, *C. puberula*, *C. tankervilleae*, *C. tricarinata* and *C. woodfordii*. The elliptic leaves are present in only two species; *C. alpina* and *C. masuca*. And the ovate lanceolate leaves are present in *C. plantaginea* and *C. chloroleuca*.

The size of the leaf ranges from 8-60 × 0.7-13 cm. The leaf apex is usually acute among species but they are acute to acuminate in some of the species (Table 1). *Calanthe woodfordii* bears the unique character of having the yellowish spots in leaf surface. In general, the leaf holds less specific and remarkable taxonomic characters.

Table 1: Comparative study of leaves of *Calanthe* species.

S. N.	Species	No. of leaves	Leaf development	Shape	Size (cm)	Petiole	Apex
1	<i>Calanthe alpina</i>	3-4	Basal	Elliptic	12-25 × 4-7	Petiole like base	Acute
2	<i>C. arcuata</i>	5	Basal	Linear	20-25 × 1-2	Petiole like base	Acute to acuminate
3	<i>C. brevicornu</i>	3-4	Basal	Lanceolate	30-45 × 5-7	Petiole like base	Acute
4	<i>C. chloroleuca</i>	2-3	Basal	Ovate lanceolate	21-51 × 5-10	Distinct petiole	Acute
5	<i>C. davidii</i>	3-4	Basal	Linear	20-30 × 0.7-1	Petiole like base	Acute
6	<i>C. densiflora</i>	3	Basal	Lanceolate	28-33 × 4-5	Petiole like base	Acute
7	<i>C. griffithii</i>	3-4	Basal	Lanceolate	8-11 × 3-4	Petiole like base	Acute
8	<i>C. mannii</i>	2-4	Basal	Lanceolate	15-38 × 3-4	Distinct petiole	Acute
9	<i>C. masuca</i>	3	Basal	Elliptic	30-37 × 4-7	Distinct petiole	Acute
10	<i>C. plantaginea</i>	3-5	Basal	Ovate lanceolate	18-44 × 2.5-13	Distinct petiole	Acute
11	<i>C. puberula</i>	4-5	Basal	Lanceolate	14-37 × 3.5-6.5	Petiole like base	Acute to acuminate
12	<i>C. tankervilleae</i>	2-3	Basal	Lanceolate	40-60 × 2.5-3	Distinct petiole	Acute
13	<i>C. tricarinata</i>	3-4	Basal	Lanceolate	22-52 × 5-10	Distinct petiole	Acute
14	<i>C. trulliformis</i>	2-5	Basal	Linear	23-38 × 1.5-2.5	Petiole like base	Acute to acuminate
15	<i>C. woodfordii</i>	3-5	Cauline	Lanceolate	8.5-37.5 × 3-8.5	Petiole like base	Acute to acuminate

4.1.1.5 Sterile bract

The sterile bracts have not been given the priority in previous taxonomic study of *Calanthe* in many cases. But this study has used sterile bract for the delimitation of species. Usually only one sterile bract is present in most species but two or more than two sterile bracts are present in *C. davidii*, *C. densiflora*, *C. puberula*, *C. tankervilleae* and *C. woodfordii*. Most of the species have lanceolate or linear-lanceolate sterile bracts but *C. densiflora*, *C. puberula*, *C. tankervilleae* and *C. woodfordii* have tubular sterile bract (Table 2 and Figure 1).

Table 2: Comparative study of sterile bracts of *Calanthe* species.

S. N.	Species	No of sterile bract	Shape	Size (cm)	Veins	Surface	Apex
1	<i>Calanthe alpina</i>	1	Lanceolate	1.5-3 × 0.5-1	5	slightly pubescent outside	Acute
2	<i>C. arcuata</i>	1	Linear-lanceolate	ca. 1.9 × ca. 0.4	5	slightly pubescent outside	Acuminate
3	<i>C. brevicornu</i>	1	Lanceolate	1.5-2 × 0.5-1	5	slightly pubescent outside	Acute
4	<i>C. chloroleuca</i>	1	Lanceolate	0.5-1.5 × 0.2-0.4	1	glabrous	Acute
5	<i>C. davidii</i>	More than 2	Linear-lanceolate	ca. 2.4 × 0.3		pubescent	Acute
6	<i>C. densiflora</i>	More than 2	Tubular	1.5-3 × 0.5-1	More than 5	Glabrous	Round to acute
7	<i>C. griffithii</i>	1	Lanceolate	ca. 1 × 0.4	1	pubescent	Acute
8	<i>C. mannii</i>	1	Lanceolate	0.5-1.5 × 0.3-0.4	1	glabrous	Acute
9	<i>C. masuca</i>	1	Lanceolate	ca. 1.8 × 0.3			Acute
10	<i>C. plantaginea</i>	1	Lanceolate	0.6-1.2 × 0.2-0.7	1	pubescent	Acute
11	<i>C. puberula</i>	2 or more than 2	Tubular	1.3-2.7 × 0.3-0.6	5	pubescent	Acute
12	<i>C. tankervilleae</i>	More than 2	Tubular	4-4.5	More than 5		Acute
13	<i>C. tricarinata</i>	1	Lanceolate	0.6-1.7 × 0.2-0.6	3	slightly pubescent outside	Acute
14	<i>C. trulliformis</i>	1	Linear lanceolate	2-2.2 × 0.4-0.6	5	glabrous	Acuminate
15	<i>C. woodfordii</i>	More than 2	Tubular	3.3-6.2 × 0.8-1	More than 5	Slightly pubescent	Acute

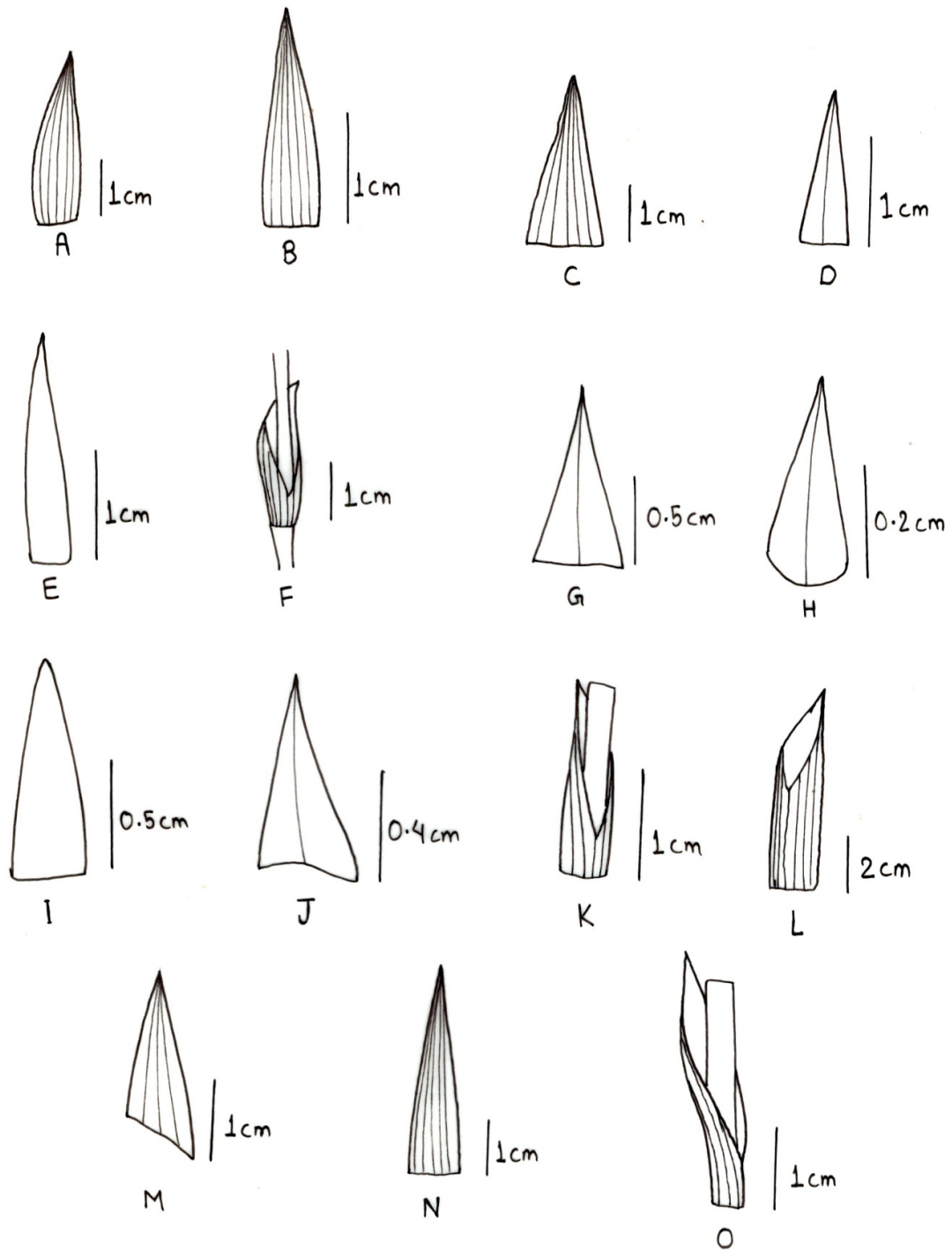


Figure 1: Sterile bracts of *Calanthe* species (A-O). A. *C. alpina*, B. *C. arcuata*, C. *C. brevicornu*, D. *C. chloroleuca*, E. *C. davidii*, F. *C. densiflora*, G. *C. griffithii*, H. *C. mannii*, I. *C. masuca*, J. *C. plantaginea*, K. *C. puberula*, L. *C. tankervilleae*, M. *C. tricarinata*, N. *C. trulliformis*, O. *C. woodfordii*.

4.1.2 Reproductive Structures

4.1.2.1 Inflorescence

Scape arises from the leaf axil in most of the species but it develops from the pseudobulb or side of pseudobulb in *C. densiflora*. In the case of *C. tankervilleae* and *C. woodfordii*, it develops from the side of stem. The number of scape is one in majority of species but in some species sometimes 2 scapes develops; *C. brevicornu*, *C. chloroleuca*, *C. davidii*, *C. manni*, *C. masuca*, *C. puberula* and *C. tricarinata*. Inflorescence is always racemose and flowers are laxly to densely arranged in the spike (Table 3).

Table 3: Comparative study of Inflorescence of *Calanthe* species.

S. N.	Species	No. of scape	Development of scape from	Surface	Length of scape (cm)	Flower arrangement
1	<i>C. alpina</i>	Usually 1	Leaf axil	Pubescent	30-40	15-24 laxly
2	<i>C. arcuata</i>	Usually 1	Leaf axil	Pubescent	45	More than 10 laxly
3	<i>C. brevicornu</i>	1 or 2	Leaf axil	Pubescent	30-60	15-24 laxly
4	<i>C. chloroleuca</i>	1 or 2	Leaf axil	Pubescent	30-45	5-8 laxly
5	<i>C. davidii</i>	1 or 2	Leaf axil	Pubescent	48	More than 25 densely
6	<i>C. densiflora</i>	Usually 1	Rhizome	Pubescent	18	4-10 densely
7	<i>C. griffithii</i>	Usually 1	Leaf axil	Densely pubescent	13-24	4-10 laxly
8	<i>C. mannii</i>	1 or 2	Leaf axil	Pubescent	30-60	4-37 densely
9	<i>C. masuca</i>	1 or 2	Leaf axil	Pubescent	Upto 50	Few to many densely flowered
10	<i>C. plantaginea</i>	Usually 1	Leaf axil	Pubescent	24-62	7-25 laxly
11	<i>C. puberula</i>	1-3	Leaf axil	Pubescent	13-41	4-13 laxly
12	<i>C. tankervilleae</i>	Usually 1	Side of leaf axil	Pubescent	43-61	7-10 laxly
13	<i>C. tricarinata</i>	1 or 2	Leaf axil	Pubescent	30-60	6-20 laxly
14	<i>C. trulliformis</i>	Usually 1	Leaf axil	Pubescent	42-60	5-23 laxly
15	<i>C. woodfordii</i>	Usually 1	Side of leaf axil		14-45	6-8 laxly

4.1.2.2 Floral bract

Floral bracts are present at the base of pedicel and ovary. They are mostly membranous in all species. The floral bracts are lanceolate in *C. alpina*, *C. brevicornu*, *C. chloroleuca*, *C. griffithii*, *C. mannii*, *C. plantaginea*, *C. puberula* and *C. tricarinata*, linear in *C. arcuata*, *C. davidii* and *C. trulliformis* and linear-lanceolate in *C. densiflora*, *C. masuca*, *C. tankervilleae* and *C. woodfordii* (Figure 2).

The size of floral bracts ranges from 0.3-5 × 0.1-1.2 cm among the species. The number of vein is either one (*C. chloroleuca*, *C. mannii* and *C. plantaginea*) or three (*C. arcuata*, *C. brevicornu*, *C. davidii*, *C. densiflora*, *C. griffithii*, *C. masuca*, *C. puberula* and *C. tricarinata*) or five (*C. alpina* and *C. trulliformis*). The number of vein in floral bracts of *C. tankervilleae* and *C. woodfordii* is more than 5 (Table 4).

The floral bracts in *C. davidii* are reflexed. The apex of floral bract is acute in most of the species except *C. densiflora* and *C. trulliformis* which have acuminate apex (Figure 2).

Table 4: Comparative study of floral bracts of *Calanthe* species.

S. N.	species	shape of floral bract	size (cm)	vein	surface	Apex
1	<i>Calanthe alpina</i>	lanceolate	1-3 × 0.3-0.5	5	glabrous	Acute
2	<i>C. arcuata</i>	linear	2.3-2.6 × 0.3-0.4	3	Slightly pubescent	Acuminate
3	<i>C. brevicornu</i>	lanceolate	1.5-2 × 0.2-0.4	3	pubescent	Acute
4	<i>C. chloroleuca</i>	lanceolate	0.5-1.2 × 0.1-0.2	1	Slightly pubescent	Acute
5	<i>C. davidii</i>	linear	0.8-1.1 × 0.1-0.2	3	Slightly pubescent	Acuminate
6	<i>C. densiflora</i>	Linear-lanceolate	1.3-1.6 × 0.2-0.3	3	glabrous	Acuminate
7	<i>C. griffithii</i>	lanceolate	1-1.2 × 0.1-0.2	3	glabrous	Acuminate
8	<i>C. mannii</i>	lanceolate	0.2-0.4 × ca. 0.1	1	glabrous	Acute
9	<i>C. masuca</i>	Linear-lanceolate	0.9-1.7 × 0.2-0.4	3	glabrous	Acute to acuminate
10	<i>C. plantaginea</i>	lanceolate	0.5-1.1 × 0.1-0.4	1	glabrous	Acute
11	<i>C. puberula</i>	lanceolate	1.2-3 × 0.2-0.5	3	pubescent	Acuminate
12	<i>C. tankervilleae</i>	Linear-lanceolate	3-5 × 0.3-0.6	More than 5	glabrous	Acuminate
13	<i>C. tricarinata</i>	lanceolate	0.7-1.7 × 0.2-0.4	3	Slightly pubescent	Acute
14	<i>C. trulliformis</i>	linear	1.6-3 × 0.2-0.4	5	glabrous	Acute to acuminate
15	<i>C. woodfordii</i>	Linear-lanceolate	2.5-5 × 0.5-1.2	More than 5	glabrous	Acute

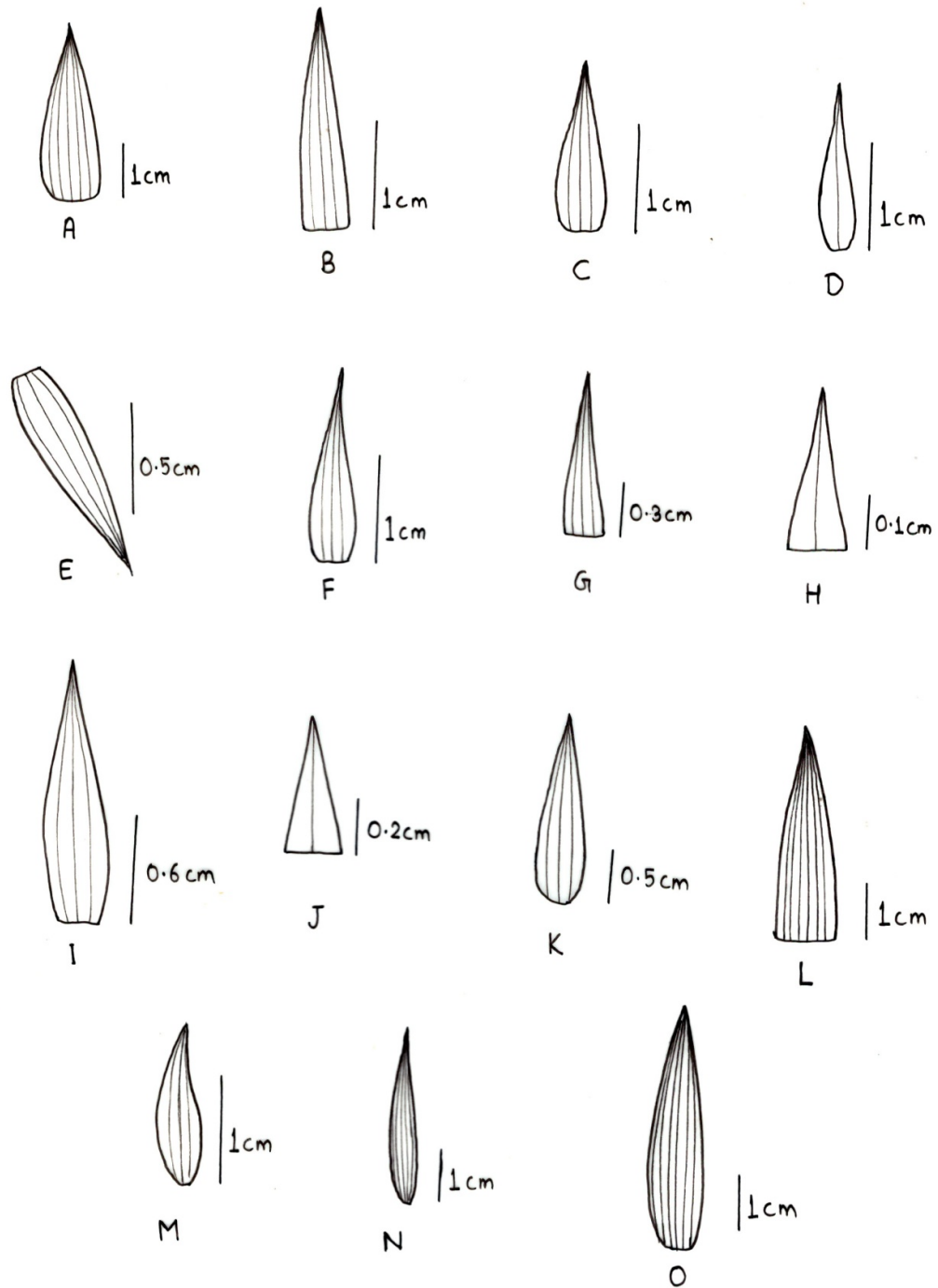


Figure 2: Floral bracts of *Calanthe* species (A-O). A. *C. alpina*, B. *C. arcuata*, C. *C. brevicornu*, D. *C. chloroleuca*, E. *C. davidii*, F. *C. densiflora*, G. *C. griffithii*, H. *C. mannii*, I. *C. masuca*, J. *C. plantaginea*, K. *C. puberula*, L. *C. tankervilleae*, M. *C. tricarinata*, N. *C. trulliformis*, O. *C. woodfordii*.

4.1.2.3 Dorsal sepal

The dorsal sepals in the species are ovate-lanceolate, lanceolate and oblong. Most of the species have ovate-lanceolate dorsal sepal; *C. alpina*, *C. brevicornu*, *C. chloroleuca*, *C. davidii*, *C. densiflora*, *C. masuca*, *C. puberula*, *C. tricarinata* and *C. woodfordii*. The lanceolate type is present in *C. arcuata*, *C. griffithii*, *C. plantaginea*, *C. tankervilleae* and *C. trulliformis* and oblong type is present only in *C. mannii*.

The size of dorsal sepals ranges from 0.6-4 × 0.2-1.5 cm among the species. The number of vein is either three (*C. brevicornu*, *C. densiflora*, *C. griffithii*, *C. mannii*, *C. masuca* and *C. plantaginea*) or five (*C. alpina*, *C. arcuata*, *C. chloroleuca*, *C. davidii*, *C. puberula*, *C. tricarinata* and *C. trulliformis*) and more than five veins are present in *C. tankervilleae* and *C. woodfordii* (Table 5). The apex is acute to acuminate in all species except *C. densiflora* which has round apex (Figure 3).

Table 5: Comparative study of Dorsal sepal of *Calanthe* species.

S. N.	Species	Shape	Size (cm)	No. of vein	Apex
1	<i>Calanthe alpina</i>	Ovate-lanceolate	1.5-2.5 × 0.4-0.8	5	Narrowly acuminate
2	<i>C. arcuata</i>	Lanceolate	1-1.3 × 0.2-0.4	5	Acuminate
3	<i>C. brevicornu</i>	Ovate-lanceolate	1.7-2 × 0.6-0.8	3	Acute
4	<i>C. chloroleuca</i>	Ovate-lanceolate	1-2 × 0.4-0.6	5	Acute
5	<i>C. davidii</i>	Ovate-lanceolate	0.6-0.7 × 0.3-0.4	5	Acute to round
6	<i>C. densiflora</i>	Ovate -lanceolate	1-1.2 × ca. 0.2	3	Round
7	<i>C. griffithii</i>	Lanceolate	1-1.3 × 0.3-0.4	3	Acute
8	<i>C. mannii</i>	Oblong	0.6-0.8 × 0.2-0.3	3	Acute
9	<i>C. masuca</i>	Ovate-lanceolate	2-2.5 × 0.6-0.8	3	Acute
10	<i>C. plantaginea</i>	Lanceolate	1.5-1.8 × 0.4-0.7	3	Acute
11	<i>C. puberula</i>	Ovate-lanceolate	1.2-1.5 × 0.4-0.5	5	Acuminate
12	<i>C. tankervilleae</i>	Lanceolate	3-3.5 × ca. 0.5	More than 5 veins	Acute
13	<i>C. tricarinata</i>	Ovate-lanceolate	1.2-2 × 0.4-0.8	5	Acute
14	<i>C. trulliformis</i>	Lanceolate	1.3-1.6 × 0.2-0.4	5	Acuminate
15	<i>C. woodfordii</i>	Ovate-lanceolate	2.4-4 × 0.6-1.5	More than 5	Obtuse

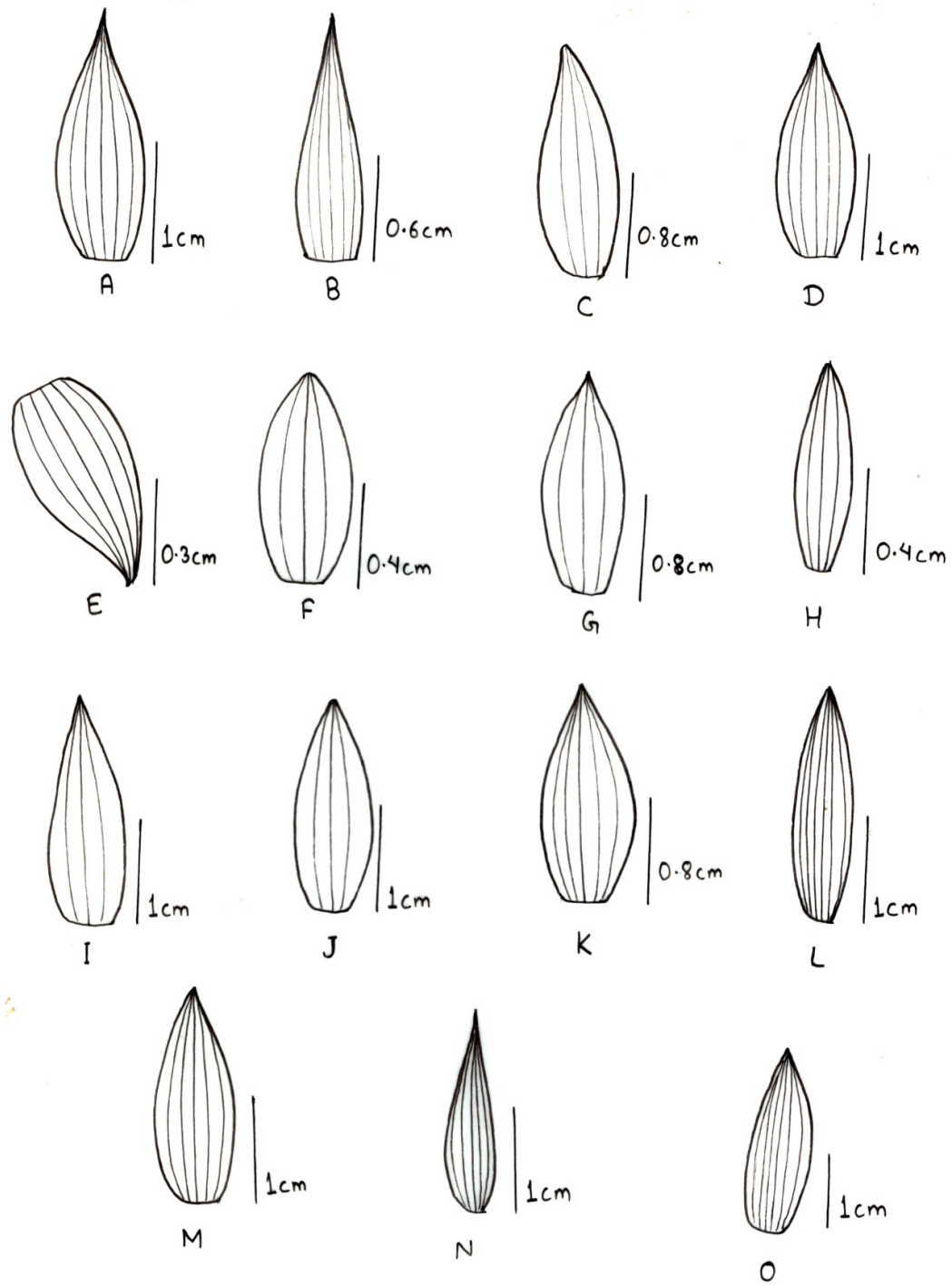


Figure 3: Dorsal sepal of *Calanthe* species (A-O). A. *C. alpina*, B. *C. arcuata*, C. *C. brevicornu*, D. *C. chloroleuca*, E. *C. davidii*, F. *C. densiflora*, G. *C. griffithii*, H. *C. mannii*, I. *C. masuca*, J. *C. plantaginea*, K. *C. puberula*, L. *C. tankervilleae*, M. *C. tricarinata*, N. *C. trulliformis*, O. *C. woodfordii*.

4.1.2.4 Lateral sepals

The lateral sepals show more variation than the dorsal sepal among the species. The different shapes of lateral sepals are ovate-lanceolate, lanceolate, oblong, falcate and oblong lanceolate (Figure 4). Ovate-lanceolate sepal is present in *C. alpina* and *C. davidii*. The lanceolate sepal is present in *C. arcuata*, *C. brevicornu*, *C. chloroleuca*, *C. griffithii*, *C. masuca*, *C. plantaginea*, *C. tankervilleae*, *C. tricarinata*, *C. trulliformis* and *C. woodfordii*. The oblong lateral sepal is present in *C. mannii*, falcate type is present in *C. puberula* and oblong-lanceolate type is present in *C. densiflora* (Figure 4).

The size of the lateral sepals ranges from 0.6-4 × 0.2-1.5 cm among the species. The number of vein is three in *C. brevicornu*, *C. mannii* and *C. masuca* and five in all remaining species. In case of *C. tankervilleae* and *C. woodfordii* more than five veins are present. The apex is acute to acuminate in all species (Table 6).

Table 6: Comparative study of lateral sepals of *Calanthe* species.

S.N.	Species	Shape	Size (cm)	No. of vein	Apex
1	<i>Calanthe alpina</i>	Ovate-lanceolate	1.5-2.5 × 0.5-1	5	Narrowly acuminate
2	<i>C. arcuata</i>	Lanceolate	1-1.3 × 0.2-0.4	5	Acuminate
3	<i>C. brevicornu</i>	Lanceolate	1.7-2 × 0.6-0.8	3	acute
4	<i>C. chloroleuca</i>	Lanceolate	1.6-2 × 0.4-0.6	5	Acute
5	<i>C. davidii</i>	Ovate-lanceolate	0.6-0.7 × 0.3-0.4	5	Acute to round
6	<i>C. densiflora</i>	Oblong-lanceolate	1.3-1.5 × 0.2-0.3	5	Acute
7	<i>C. griffithii</i>	Lanceolate	1.6 × 0.5	5	Acute
8	<i>C. mannii</i>	Oblong	0.7-0.9 × ca. 0.2	3	Acute
9	<i>C. masuca</i>	Lanceolate	2-2.4 × 0.6-0.7	3	Acute
10	<i>C. plantaginea</i>	Lanceolate	1.5-2 × 0.5-0.8	5	Acute
11	<i>C. puberula</i>	Falcate	1.3-1.8 × 0.4-0.7	5	Acuminate
12	<i>C. tankervilleae</i>	Lanceolate	2.3-2.5 × 0.5-0.7	More than 5	Acute
13	<i>C. tricarinata</i>	Lanceolate	1.4-2 × 0.3-0.8	5	Acute
14	<i>C. trulliformis</i>	Lanceolate	1.3-1.6 × 0.2-0.4	5	Acuminate
15	<i>C. woodfordii</i>	Lanceolate	2.4-4 × 0.6-1.5	More than 5	Obtuse

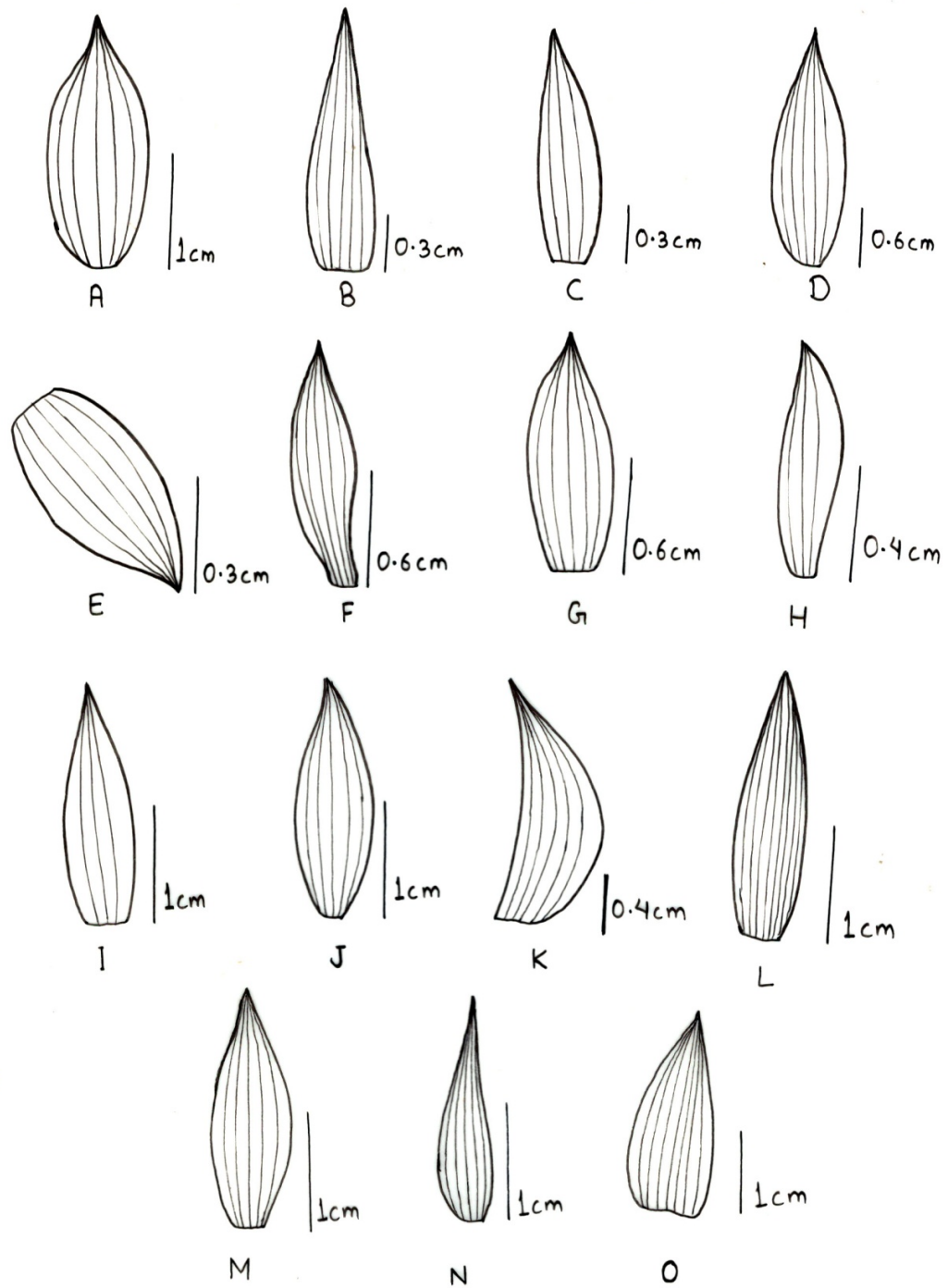


Figure 4: Lateral sepals of *Calanthe* species (A-O). A. *C. alpina*, B. *C. arcuata*, C. *C. brevicornu*, D. *C. chloroleuca*, E. *C. davidii*, F. *C. densiflora*, G. *C. griffithii*, H. *C. mannii*, I. *C. masuca*, J. *C. plantaginea*, K. *C. puberula*, L. *C. tankervilleae*, M. *C. tricarinata*, N. *C. trulliformis*, O. *C. woodfordii*.

4.1.2.5 Petals

The shape of petal is more different than the sepals, they are usually smaller than sepals in all species. The shape of petals are ovate-lanceolate, lanceolate, elliptic-lanceolate, narrowly lanceolate, oblong-lanceolate, linear and oblong-oblique among the species. The ovate-lanceolate petals are present in *C. alpina* and *C. densiflora*, lanceolate in *C. arcuata*, *C. davidii* and *C. trulliformis*, elliptic-lanceolate in *C. brevicornu*, *C. chloroleuca*, *C. griffithii*, *C. plantaginea*, *C. tankervilleae* and *C. tricarinata*. Similarly, the narrowly lanceolate petals are present in *C. mannii*, oblong lanceolate type in *C. masuca*, linear in *C. puberula* and oblong-oblique petals are present in *C. woodfordii* (Figure 5).

The size of petals ranges from 0.6-4 × 0.1-1.5 cm among the species. The number of vein in *C. puberula* is one, more than 5 veins are present in *C. tankervilleae* and *C. woodfordii* while 3 veins are present in remaining all species of *Calanthe*. The apex of petal is usually acute among the species (Table 7).

Table 7: Comparative study of petals of *Calanthe* species.

S.N.	Species	Shape of petal	Size	No. of vein	Apex
1	<i>Calanthe alpina</i>	Ovate-lanceolate	1.5-1.8 × 0.3-0.5	3	Narrowly acuminate
2	<i>C. arcuata</i>	Lanceolate	0.7-1 × ca. 0.2	3	Acute
3	<i>C. brevicornu</i>	Elliptic-lanceolate	1.3-1.8 × 0.3-0.6	3	Acute
4	<i>C. chloroleuca</i>	Elliptic-lanceolate	1.5-1.8 × 0.2-0.6	3	Acute to acuminate
5	<i>C. davidii</i>	Lanceolate	ca. 0.6 × 0.3	3	Acute
6	<i>C. densiflora</i>	Ovate-lanceolate	0.8-0.9 × ca. 0.2	3	Acute
7	<i>C. griffithii</i>	Elliptic-lanceolate	ca. 1.3 × 0.2	3	Acuminate
8	<i>C. mannii</i>	Narrowly lanceolate	0.6-0.7 × 0.1-0.2	3	Acute
9	<i>C. masuca</i>	Oblong-lanceolate	0.8-1.2 × 0.2-0.3	3	Acute
10	<i>C. plantaginea</i>	Elliptic-lanceolate	1-1.8 × 0.2-0.5	3	Acute
11	<i>C. puberula</i>	Linear	0.9-1.3 × ca. 0.1	1	Acute
12	<i>C. tankervilleae</i>	Elliptic-lanceolate	ca. 2.5 × 0.4	More than 5	Acute
13	<i>C. tricarinata</i>	Elliptic-lanceolate	1-1.9 × 0.3-0.6	3	Acute
14	<i>C. trulliformis</i>	Lanceolate	1-1.5 × 0.1-0.2	3	Acute
15	<i>C. woodfordii</i>	Oblong-oblique	2.4-4 × 0.6-1.5	More than 5	Obtuse-subacute

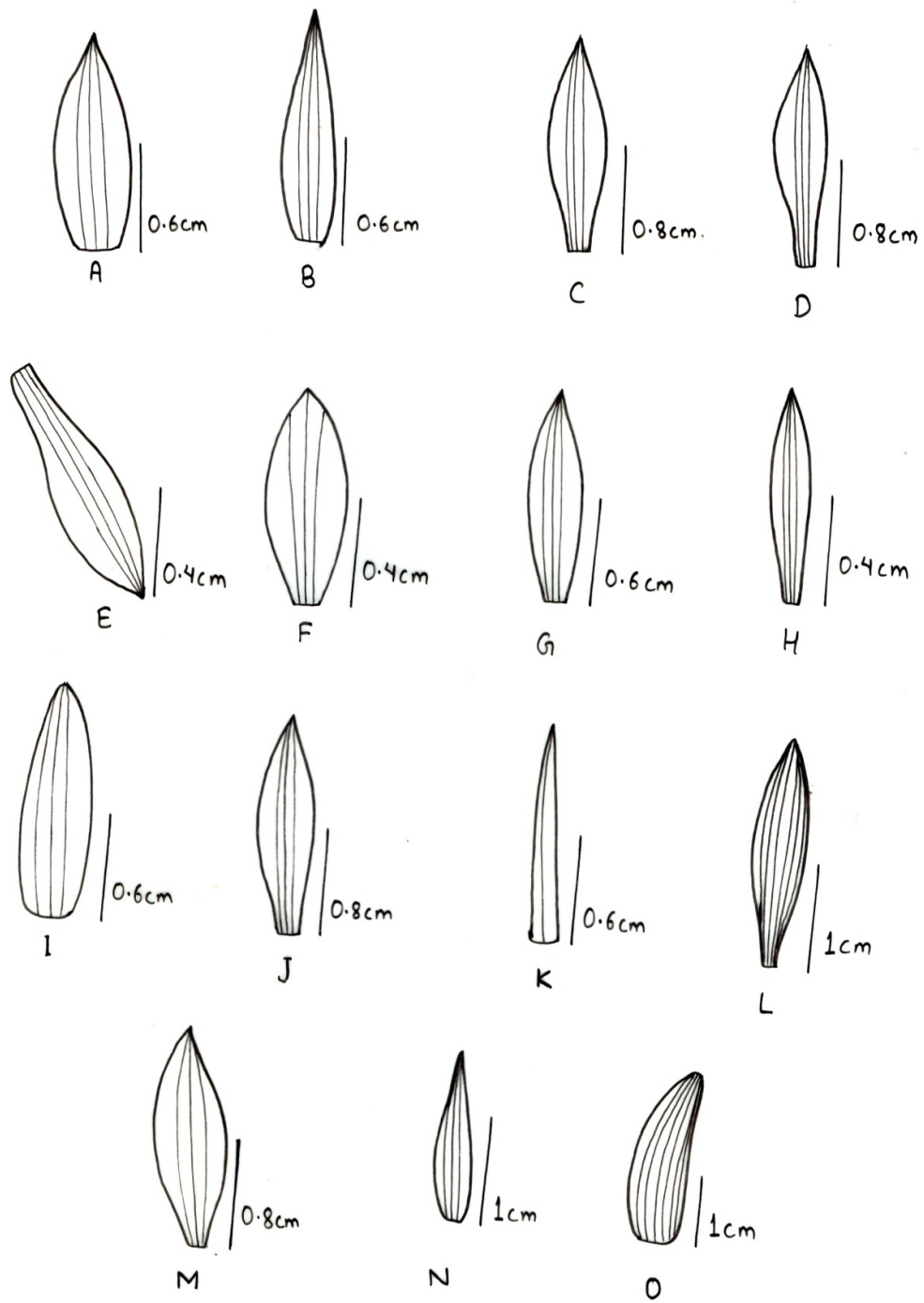


Figure 5: Petals of *Calanthe* species (A-O). A. *C. alpina*, B. *C. arcuata*, C. *C. brevicornu*, D. *C. chloroleuca*, E. *C. davidii*, F. *C. densiflora*, G. *C. griffithii*, H. *C. mannii*, I. *C. masuca*, J. *C. plantaginea*, K. *C. puberula*, L. *C. tankervilleae*, M. *C. tricarinata*, N. *C. trulliformis*, O. *C. woodfordii*.

4.1.2.6 Lip

The lip is one of the petals which are highly modified and it shows great variation among all the species. The lip is adnate to the column at its base in *C. alpina*, *C. brevicornu*, *C. densiflora*, *C. griffithii*, *C. puberula* and *C. tricarinata*. It is adnate to entire length of column in *C. arcuata*, *C. chloroleuca*, *C. davidii*, *C. mannii*, *C. masuca*, *C. plantaginea* and *C. trulliformis*. And the lip is free from column in two species; *C. tankervilleae* and *C. woodfordii* (Table 8).

They are usually 3-lobed with two side lobes and a mid lobe. The 3-lobed lip is present in *C. brevicornu*, *C. chloroleuca*, *C. davidii*, *C. densiflora*, *C. griffithii*, *C. mannii*, *C. masuca*, *C. plantaginea*, *C. puberula*, *C. tankervilleae*, *C. tricarinata* and *C. woodfordii*. And the unlobed lip is present only in three species; *C. alpina*, *C. arcuata* and *C. trulliformis* (Figure 6).

Table 8: Comparative study of lip of *Calanthe* species.

S. N.	Species	Lip lobe	Callus in disk	Attachment with column
1	<i>Calanthe alpina</i>	unlobed		At base
2	<i>C. arcuata</i>	unlobed	3	Entire length
3	<i>C. brevicornu</i>	Lobed	3	At base
4	<i>C. chloroleuca</i>	Lobed		Entire length
5	<i>C. davidii</i>	Lobed	3 clusters of calli	Entire length
6	<i>C. densiflora</i>	Lobed	2	At base
7	<i>C. griffithii</i>	Lobed	1	At base
8	<i>C. mannii</i>	Lobed	3	Entire length
9	<i>C. masuca</i>	Lobed	3	Entire length
10	<i>C. plantaginea</i>	Lobed	3	Entire length
11	<i>C. puberula</i>	Lobed	No callus	At base
12	<i>C. tankervilleae</i>	Lobed		Free from column
13	<i>C. tricarinata</i>	Lobed	3	At base
14	<i>C. trulliformis</i>	unlobed	2	Entire length
15	<i>C. woodfordii</i>	lobed		Free from column

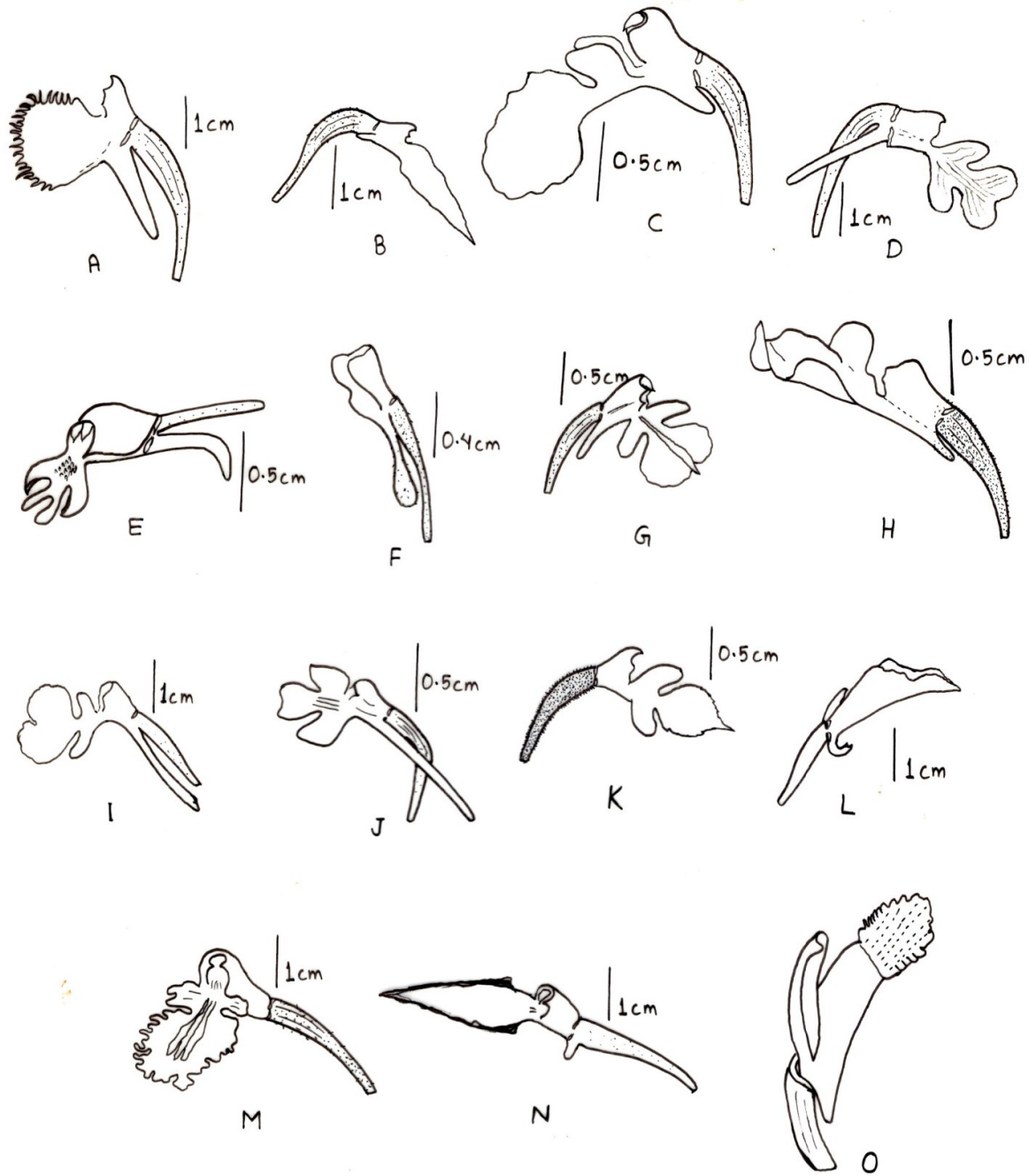


Figure 6: Lip, spur and pedicel and ovary of *Calanthe* species. A. *C. alpina*, B. *C. arcuata*, C. *C. brevicornu*, D. *C. chloroleuca*, E. *C. davidii*, F. *C. densiflora*, G. *C. griffithii*, H. *C. manni*, I. *C. masuca*, J. *C. plantaginea*, K. *C. puberula*, L. *C. tankervilleae*, M. *C. tricarinata*, N. *C. trulliformis*, O. *C. woodfordii*.

4.1.2.7 Spur

Spur is present in all of the species except *C. puberula* and *C. tricarinata* (Figure 6: K & M). The length and shape of spur vary greatly in all remaining species. Spur is long, cylindrical in *C. alpina*, *C. chloroleuca*, *C. masuca*, and *C. plantaginea*, short, cylindrical in *C. arcuata*, *C. brevicornu*, *C. davidii*, *C. griffithii*, and *C. trulliformis*. Spur is conical in *C. mannii* and *C. woodfordii*. Similarly, it is globular in *C. densiflora* and hooked in *C. tankervilleae* (Table 9).

Table 9: Comparative study of spur of *Calanthe* species.

S.N.	Species	Presence	Size (cm)	Shape	Length respect to pedicel and ovary (P/O)
1	<i>Calanthe alpina</i>	Present	0.8-1.5	Cylindric	Short/equal
2	<i>C. arcuata</i>	Present	0.2-0.3 × ca. 0.1	Cylindric	Short
3	<i>C. brevicornu</i>	Present	0.3 × 0.2	Cylindric	Short
4	<i>C. chloroleuca</i>	Present	1.5-2 × 0.2	Cylindric	Short/equal
5	<i>C. davidii</i>	Present	1.2-1.5	Cylindric	Long
6	<i>C. densiflora</i>	Present	0.8-1.3	Globular	Short
7	<i>C. griffithii</i>	Present	0.4 × 0.2	Cylindric	Short
8	<i>C. mannii</i>	Present	0.2 × 0.1	Conical	Short
9	<i>C. masuca</i>	Present	3-3.5	Cylindric	Long
10	<i>C. plantaginea</i>	Present	2-2.7	Cylindric	Short/equal
11	<i>C. puberula</i>	Absent			
12	<i>C. tankervilleae</i>	Present	0.1-0.2	Hooked	Short
13	<i>C. tricarinata</i>	Absent			
14	<i>C. trulliformis</i>	Present	0.1	Cylindric	Short
15	<i>C. woodfordii</i>	Present	0.5-0.8 × 0.2	conical	Short

4.1.2.8 Column

The column in all the species is usually short, thick and glabrous but pubescent or slightly pubescent in some species. The lip of all the species is either adnate to the column base or the entire length of column. But the lip of *C. tankervilleae* and *C. woodfordii* are free from the column (Table 9).

4.1.2.9 Pollinia

Total of 8 Pollinia are present which are usually white or light yellow in colour among the species. The shape of pollinia is dome shaped among the species and they are usually not equal in length. The size ranges from 1 to 2 mm in length.

4.2 Taxonomic treatment

4.2.1 *Calanthe* R. Br. *Bot. Reg.* 7:t. 573 (1821).

Alismorkis Thouars, *Nouv. Bull.* : t. 1 (1807)

Styloglossum Breda, *Gen. Sp. Orchid. Asclep.* 2: t. 7 (1829)

Zeduba Ham. ex Meisn., *Pl. Vasc. Gen.* 2: 280 (1842)

Type: *C. veratrifolia* R. Br.

Terrestrial herbs. Usually pseudobulbous. Pseudostem variable in length, present with the tubular sheaths at base. Leaves usually basal, rarely cauline, plicate; blade usually elliptic, lanceolate, linear in some. Scape arising from the leaf axil or rising directly from the rhizome or pseudobulb in some and arising from side of stem in some, erect. Inflorescence raceme, few to many flowered, sterile bract often one, two or more in some, membranous. Floral bracts persistent, rarely caducous, membranous, white, short to longer. Flower resupinate, usually spreading, small to medium sized, usually showy, some with fragrance. Pedicel and ovary straight, arcuate in some. Sepals free, usually similar, ovate to lanceolate, 3-5 veins, rarely more than 5 veins. Petals often free, smaller than sepals, usually linear-lanceolate. Lip adnate to either base of the column or to the entire length of the column, free from column in some, lobed or unlobed, spur present or absent. Column often short and thick; pollinia waxy, 8 in 2 groups, often unequal in size, adherent to sticky viscidium.

Distribution: Mexico, Central America, Colombia, Caribbean states, Southern Africa, Madagascar, South Asia, East Asia, Southeast Asia, Japan, Australia and Papua New Guinea.

The genus consists of about 216 species (Chase *et al.* 2015) in the world and 15 species in Nepal.

4.2.2 Synopsis of classification of genus *Calanthe* R. Br.

Order: Asparagales

Family: Orchidaceae

Subfamily: Epidendroideae

Tribe: Collabieae

Genus: *Calanthe* R. Br.

4.2.3 Keys to species

1. Scape developing from side of stem2
 Scape developing from rhizome or leaf axil.....3
2. Leaves cauline; with yellow spots on blade.....15. *C. woodfordii*
 Leaves basal; without yellow spots on blade.....12. *C. tankervilleae*
3. Scape developing from rhizome. Floral bracts caducous.....6. *C. densiflora*
 Scape developing from leaf axil. Floral bracts persistent.....4
4. Lip spur absent.....5
 Lip spur present.....6
5. Lip with 3 prominent lamella or ridges on the disk.....13. *C. tricarinata*
 Lip without lamella or ridges on the disk.....11. *C. puberula*
6. Lip unlobed.....7
 Lip 3-lobed.....9
7. Lip margin fimbriate.....1. *C. alpina*
 Lip margin not fimbriate.....8
8. Pedicel and ovary arcuate.....2. *C. arcuata*
 Pedicel and ovary straight.....14. *C. trulliformis*
9. Lip calli wart like.....9. *C. masuca*
 Lip calli lamellae or ridges.....10
10. Lip spur cylindric, 2-2.7 cm long.....10. *C. plantaginea*
 Lip spur cylindric or conical, under 2 cm.....11
11. Spur curved, sepals and petals reflexed.....5. *C. davidii*
 Spur straight, sepals and petals not reflexed.....12

12. Sepals 6-9 mm long8. *C. mannii*
 Sepals exceeding 10 mm.....13
13. Spur 15-20 mm long.....4. *C. chloroleuca*
 Spur 3-4 mm long.....14
14. Lip midlobe with single lamella.....7. *C. griffithii*
 Lip midlobe with 3 lamella.....3. *C. brevicornu*

4.2.4 Description of the species

1. *Calanthe alpina* Hook.f. ex Lindl. *Fol. Orchid.* 6: 4 (1855); *Fl. Brit. Ind.* 5:850 (1890); King & Pantl. *Ann. Roy. Bot. Gard. Calcutta* 8: 170 (1898); Hara *et al. Enum. Fl. Pl. Nep.* 1:34 (1978); Press *et al. Ann. Ch. Fl. Pl. Nep.* 210 (2000); Pearce & Cribb *Fl. Bhutan.* 3:283 (2002); Chen *et al. Fl. China.* 25:292-301. (2009); Rokaya *et al. Ann. Ch. Fl. Pl. Nep.*:518 (2013); Rajbhandari *Hand. Orchid. Nep.*:21 (2015); Rajbhandari & Rai *Hand. Fl. Pl. Nep.* 1:78 (2017); Shrestha *et al. Hand. Fl. Pl. Nep.* 1:100 (2018); Shrestha *et al. Pl. Nep.* 77 (2022).

Alismorchis alpina Kuntze, *Revis. Gen. Pl.* 2: 650.1891

Calanthe buccinifera Rolfe ex Hemsl., *J. Linn. Soc., Bot.* 29: 318 (1892)

Calanthe fimbriata Franch., *Nouv. Arch. Mus. Hist. Nat.*, ser. 2, 10: 86 (1887 publ. 1888)

Type specimen: India, Lachen, 10,000 ft, 1783, *J. D. Hooker* 245 (Holotype: K001368944, Isotype:P).

Plants 22-40 cm tall. Pseudobulb subcylindric. Pseudostem 4-10 × 1.5-2 cm with 2 or 3 tubular sheaths. Leaves 3-4, basal, elliptic, 12-25 × 4-7 cm, petiole like base sheathing, acute. Scape usually 1, arising from leaf axil, 30-40 cm long, longer than mature leaves, pubescent. Peduncle 7-11 cm long, raceme 5-12 cm long, 15-24 laxly flowered. Sterile bract 1, lanceolate, 1.5-3 × 0.5-1 cm, 5 veins, slightly pubescent in outer surface, acute. Floral bracts lanceolate, shorter or equal to pedicel and ovary, 1-3 × 0.3-0.5 cm, 5 veins, glabrous, acute. Pedicel and ovary 1.5-3 cm long, pubescent. Sepals subsimilar; dorsal sepal lemon yellow colour, ovate-lanceolate, 1.5-2.5 × 0.4-0.8 cm, 5 veins, narrowly acuminate; lateral sepals ovate-lanceolate, 1.5-2.5 × 0.5-1 cm. Petals slightly shorter than sepals, lanceolate to ovate-lanceolate, 1.5-1.8 × 0.3-0.5 cm, 3 veins, narrowly acuminate.

Lip adnate to base of the column, unlobed, red brown colour, 0.8-1.5 × 0.5-1 cm, fimbriate apical edges; spur cylindric, smaller than pedicel and ovary, 0.8-1.5 cm long, glabrous. Column short, 7-8 mm, broadly winged, glabrous. (Figure 7).

Altitude: 1900 – 3020 m

Ecology: On dense, moist and shady forest floor like *Tsuga* forest, *Castanopsis* forest.

Flowering: June – September

Notes: The species is one of them in the genus whose flowers are not opening widely. Hooker (1890) mentioned that the lip is white stripped with purple. King & Pantling (1898) also described about the colour of sepals and petals, they said that the sepals and petals are white tipped with green; the lamina of the lip is dull red, its base and spur being pale yellowish. Finet (1899) mentioned that *Calanthe fargesii* is closely related to *Calanthe alpina* on having the unlobed lip absolutely bare, without any kind of lamellae or calluses. The study of this species confirmed that it contains 5 veins in the floral bracts but Swami (2016) mentioned that the floral bracts contain only 3 veins in this species and the number of veins in floral bract was usually not mentioned in most of the old literatures.

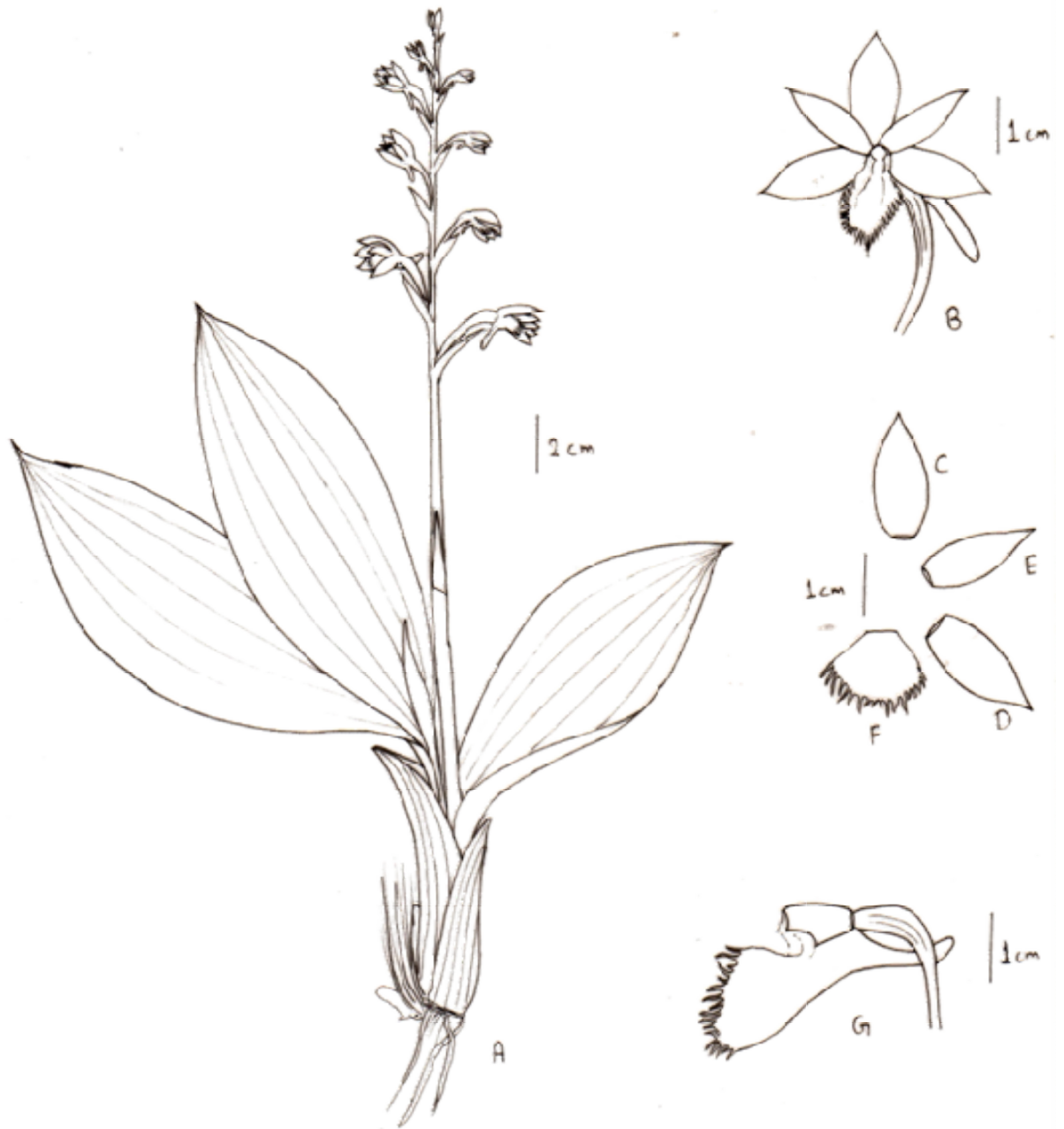
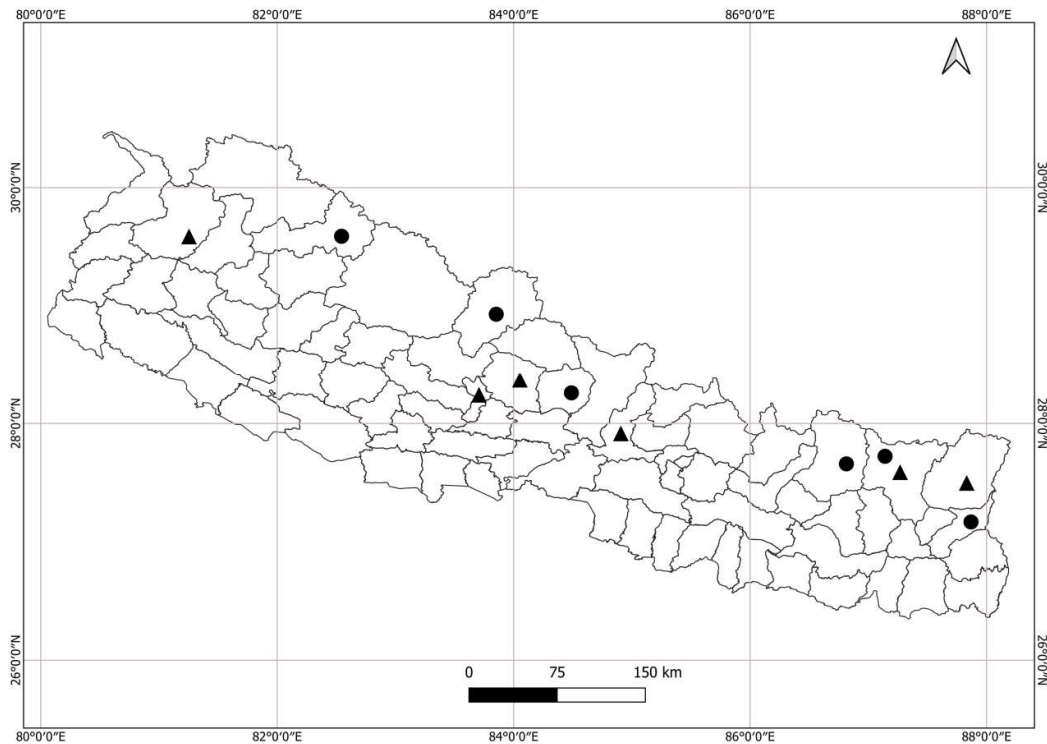


Figure 7: *Calanthe alpina* Hook.f. ex Lindl. A. Habit sketch. B. Single flower. C. Dorsal sepal. D. Lateral sepal. E. Petal. F. Lip. G. Lip attachment with column. (P.R. Shakya *et al.* 6344, KATH).

Distribution: Nepal: West, Central, East (Map 2), Bhutan, China, India, Japan, Myanmar, Taiwan.



Map 2: Distribution of *C. alpina* Hook.f. ex Lindl. in Nepal.

Specimens examined:

Western Nepal: *Sudurpaschim province:* [**Bajhang**] Above Thengnada [Thogundanda], 2700 m, 8 July 1981, *P. R. Shakya, L. R. Sharma & K. R. Amatya* 6344 (KATH002258!).
Karnali province: **Mugu**, Chankheli Lagna, 10,000 ft, 19 June 1952, *Polunin, Sykes & Williams* 4332 (BM000514457).

Central Nepal: *Gandaki Province:* **Kaski**, Himalaya-Doram, 2460 m, 30 June 2001, *P. R. Shakya & S. Poudel* 10499 (KATH!); **Parbat**, Ghodepani, 2750 m, 23 June 1975, *D. P. Joshi & T. K. Bhattacharya* 75/2928 (KATH002261!, KATH002262!); Ghodepani, 2700 m, 21 July 1976, *D.P. Joshi & S. K. Dhungana* 76/3875 (KATH!).
Bagmati Province : **Dhading**, Ganesh Himal, 2800 m, 14 July 1992, *W. J. Baker, T. A. Burkilt, J. T. Miller & R. Shrestha* 13 (KATH!); Ganesh Himal, Ankhukhola, 2800 m, 14 July 1992, *W. J. Baker, T. A. Burkilt, J. T. Miller & R. Shrestha* 12 (KATH002263!);
Lamjung, Lamjung Himal, 10,500 ft, 16 July 1954, *Stainton, Sykes & Williams* 6381 (BM000514460); **Mustang**, 2470 m, 29-40°N 83 – 35°E, 29 August 1988, *M. Suzuki et*

al. 8800564 (TI); 2470 m, 29-40°N 83 – 35°E, 29 August 1988, *M. Suzuki et al.* 8800572 (TI); 2480 m, 29-40°N 83 – 35°E, 2 September 1988, *M. Suzuki et al.* 8830684 (TI).

Eastern Nepal: Province 1: [Taplejung], Ramite, 2700 m, 3 July 1972, *P.R. Shakya* 1948 (KATH!); **Sankhuwasabha**, Chichila, 1900 m, 13 December, *D. B. Karkee* 821 (KATH!); **Panchthar**, 1970- 2750 m, 27-10°E 87-54°N, 25 June 1992, *S. Noshiro et al.* 9241063 (TI); 2160 – 2540 m, 27-35°E 87-15°N, 14 July 1988, *M. Suzuki et al.* 10009087 (TI); **Solukhumbu**, 2860 m, 27 – 34° N 86 – 48°E, 4 August 1997, *M. Wakabayashi et al.* 9730120 (TI); 3020 m, 27 – 35°N 86 – 44°E, 3 August 1997, *M. Wakabayashi et al.* 9715060 (TI).

2. *Calanthe arcuata* Rolfe. Bull. Misc. Inform. Kew 1896: 196 (1896). *Chen et al., Fl. China.* 25:292-301. (2009); *Raskoti & Ale Phytotaxa* 394: 257-266 (2019); *Shrestha et al. Pl. Nep.* :77 (2022).

Calanthe arcuata var. *brevifolia* Z. H. Tsi, *Acta Phytotax. Sin.* 19: 508 (1981)

Calanthe caudatilabella var. *latiloba* F. Maek. Ex Yamam., *J. Jap. Bot.* 15: 118 (1939)

Type specimen: China, Hubei [Hupei], *A. Henry* 6514 (Holotype: K)

Plants ca. 46 cm tall. Pseudobulb conic. Pseudostem very short, 2.5-3 × 1.5 cm with 2 or 3 tubular sheaths. Leaves 5, basal, linear, 20-25 × 1-2 cm, petiole like base sheathing, acute to acuminate. Scape usually 1, arising from leaf axil, 45 cm long, longer than mature leaves, pubescent. Peduncle 12 cm long, raceme 15 cm long, ca. 15 laxly flowered. Sterile bract 1, linear-lanceolate, ca. 1.9 × ca. 0.4 cm, 5 veins, slightly pubescent in outer surface, acuminate. Floral bracts linear, shorter than length of pedicel and ovary, 2.3-2.6 × 0.3-0.4 cm, 3 veins, slightly pubescent, acuminate. Pedicel and ovary arcuate, 1.5-2.2 cm long, pubescent. Sepals similar, lanceolate, 1-1.3 × 0.2-0.4 cm, 5 veins, acuminate. Petals shorter than sepals, linear-lanceolate, 0.7-1 × ca. 0.2 cm, 3 veins, acute. Lip adnate to entire length of the column, unlobed, lanceolate, disk with 3 ridges, 0.6-0.8 × ca. 0.2cm, aristate apex; spur cylindrical, smaller than pedicel and ovary, 0.2-0.3 × ca. 0.1 cm, slightly pubescent. Column short, 4-5 mm, broadly winged, glabrous. (Figure 8).

Altitude: 2000 m

Ecology: Humid places

Flowering: August

Notes: The description is based on examination of single herbarium specimen from KATH. However the taxonomic character about the species was not mentioned in the field note of herbarium specimen. According to Raskoti & Ale (2019) the flower of this species is yellowish green colour flushed with purplish brown markings and the lip to be not unlobed.

The type specimen (*A. Henry* 6514, K000810936) stated the colour of flower as yellow purplish. And the lip is distinctly 3 lobed, with the orbicular side lobes and a mid lobe with dented edges at upper part. The petal is extremely linear like that of *Calanthe puberula*. The species studied here does not have such linear petal.

In the protologue of this species, it was mentioned that the species has 3-lobed lip, however the examination of specimen confirmed that it has unlobed lip. This fact is supported in the *Flora of China* which has described that the lip of this species may be 3 lobed or rarely unlobed lip.

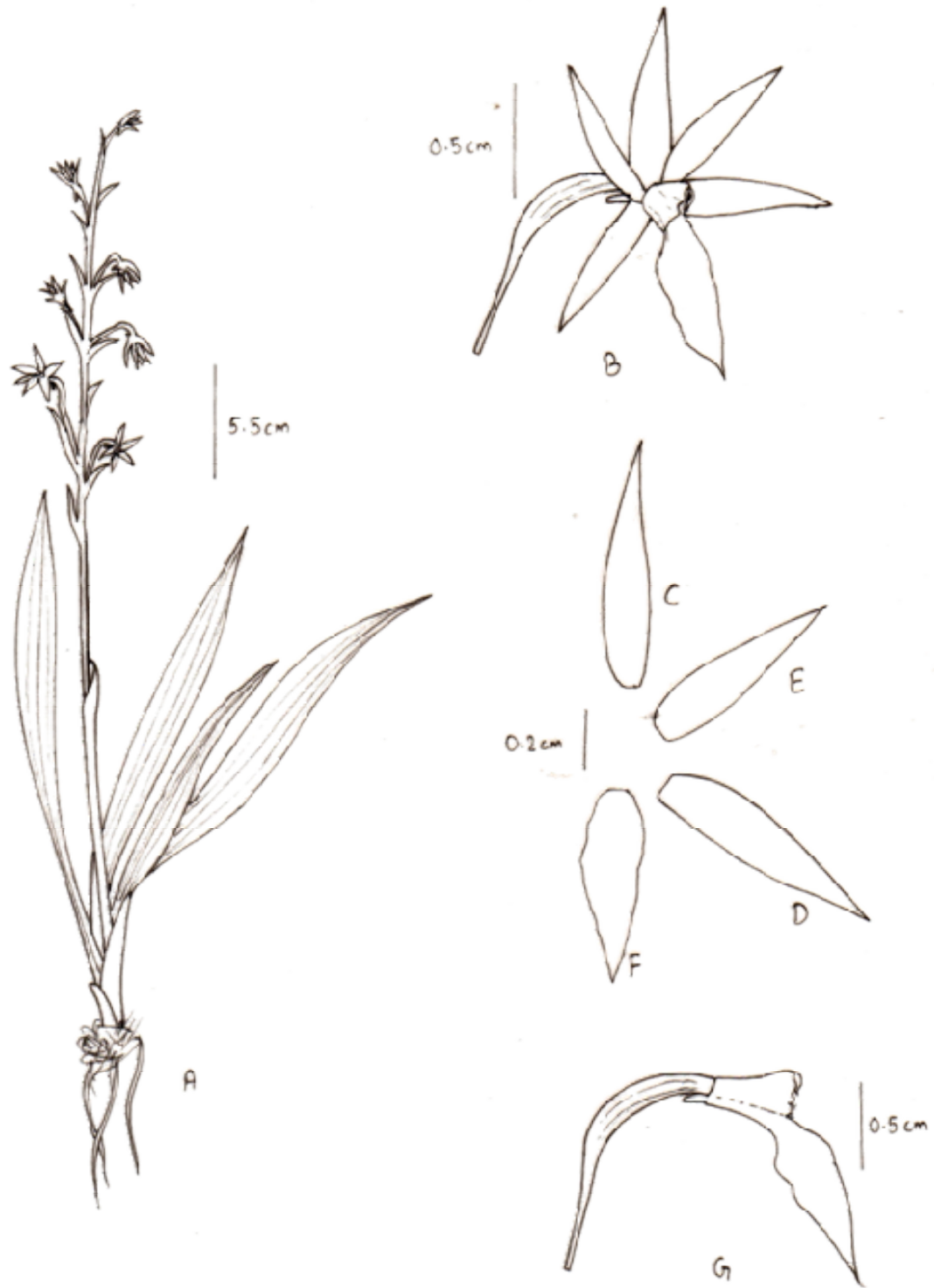
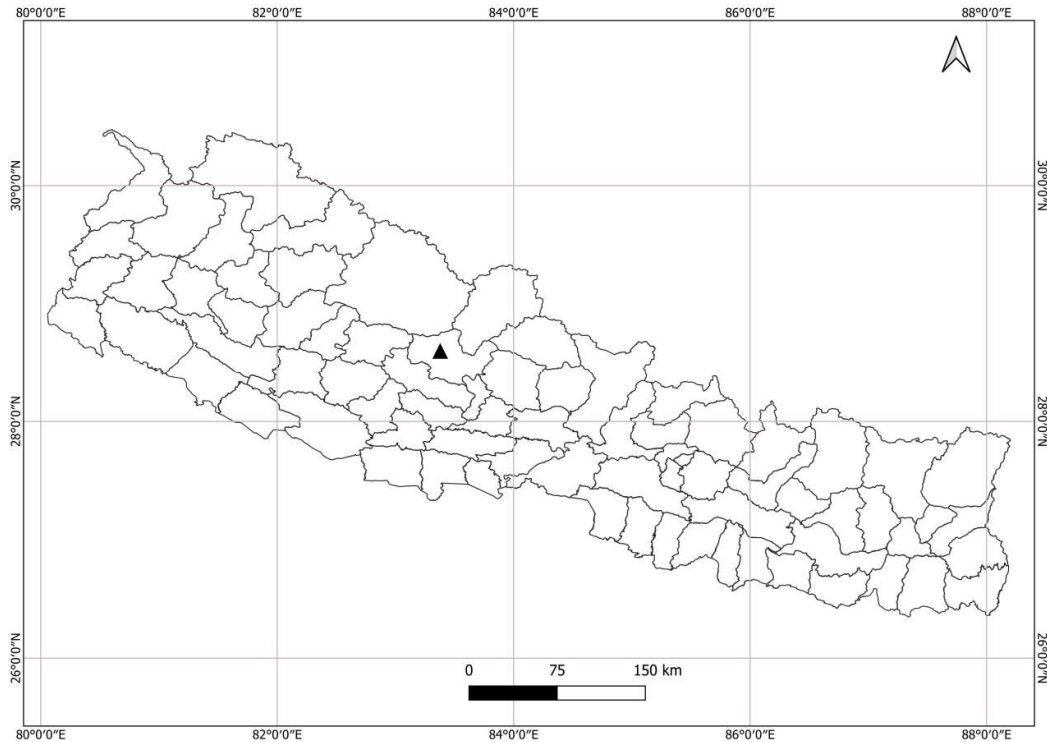


Figure 8: *Calanthe arcuata* Rolfe A. Habit sketch. B. Single flower. C. Dorsal sepal. D. Lateral sepal. E. Petal. F. Lip. G. Lip attachment with column. (B.B. Raskoti 007, KATH038917).

Distribution: Nepal: Central (Map 3), China, Myanmar, Taiwan.



Map 3: Distribution of *C. arcuata* Rolfe in Nepal.

Specimens examined:

Central Nepal: Gandaki Province, **Myagdi**, Moreni, 2000 m, 9 August 2007, Raskoti, Bhakta Bahadur 007 (KATH038917!).

3. *Calanthe brevicornu* Lindl. *Gen. Sp. Orchid Pl.*: 251 (1830-1840); *Fol. Orchid.* 6: 3 (1855); *Fl. Brit. Ind.* 5:848 (1890); King & Pantl. *Ann. Roy. Bot. Gard. Calcutta* 8:168 (1898); Hara *et al. Enum. Fl. Pl. Nep.* 1:34 (1978); Press *et al. Ann. Ch. Fl. Pl. Nep.*:210 (2000); Pearce & Cribb *Fl. Bhutan.* 3:284 (2002); Chen *et al. Fl. China.* 25:292-301. (2009); Rokaya *et al. Ann. Ch. Fl. Nep.*:518 (2013); Rajbhandari *Hand. Orchid. Nep.* :21 (2015); Rajbhandari & Rai *Hand. Fl. Pl. Nep.* 1:79 (2017); Shrestha *et al. Hand. Fl. Pl. Nep.* 1:100 (2018); Shrestha *et al. Pl. Nep.*:77 (2022).

Alismorkis brevicornu (Lindl.) Kuntze, *Revis. Gen. Pl.* 2: 650 (1891)

Calanthe brevicornu var. *wattii*. Hook. f., *Fl. Brit. India* 5(2): 848 (1890)

Type specimen: Nepal, Sheopore [Shivapuri], May 1821, *Wallich*, N. 7338 (holotype: K).

Plants 30-60 cm tall. Pseudobulb small, ovoid, 2 cm in diameter. Pseudostem 18 cm with 5 tubular sheaths; basal white, membranous, upper green, 2.5-15 cm long. Leaves 3-4, basal, lanceolate, 30-45 × 5-7 cm, petiole like base sheathing, acute. Scapes 1 or 2 arising from leaf axil, 30-60 cm long, longer than the mature leaves, pubescent. Peduncle 9.5 cm long, surface shiny, slightly pinkish stripes present, raceme 16 cm long, 15-24 laxly flowered. Sterile bract usually 1, lanceolate, 1.5-2 × 0.5-1 cm, slightly pubescent in outer surface, 5 veins, acute. Floral bracts lanceolate, smaller than or equal to pedicel and ovary, 1.5-2 × 0.2-0.4 cm, 3 veins (green colour), slightly pubescent outside, acute. Pedicel and ovary 1.8 cm long, pubescent. Sepals subsimilar; ovate-lanceolate, 1.7-2 × 0.6-0.8 cm, 3 veins, slightly pubescent in outer surface, acute; lateral sepals lanceolate, 1.7-2 × 0.6-0.8 cm. Petals as same as sepals, elliptic-lanceolate, 1.3-1.8 × 0.3-0.6 cm, 3 veins, acute. Lip adnate to base of the column, dark pink with white marginal edges, 3 lobed; side lobes falcate obtuse, 0.4 × 0.5 cm; mid lobe reniform, yellowish colour in the base, 0.6-1 × 0.8-1 cm, disk with 3 fleshy tubercled lamellae, apex emarginate with mucronate in sinus; spur short, pink, cylindrical, smaller than pedicel and ovary, 0.3 × 0.2 cm, glabrous, blunt tip. Column short, 5 mm long, pubescent at base. (Figure 9).

Altitude: 2000 – 2500 m

Ecology: Shady place.

Flowering: March – August

Notes: On the examination of fresh plant material, these characters are noted: The sepals and petals are present with 3 yellowish white stripes in the inner surfaces. Also the sepals and petals are yellow white colour in outer surface, shiny red brown in inner surface with white distinct edges. The lower part of pedicel and ovary is pink and upper is green.

Voucher specimens: Kavrepalanchok, Parthali, 2220 m, 27°32'20"N 85°28'43"E, 10 Aug 2022, *Rina Duwal, Pushpa Shakya & Nabina Kasichhwa* R106 (ASCOL).

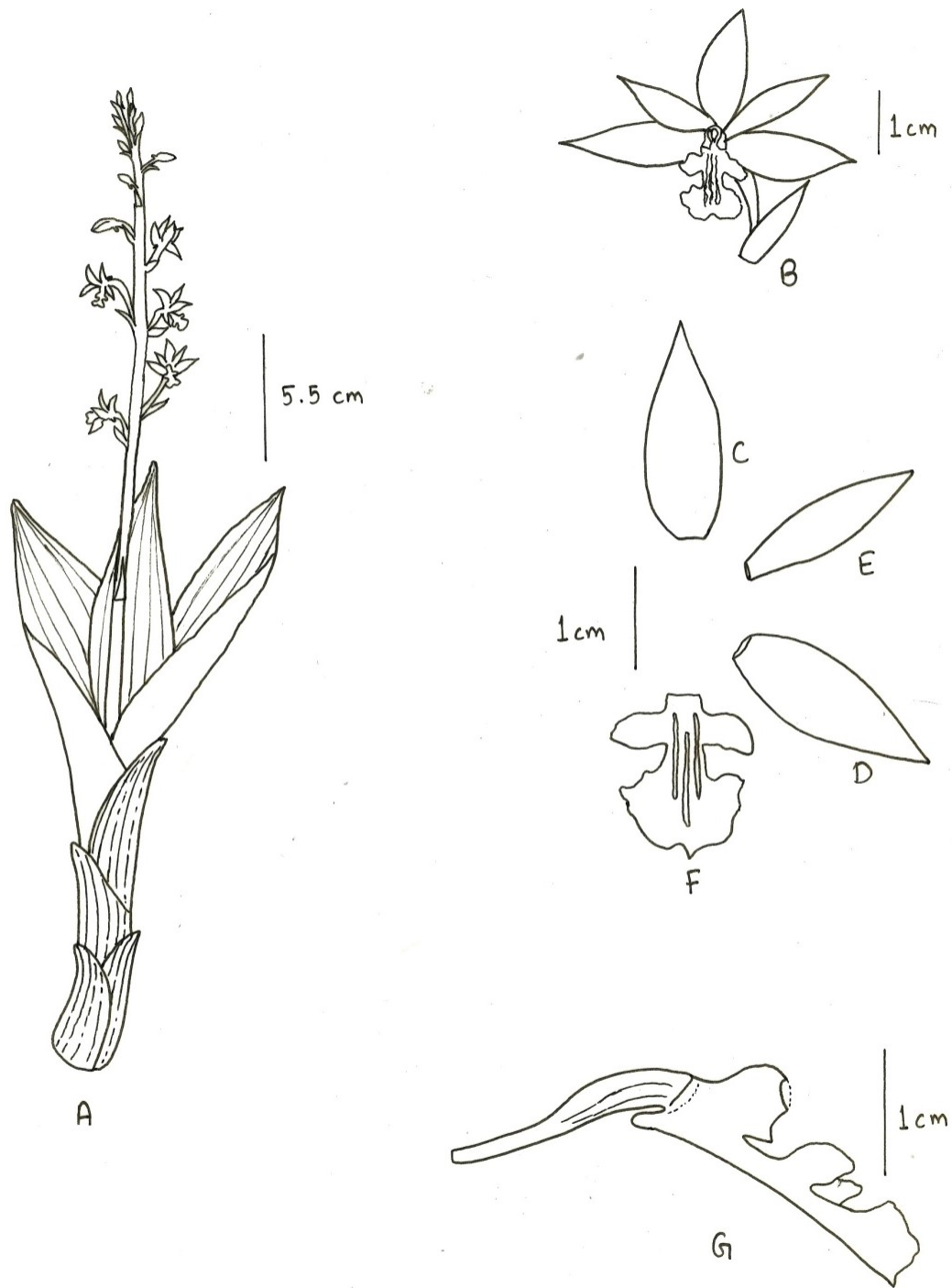
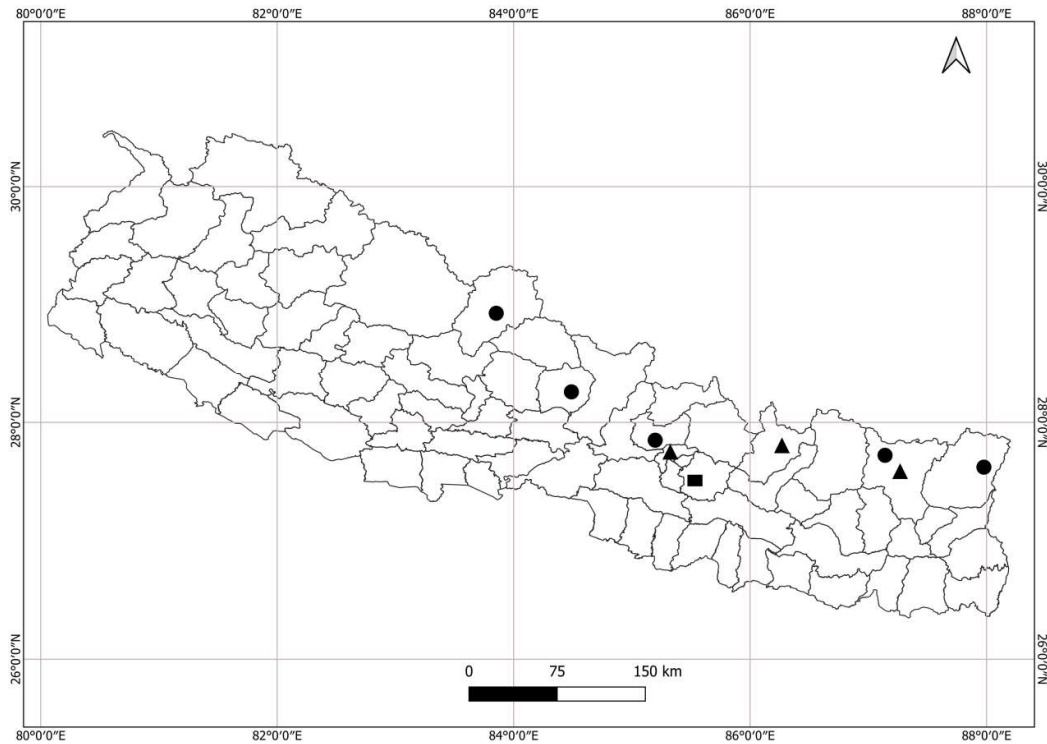


Figure 9: *Calanthe brevicornu* Lindl. A. Habit sketch. B. Single flower. C. Dorsal sepal. D. Lateral sepal. E. Petal. F. Lip. G. Lip attachment with column. (Rina Duwal *et al.* R106, ASCOL).

Distribution: Nepal: Central, East (Map 4), Bhutan, Burma, China, India, Myanmar.



Map 4: Distribution of *C. brevicornu* Lindl. in Nepal.

Specimens examined:

Central Nepal: *Bagmati Province* : **Dolakha**, Jungu, Gaurisankar RM, 2000 m, 23 May 2018, *P. Bhandari & S. Gurung* J35 (KATH!); near Deurali, 2230 m, 6 March 2017, *Sangram Karki* D01 (TUCH!); [**Kathmandu**], Chandragiri, 2050 m, 17 July 1982, *Mahesh* (TUCH!); *Gandaki province*: [**Lamjung**], Lamjung Himal, 5 June 1975, *Stainton, J. D. Adam* 7363 (E00296621); **Mustang**, Below Gandrung. 6000 ft, 25 June 1971, *C. Barclay & P.M. Syngé* 2333 (K). **Nuwakot**, Kutumchang, North of Kathmandu, 2700 m, 26 June 1973, *Grey-Wilson & Philips* 137 (K).

Eastern Nepal: *Province 1* : **Sankhuwasabha**, Below Namche Kharka, 2180 m, 11 June 1994, *P. R. Shakya & K. K. Dangol* 10060 (KATH002264!); Below Tashigaun, M.B.N. Park, 2000 m, 29 May 2011, *M. L. Pathak & L. R. Tharu* 20110550 (KATH!); Sedua, 31 May 1981, *Stainton, J. D. A* 8313 (E00296620); [**Taplejung**] Mewa Khola, 27°30'N 87°38'E, 7500 ft, 16 May 1974, *Stainton, J. D. A* 7024 (E00694021).

4. *Calanthe chloroleuca* Lindl. *Fol. Orchid.* 6: 10 (1855); *Fl. Brit. Ind.* 5:852 (1890): King & Pantl. *Ann. Roy. Bot. Gard. Calcutta* 8: 171 (1898); Pearce & Cribb *Fl. Bhutan* 3: 285 (2002); Rokaya *et al. Ann. Ch. Fl. Nep.*:518 (2013); Rajbhandari *Hand. Orchid. Nep.*:21 (2015); Rajbhandari & Rai *Hand. Fl. Pl. Nep.* 1:79 (2017); Shrestha *et al. Hand. Fl. Pl. Nep.* 1:100 (2018); Shrestha *et al. Pl. Nep.*:77 (2022).

Alismorkis chloroleuca (Lindl.) Kuntze, *Revis. Gen. Pl.* 2: 650 (1891)

Calanthe galeata Lindl., *Fol. Orchid.* 6: 5 (1855)

Type specimen: India, Sikkim, 2000 ft, *J.D. Hooker* 244 (holotype: K-LINDL)

Plants 35-63 cm tall. Pseudobulb ovoid. Pseudostem 11-15 × 1-1.5 cm with 3-5 tubular sheaths. Leaves 2-3, subequal, ovate lanceolate, 21-51 × 5-10 cm, distinct petiole, acute. Scapes 1 or 2, arising from leaf axil, 30-45 cm long, pubescent. Peduncle 6.5-8.5 cm long, raceme 7-18 cm long, 5-8 laxly flowered. Sterile bract usually 1, lanceolate, 0.5-1.5 × 0.2-0.4 cm, single vein, glabrous, acute. Floral bracts concave, lanceolate, smaller than pedicel and ovary, 0.5-1.2 × 0.1-0.2 cm, single vein, slightly pubescent outside, acute. Pedicel and ovary 1.5-2.5 cm long, pubescent. Sepals subsimilar; dorsal sepal light green, ovate-lanceolate, 1-2 × 0.4-0.6 cm, 5 veins, pubescent in outer surface, acute; lateral sepals longer than dorsal sepal, lanceolate, 1.6-2 × 0.4-0.6 cm. Petals elliptic-lanceolate, 1.5-1.8 × 0.2-0.6 cm, 3 veins, pubescent in outer surface, acute to acuminate. Lip adnate to entire length of the column, 1.5-2 cm long, white, yellowish at base, 3 lobed; side lobes small, broadly oblong, 0.6 × 0.3 cm; mid lobe broad, divided by a narrow sinus into two broad rounded lobules, 0.8-1.3 × 1.2-1.5 cm; spur stout, cylindrical, club shaped, smaller or equal to pedicel and ovary, 1.5-2 × 0.2 cm, pubescent. Column short, 5 mm long, broad, pubescent at base. (Figure 10).

Altitude: 2100 – 2400 m

Ecology: Moist and shady place.

Flowering: April – May

Notes: King & Pantling (1898) noted that this species is closely allied to *C. herbacea* Lindl. which differs in having more flowers than *C. herbacea*. The floral bracts and spur of *C. chloroleuca* are smaller than that of *C. herbacea*. They also stated that the apical lobules of mid lobe in *C. chloroleuca* are crenate, broad, rounded and not diverging but in *C. herbacea*, the lobules in mid lobe of lip are entire, narrowly oblong and diverging.

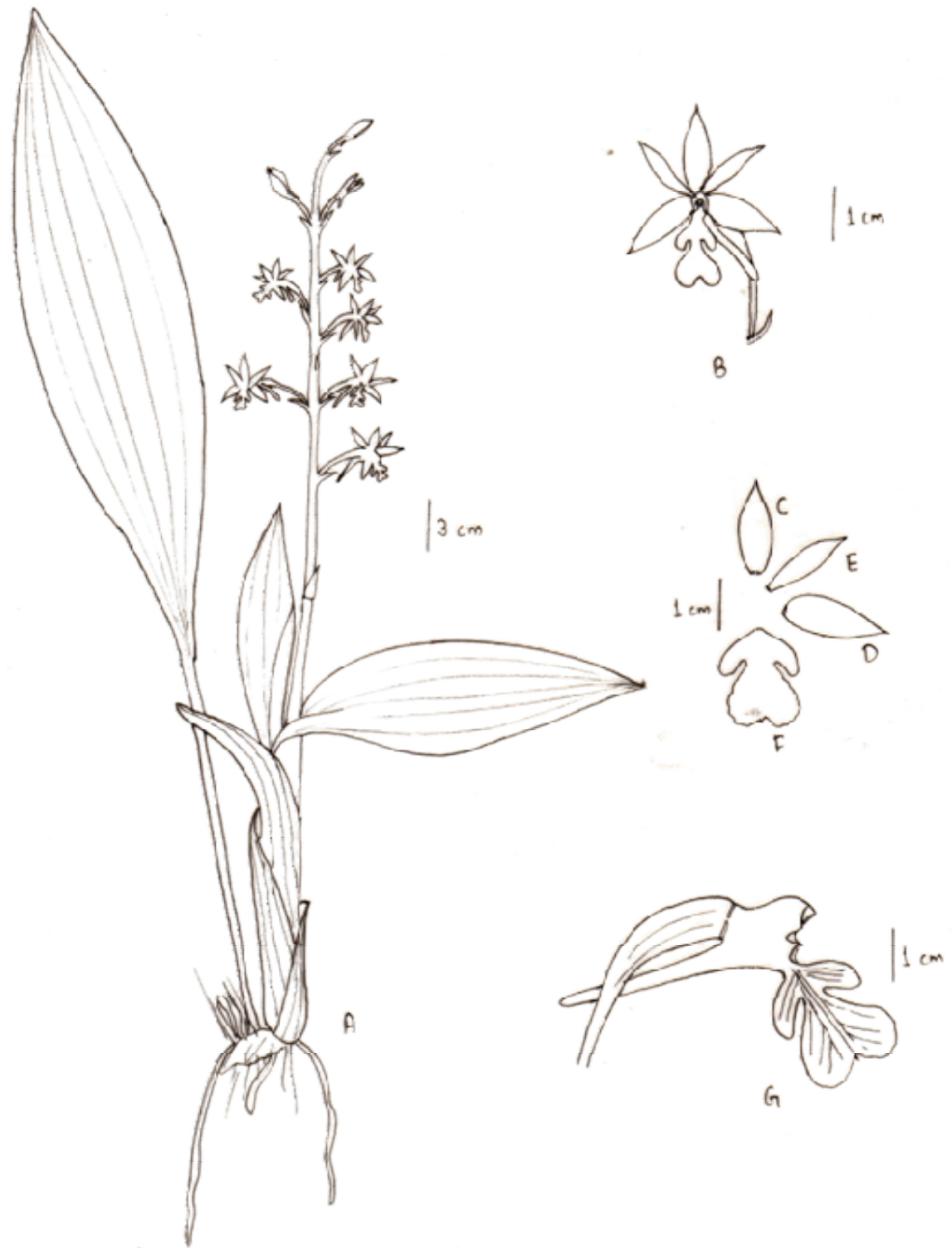
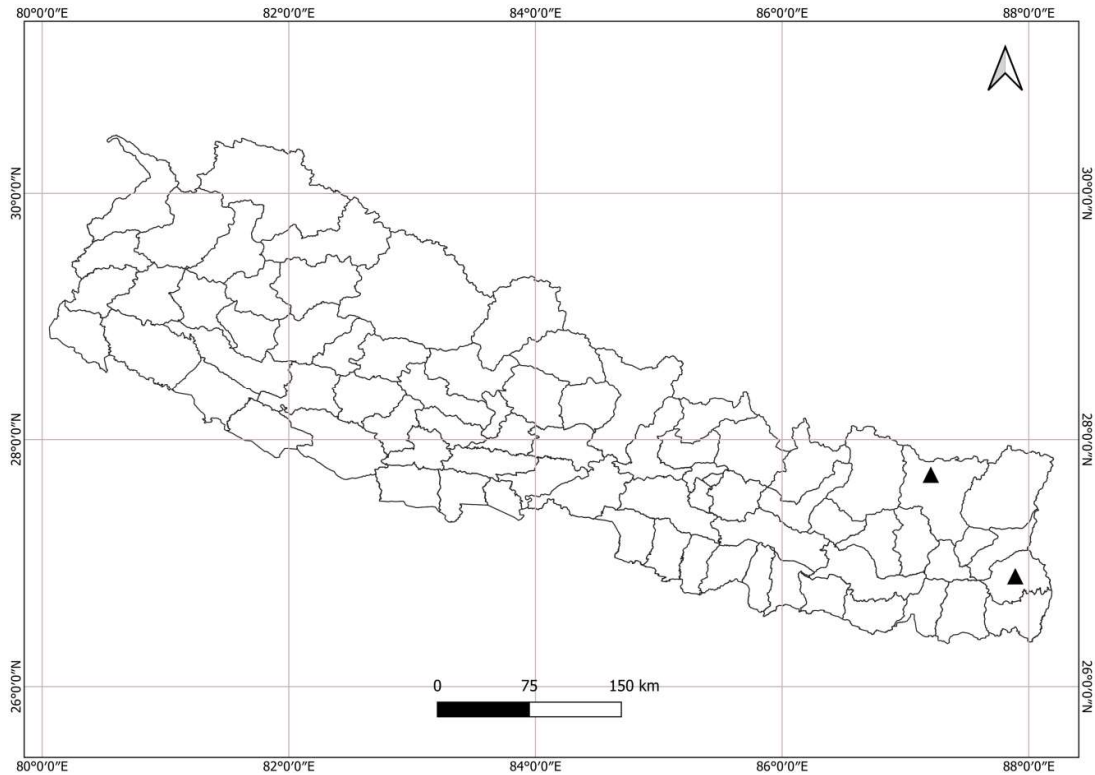


Figure 10: *Calanthe chloroleuca* Lindl. A. Habit sketch. B. Single flower. C. Dorsal sepal. D. Lateral sepal. E. Petal. F. Lip. G. Lip attachment with column. (S. Dahal 9777, KATH).

Distribution: Nepal: East (Map 5), Bhutan, China, India, Myanmar.



Map 5: Distribution of *C. chloroleuca* Lindl. in Nepal.

Specimens examined:

Eastern Nepal: *Province 1* : Shepawa to Honggaun, 8000 ft [2438 m], 16 May 1965, *Dr. Banerjii, Upadhyaya & Baskola* 3501 (KATH002266!); **Illam**, Maipokhari, 2150 m, 13 April 1977, *P. R. Shakya* 4033 (KATH002267!, KATH002268!, KATH002269!); **Sankhuwasabha**, Chhyangmarimu – Chhyumsur, 2220 m, 20 April 1991, 9777 (KATH!).

5. *Calanthe davidii* Franch. *Nouv. Arch. Mus. Hist. Nat.*, sér. 2, 10: 85 (1887 publ. 1888); *Fl. Brit. Ind.* 5:850 (1890); Hara *et al. Enum. Fl. Pl. Nep.*1:35 (1978); Press *et al. Ann. Ch. Fl. Pl. Nep.*:210 (2000); Chen *et al. Fl. China.* 25:292-301. (2009); Rokaya *et al. Ann. Ch. Fl. Nep.*:518 (2013); Rajbhandari *Hand. Orchid. Nep.*:21 (2015); Rajbhandari & Rai *Hand. Fl. Pl. Nep.* 1:79 (2017); Shrestha *et al. Pl. Nep.*: 77 (2022).

Alismorchis pachystalyx Kuntze, *Revis. Gen. Pl.* 2: 650. 1891

Calanthe bungoana Ohwi, *Acta Phytotax. Geobot.* 5: 56 (1936)

Calanthe pachystalyx Rchb.f. ex Hook. f., *Fl. Brit. India* 5: 850 (1890)

Type specimen: China, Moupin, *David, A* #s.n. (Syntype: P00378879).

Plants ca. 50 cm tall. Pseudobulb not distinct. Pseudostem 7-8 cm long with 2 or 3 tubular sheaths. Leaves 3-4, basal, linear, 20-30 × 0.7-1 cm, petiole like base sheathing, acute. Scapes 1 or 2, arising from leaf axil, ca. 48 cm long, longer than the mature leaves, pubescent, more than 25 densely flowered. Sterile bracts more than 2, linear-lanceolate, ca. 2.4 × 0.3 cm, pubescent, acute. Floral bracts linear, reflexed, longer than pedicel and ovary, 0.8-1.1 × 0.1-0.2 cm, 3 veins, slightly pubescent in outer surface, acuminate. Pedicel and ovary 0.5-0.8 cm long, pubescent. Sepals similar; ovate-lanceolate, reflexed, 0.6-0.7 × 0.3-0.4 cm, 5 veins, acute to round apex. Petals lanceolate, reflexed, ca. 0.6 × 0.3 cm, 3 veins, acute. Lip adnate to entire length of the column wings, 3 lobed; side lobes ovate oblong, mid lobe broad, divided by a deep sinus into two broad rounded lobules; lobules divergent, suboblong; spur cylindrical, longer than pedicel and ovary, 1.2-1.5 cm long. Column short, broad, 3 mm long, glabrous. (Figure 11).

Altitude: 2100 m

Ecology: In a dense forest

Flowering: July

Notes: The above description is based on a single herbarium specimen deposited at BM. The reference was taken from the type specimen. There is no herbarium specimen deposited in KATH. This is the only species of *Calanthe* present in Nepal which have reflexed sepals, petals and floral bracts.

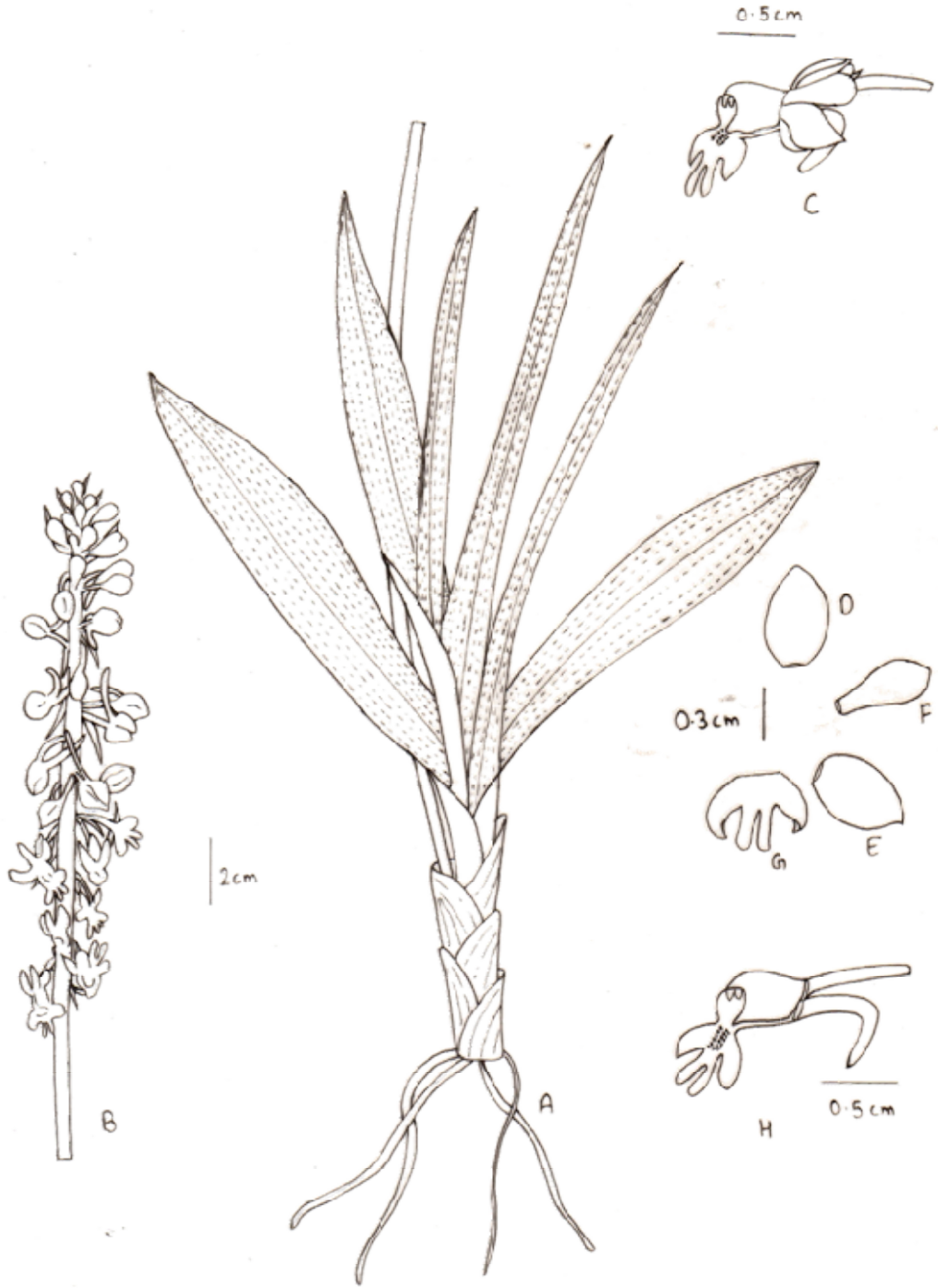
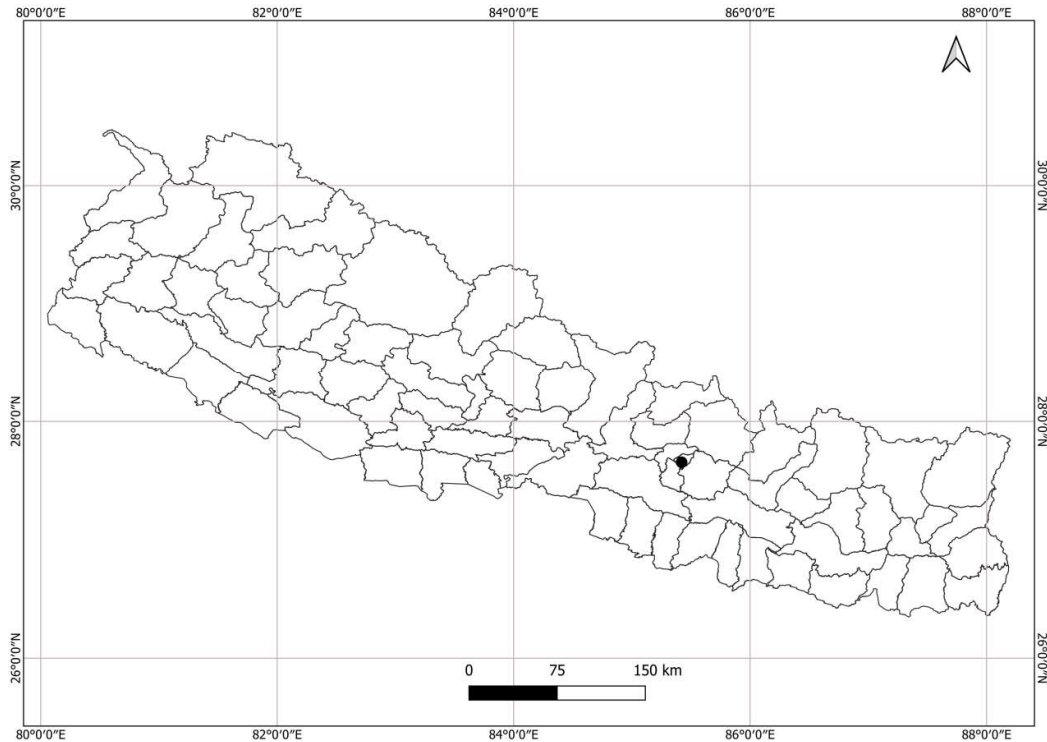


Figure 11: *Calanthe davidii* Franch. A-B Habit sketch. C. Single flower. D. Dorsal sepal. E. Lateral sepal. F. Petal. G. Lip. H. Lip attachment with column. (Illustration made by Prof. Dr. Lokesh Ratna Shakya without collecting the plant).

Distribution: Nepal: Central (Map 6), Bhutan, China, India, Japan, Taiwan, Vietnam.



Map 6: Distribution of *C. davidii* Franch. in Nepal.

Specimen examined:

Virtual specimen: Central Nepal: Bagmati Province: Bhaktapur, Nagarkot, 7000 ft [2133 m], 7/7/1935, F. M. Bailey s.n. (BM000514448).

6. *Calanthe densiflora* Lindl. *Gen. Sp. Orchid Pl.*:250 (1840); *Fol. Orchid.* 6: 9 (1855); *Fl. Brit. Ind.* 5:855 (1890); King & Pantl. *Ann. Roy. Bot. Gard. Calcutta* 8: 174 (1898); Pearce & Cribb *Fl. Bhutan.* 3:295 (2002); K. R. Rajbhandari. *J. Jpn. Bot.* **80**: 106-108 (2005); Chen *et al. Fl. China.* 25:292-301. (2009); Rokaya *et al. Ann. Ch. Fl. Nep.* :518 (2013); Rajbhandari *Hand. Orchid. Nep.*:22 (2015); Rajbhandari & Rai *Hand. Fl. Pl. Nep.* 1:79 (2017); Shrestha *et al. Hand. Fl. Pl. Nep.* 1:100 (2018); Shrestha *et al. Pl. Nep.*: 77 (2022).

Alismorkis densiflora (Lindl.) Kuntze, *Revis. Gen. Pl.* 2: 650 (1891)

Calanthe kazuoi Yamam., *Trans. Nat. Hist. Soc.* 20:38(1930)

Type specimen: India, Sylhet, *De Silva* 7344 (Syntype: K001127203).

Plants ca. 45 cm tall. Pseudobulb small, ovoid, stout, enclosed by leaf sheaths. Pseudostem, slender 9 cm long. Leaves 3, basal, lanceolate, 28-33 × 4-5 cm, glabrous, petiole like base sheathing, acute. Scape usually 1, arising from the rhizome behind the stem, erect, 18 cm long. Peduncle 5-10 cm long, pubescent, raceme short, 16 cm long, 4-10 densely flowered. Sterile bracts several, more than 2, tubular, 1.5-3 × 0.5-1 cm, more than 5 veins, glabrous, round to acute apex. Floral bracts caducous, linear-lanceolate, longer than the pedicel and ovary, 1.3-1.6 × 0.2-0.3 cm, 3 veins, glabrous, acuminate. Pedicel and ovary 1.3 cm long, pubescent. Sepals different; dorsal sepal ovate-lanceolate, yellow, connivent, 1-1.2 × ca. 0.2 cm, 3 veins, round apex; lateral sepals oblong-lanceolate, the base overlaps the spur base, 1.3-1.5 × 0.2-0.3 cm, 5 veins, acute. Petals yellow, ovate-lanceolate, 0.8-0.9 × ca. 0.2 cm, 3 veins, acute. Lip adnate to base of column, ovate, orbicular, 1.2 cm long, 3 lobed above middle, side lobes ovate triangular, large, with two large semi erect rounded lamellae between them, mid lobe subsquare, emarginated, disk with 2 lamellae; spur straight, globular, cylindric, slightly inflated towards the apex, nearly as long as the pedicel and ovary, 0.8-1.3 cm long, glabrous, obtuse apex. Column slender, base dilated, 2 mm long. (Figure 12).

Altitude: 1400 m

Ecology: Forest floor.

Flowering: November

Notes: This species is the only species which has a scape directly developing from the rhizome to the sides of the stem. And this character makes it different from other species which has the scape developing from the axil of leaf or side of stem. The current study is based on the study of only one herbarium specimen deposited in KATH.

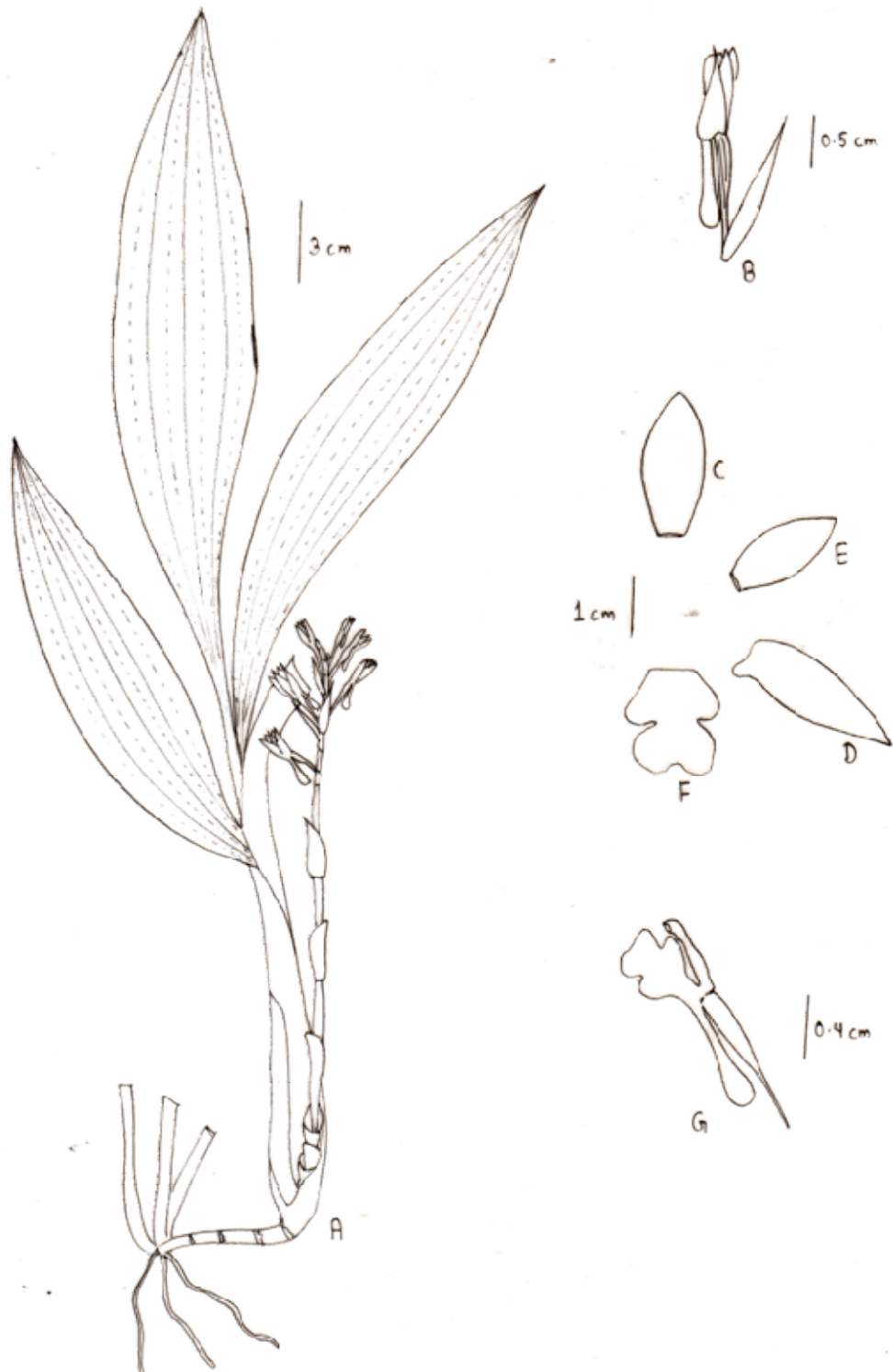
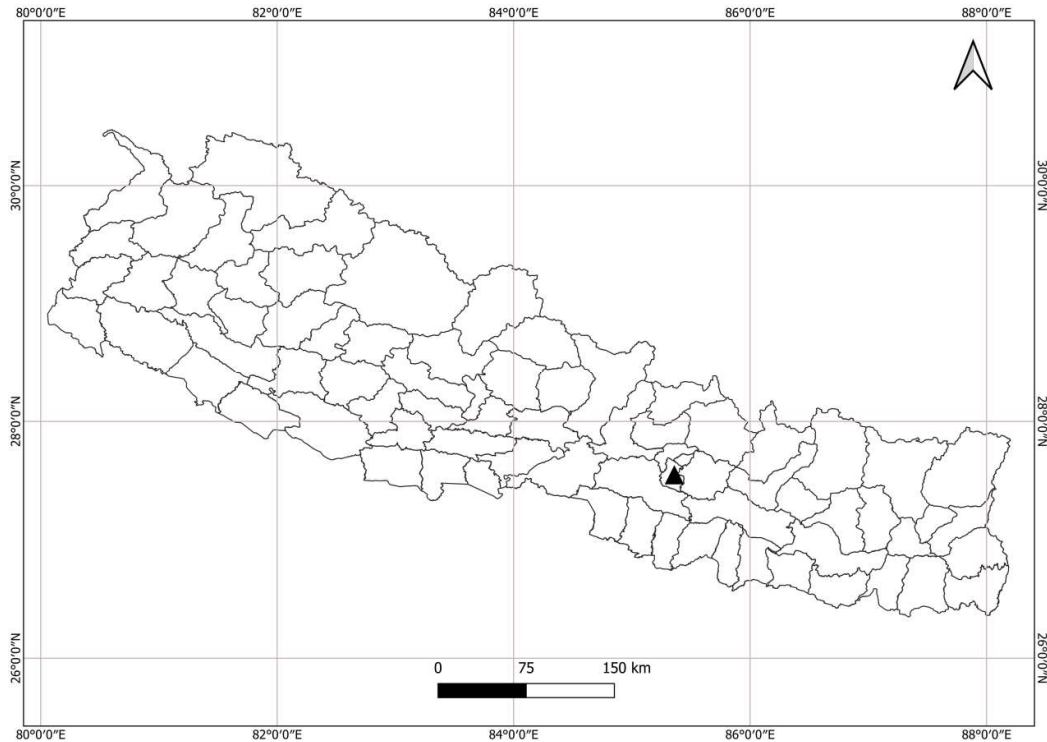


Figure 12: *Calanthe densiflora* Lindl. A. Habit sketch. B. Single flower. C. Dorsal sepal. D. Lateral sepal. E. Petal. F. Lip. G. lip attachment with column. (K.R. Rajbhandari 99/51, KATH001237).

Distribution: Nepal: Central (Map 7), Bhutan, China, India, Taiwan, Veitnam.



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

Specimens examined:

Central Nepal: *Bagmati Province:* **Lalitpur**, South of Bajrbarahi, 1400 m, 20 November 1999, *K. R. Rajbhandari* 99/51 (KATH001237!).

7. *Calanthe griffithii* Lindl. *Fol. Orchid.* 6: 9 (1855); *Fl. Brit. Ind.* 5:852 (1890); Pearce & Cribb *Fl. Bhutan.* 3:286 (2002); Chen *et al.* *Fl. China.* 25:292-301. (2009); Rokaya *et al.* *Ann. Ch. Fl. Nep.*:518 (2013); Rajbhandari *Hand. Orchid. Nep.*:22 (2015); Rajbhandari & Rai *Hand. Fl. Pl. Nep.* 1:80 (2017); Shrestha *et al.* *Hand. Fl. Pl. Nep.* 1:101 (2018); Shrestha *et al.* *Pl. Nep.*:77 (2022).

Alismorchis griffithii Kuntze, *Revis. Gen. Pl.* 2: 650. 1891

Calanthe anjanae Lucksom, *Indian J. Forest.* 16: 386 (1993 publ. 1994)

Type specimen: Bhutan, above Telagong, 1783, *Griffith* 33 (Syntype: K-LINDL).

Plants 20-25 cm tall. Pseudobulb conical, small. Pseudostem 8-13 cm long with 1-3 tubular sheaths. Leaves 3-4, basal, lanceolate, petiole like base sheathing, 8-11 × 3-4 cm, acute. Scape usually 1, arising from leaf axil, 13-24 cm long, densely pubescent.

Peduncle 4-6 cm long, raceme 4-9 cm long, 4-10 laxly flowered. Sterile bract usually 1, lanceolate, ca. 1 × 0.4 cm, single vein, pubescent, acute. Floral bracts lanceolate, smaller than pedicel and ovary, 1-1.2 × 0.1-0.2 cm, 3 veins, slightly pubescent in outer surface, acuminate. Pedicel and ovary 1.5 cm long, pubescent. Sepals subsimilar; dorsal sepal lanceolate, 1-1.3 × 0.3-0.4 cm, 3 veins, glabrous, acute; lateral sepals lanceolate, 1.6 × 0.5 cm, 5 veins, glabrous, acute. Petals elliptic-lanceolate, ca. 1.3 × 0.2 cm, 3 veins (mid darker), acuminate. Lip adnate to base of column, 1 cm long, 3 lobed, side lobes oblong, rounded, mid lobe broadly triangular, 0.8 × 1 cm, margin undulate, apex emarginate and apiculate in sinus with a callus; spur straight, cylindric, 0.4 × 0.2 cm, pubescent. Column, 8 mm long, glabrous. (Figure 13).

Altitude: 2200 m

Ecology: Grassy places.

Flowering: March

Notes: The study is based on two herbarium specimens deposited at KATH, collected from the Eastern Nepal. Jin & Li (2007) has said that *C. fugongensis* is morphologically similar to *C. griffithii*. The former is characterized by lip with hamate lateral lobes and elliptic middle lobe with three rectangular lamellae while the later one is characterized by a broad midlobe with a keel and lateral lobes oblong to spatulate.

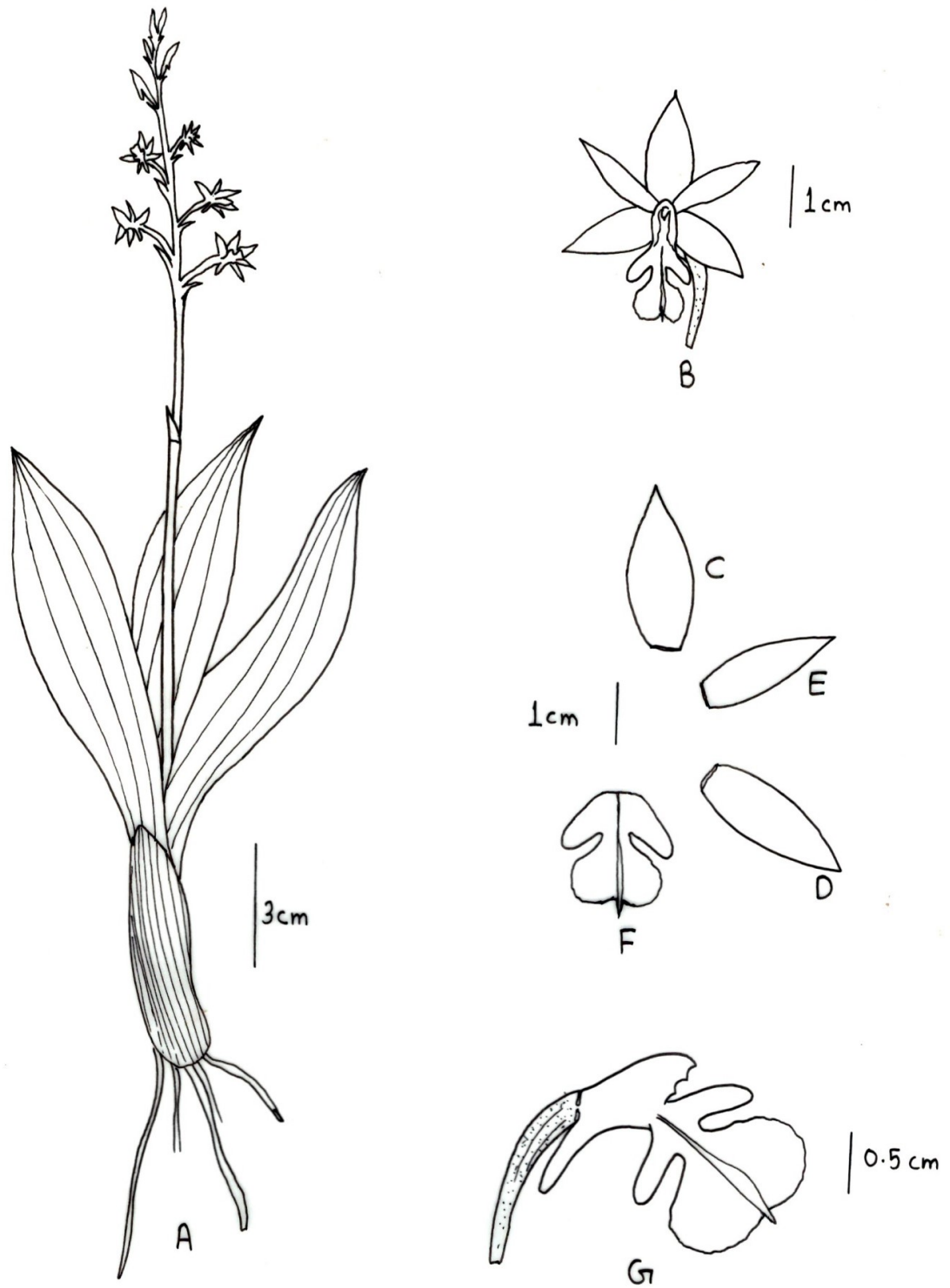
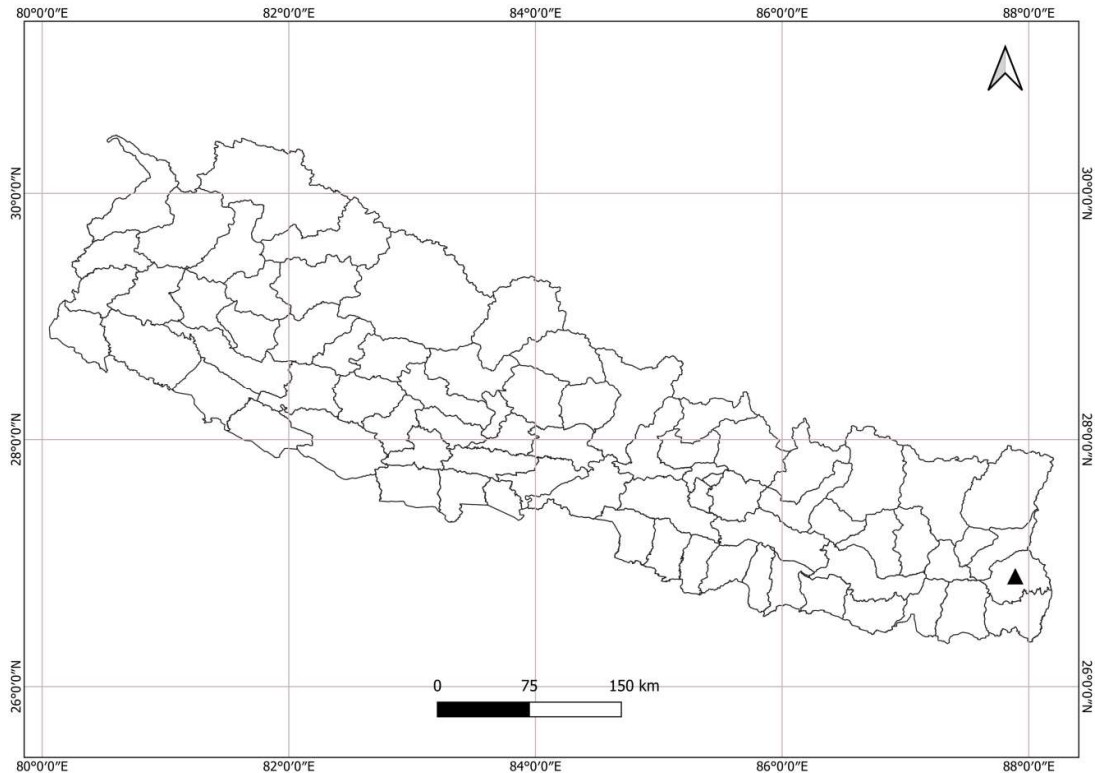


Figure 13: *Calanthe griffithii* Lindl. A. Habit sketch. B. Single flower. C. Dorsal sepal. D. Lateral sepal. E. Petal. F. Lip. G. Lip attachment with column. (K.R. Rajbhandari, S. Bhattarai & R. Joshi 32, KATH038958).

Distribution: Nepal: East (Map 8), Bhutan, Burma, China, India.



Map 8: Distribution of *C. griffithii* Lindl. in Nepal.

Specimens examined:

Eastern Nepal: Province 1 : Illam, Maipokhari, 2200 m, 31 March 1996, K. R. Rajbhandari, S. Bhattarai & R. Joshi 32 (KATH038958!, KATH0038959!).

8. *Calanthe mannii* Hook.f. *Fl. Brit. Ind.* 5:850 (1890); King & Pantl. *Ann. Roy. Bot. Gard. Calcutta* 8: 167 (1898); Hara *et al. Enum. Fl. Pl. Nep.*1:34 (1978); Press *et al. Ann. Ch. Fl. Pl. Nep.*:210 (2000); Pearce & Cribb *Fl. Bhutan.* 3:288 (2002); Chen *et al. Fl. China.* 25:292-301. (2009); Rokaya *et al. Ann. Ch. Fl. Nep.*:518 (2013); Rajbhandari *Hand. Orchid. Nep.* :22 (2015); Rajbhandari & Rai *Hand. Fl. Pl. Nep.* 1:80 (2017); Shrestha *et al. Hand. Fl. Pl. Nep.* 1:101 (2018); Shrestha *et al. Pl. Nep.*:78 (2022).

Alismorchis mannii Kuntze *Revis. Gen. Pl.* 2: 650. 1891

Calanthe brachychila Gagnep. *Bull. Soc. Bot. France* 79: 162 (1932)

Calanthe pusilla Finet *Bull. Soc. Bot. France* 46: 436 (1900)

Type specimen: India, Kumaun, below Ranikhet, 30/05/1886, *Duthie, J.F.* 5996 (Syntype: K000810903).

Plants 30-50 cm tall. Pseudobulb small, ovoid, stout. Pseudostem 9-14 cm long, 1-1.5 cm in diameter with 3-4 tubular sheaths, basal white, membranous upto 4 cm, upper green, 8.5-13.5 cm long. Leaves 2-4, basal, lanceolate, 15-38 × 4-5 cm, distinct petiole, acute. Scapes 1 or 2, arising from leaf axil, 30-60 cm long, longer than the adult leaves, pubescent. Peduncle 5-10 cm long, raceme 16 cm long, 4-37 densely flowered. Sterile bract usually 1, small, lanceolate, 0.5-1.5 × 0.3-0.4 cm, glabrous, 1 vein, acute. Floral bracts minute, lanceolate, smaller than the pedicel and ovary, 0.2-0.4 × ca. 0.1 cm, single vein, glabrous, acute. Pedicel and ovary green, 1-1.5 cm long, pubescent. Sepals subequal; dorsal sepal concave, oblong, shiny inner surface, brown, green at base, 0.6-0.8 × 0.2-0.3 cm, pubescent in the outer surface, 3 vein with light green colour, acute; lateral sepals oblong, 0.7-0.9 × ca. 0.2 cm. Petals narrowly lanceolate, shiny inner surface, brown, 0.6-0.7 × 0.1-0.2 cm, slightly pubescent outside, light green 3 veins, acute. Lip adnate to entire length of column, bright yellow, 0.5 × 0.4 cm, glabrous, 3 lobed; side lobes oblique, 0.1-0.2 × 0.1-0.2 cm, apex obtuse round; mid lobe subreniform, 0.1-0.2 × 0.2-0.3 cm, margin slightly undulate, disk with 3 dark yellow tubercled ridges, apex emarginated; spur short, green, conical, smaller than the pedicel and ovary, 0.2 × 0.1 cm, pubescent. Column white, 7-8 mm long, base light green, slightly pubescent. (Figure 14).

Altitude: 2000 – 2300 m

Ecology: Moist and shady place, in dense forest.

Flowering: March – August ; November (Fruiting)

Notes: The examination of fresh plant materials showed that the inner surface of sepals and petals are shiny. The base of the column is light green in colour with slightly pubescent base. And the anther cap is deeply placed in the apex of column. King & Pantling (1898) noted that this species is self fertile as they could not obtain pollinia among the flowers they have collected. They noticed that the pollinia are absorbed by the stigma among the living plants they collected.

Voucher Specimen: Kavrepalanchok, Parthali, 2258 m, 27°32'19"N 85°28'41"E, 10 Aug 2022, *Rina Duwal, Pushpa Shakya & Nabina Kasichhwa* R105 (ASCOL).

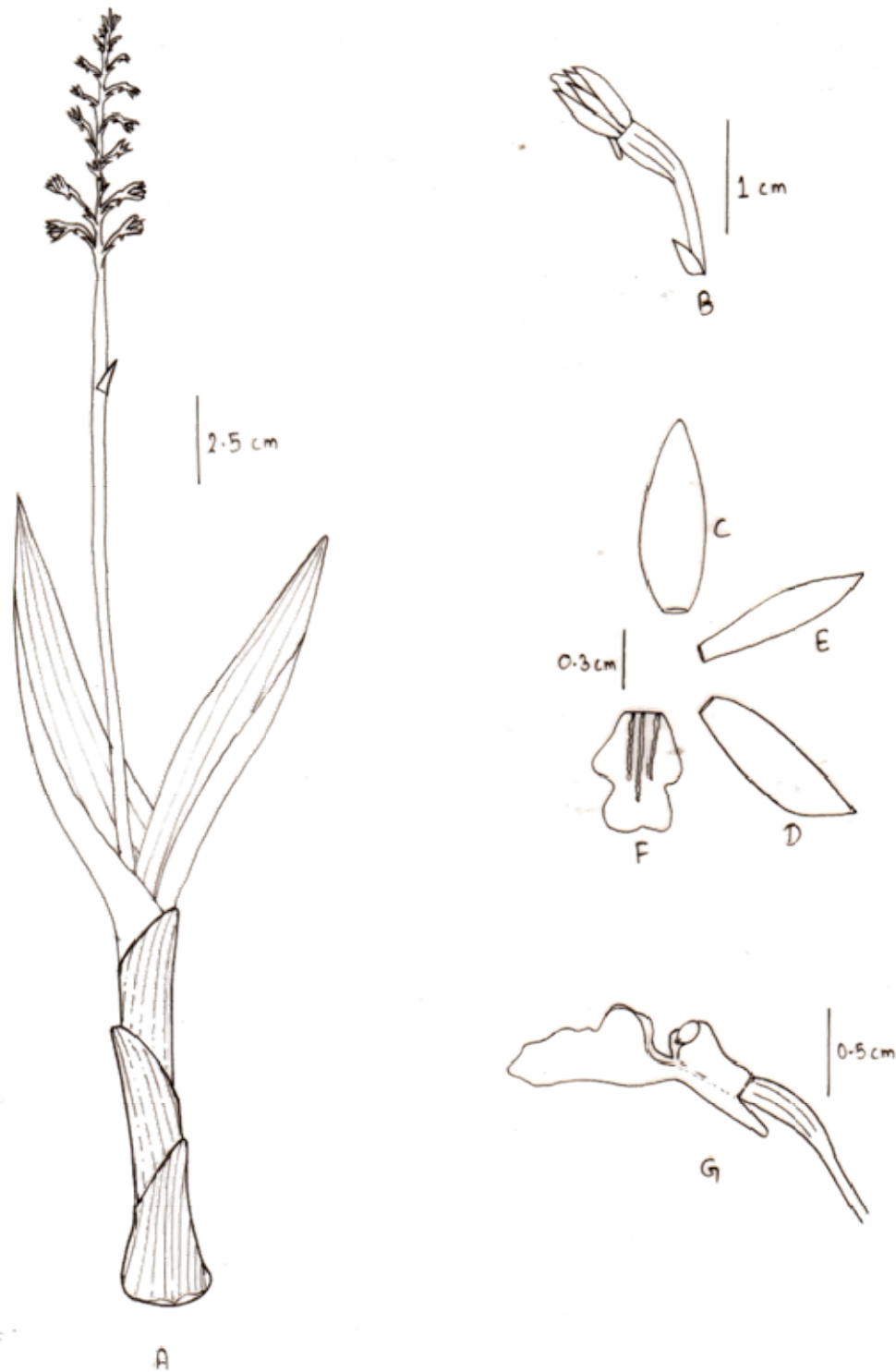
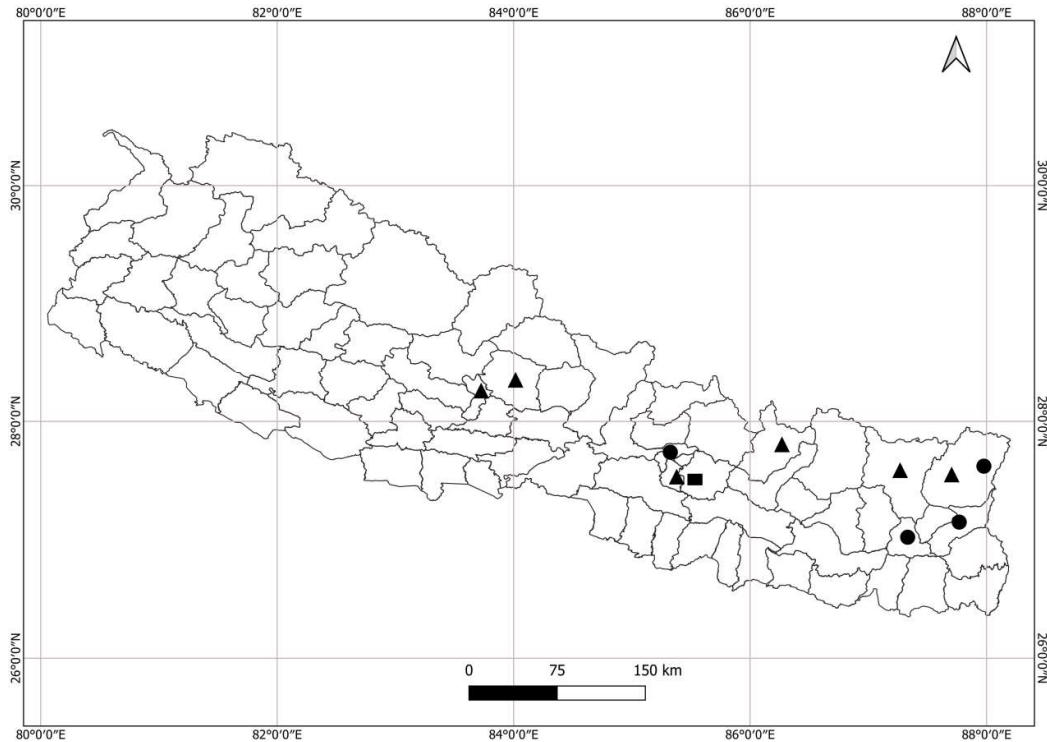


Figure 14: *Calanthe manni* Hook.f. A. Habit sketch. B. Single flower. C. Dorsal sepal. D. Lateral sepal. E. Petal. F. Lip. G. Lip attachment with column. (Rina Duwal *et al.* R105, ASCOL).

Distribution: Nepal: Central, East (Map 9), Bhutan, Burma, China, India, Veitnam.



Map 9: Distribution of *C. mannii* Hook.f. in Nepal.

Specimens examined:

Central Nepal: *Bagmati Province* : **Dolakha**, Khole, Jungu, 86.172°E 27.671°N, 2162 m, 16 June 2018, *S. Karki & Ashish P. Dhital* J17 (KATH086691!); Jungu, Gaurishankar RM, 2000-2100 m, 23 May 2018, *P. Bhandari & S. Gurung* J38 (KATH038039!, KATH0038040!); near Deurali, 2230 m, 6 March 2017, *Sangram Karki* D02 (TUCH);; **Lalitpur**, Phulchoki, 7500ft [2286 m], 28 May 1978, *Ram Bahadur* 440 (KATH002270!, KATH002271!). *Gandaki Province*: [**Parbat**], Chitray, 7600ft [2316 m], 11.9.1977, *P. Pradhan & N. Shrestha* 412 (KATH!); **Kaski**, Panchase forest, 2300 m, 27 June 2017, *P. Bhandari* P1646 (KATH038057!, KATH0038058!); **Kathmandu**, 27-35°E 85-23°N, 29 May 1969, *H. Hara et al.* 69822 (TI); 27-35°E 85-23°N, 29 May 1969, *H. Hara et al.* 10002483 (TI).

Eastern Nepal: *Province 1*: **Dhankuta**, 27-06°E 87-23°N, 6 June 1972, *H. Hara et al.* 726087(TI); 27-09°E 87-24°N, 27 October 1963, *H. Hara et al.* 6307356 (TI); **Panchthar**, 27-14°E 87-57°N, 28 November 1963, *H. Hara et al.* 6307357 (TI); **Sankhuwasabha**, Kiochma-Chumsur, 2020 m, 10 October 1999, *D. B. Karkee* 937

(KATH!); [**Taplejung**], Siringdham, 7500 ft [2286 m], 15 June 1969, *T. B. Shrestha* 15642 (KATH002272!, KATH002273!); **Taplejung**, 27-34°E 87-36°N, 29 June 1969, *H. Hara et al.* 726088 (TI); 27-31°E 87-48°N, 8 November 1963, *H. Hara et al.* 6307355 (TI); 27-31°E 87-48°N, 9 November 1963, *H. Hara & S. Kurosawa* 10002484 (TI).

9. *Calanthe masuca* (D. Don) Lindl. *Gen. Sp. Orchid. Pl.*: 249 (1833); *Fl. Brit. Ind.* 5:850-351 (1890); King & Pantl. *Ann. Roy. Bot. Gard. Calcutta* 8: 173 (1898); *Hara et al. Enum. Fl. Pl. Nep.* 1:35 (1978); *Press et al. Ann. Ch. Fl. Pl. Nep.*: 210 (2000); *Rajbhandari & Rai Hand. Fl. Pl. Nep.* 1:80 (2017); *Shrestha et al. Hand. Fl. Pl. Nep.* 1:101 (2018); *Shrestha et al. Fl. Nep.*: 78 (2022).

Amblyglottis emarginata Blume *Bijdr. Fl. Ned. Ind.*: 369 (1825)

Bletia masuca D. Don *Prodr. Fl. Nepal.* : 30 (1825)

Type specimen: Nepal [Nepal], Naranhiti, 21/2/1803, *Buchanan, H* #s.n. (holotype: BM)

Plants 53 cm tall. Pseudobulb conical. Pseudostem 6.5 × 1 cm with 3 tubular sheaths. Leaves 3, basal, elliptic, 30 - 37 × 4 - 7 cm, distinct petiole present, petiole 10 - 15 cm long, acute. Scape 1 or 2, arising from leaf axil, upto 50 cm long, pubescent. Peduncle 8 - 10 cm long, raceme 21-24 cm long, few to many densely flowered. Sterile bract usually 1, lanceolate, ca. 1.8 × 0.3 cm, acute. Floral bracts linear-lanceolate, base concave, shorter than pedicel and ovary, 0.9-1.7 × 0.2-0.4 cm, 3 veins, glabrous, acute to acuminate. Pedicel and ovary 2.7-3.5 cm long, pubescent. Sepals subsimilar; dorsal sepal ovate-lanceolate, 2-2.5 × 0.6-0.8 cm, 3 distinct veins, acute; lateral sepals lanceolate, 2-2.4 × 0.6-0.7 cm. Petals smaller than sepal, oblong-lanceolate, 0.8-1.2 × 0.2-0.3 cm, 3 veins; middle 3 darker, acute. Lip adnate to entire length of column, 3 lobed; side lobes falcate oblong; mid lobe much larger broadly or cuneately reniform, disk with 3 wart like calli, emarginate; spur cylindrical, equal or exceeding the length of pedicel and ovary, 3-3.5 cm long. Column short. (Figure 15).

Altitude: 1500 - 2100 m

Ecology: occurs on shady places

Flowering: March - August

Notes: The description for this species is extracted from the type specimen in the K (Nepalia, Nathaniel Wallich 7337, 1821). However, there is no clear information about the location in the herbarium. The necessary measurement value was manipulated from the scale given. The character of lip was extracted from the '*Flora of British India*'. The presence of this species in Central Nepal can be confirmed from the '*Flora of Kathmandu Valley*'.

The species *Bletia masuca* described by David Don in the '*Prodromus Florae Nepalensis*' was transferred to the genus *Calanthe* by John Lindley. He also described a collection made by Macrae from Srilanka as *C. purpurea* (= *C. masuca*).

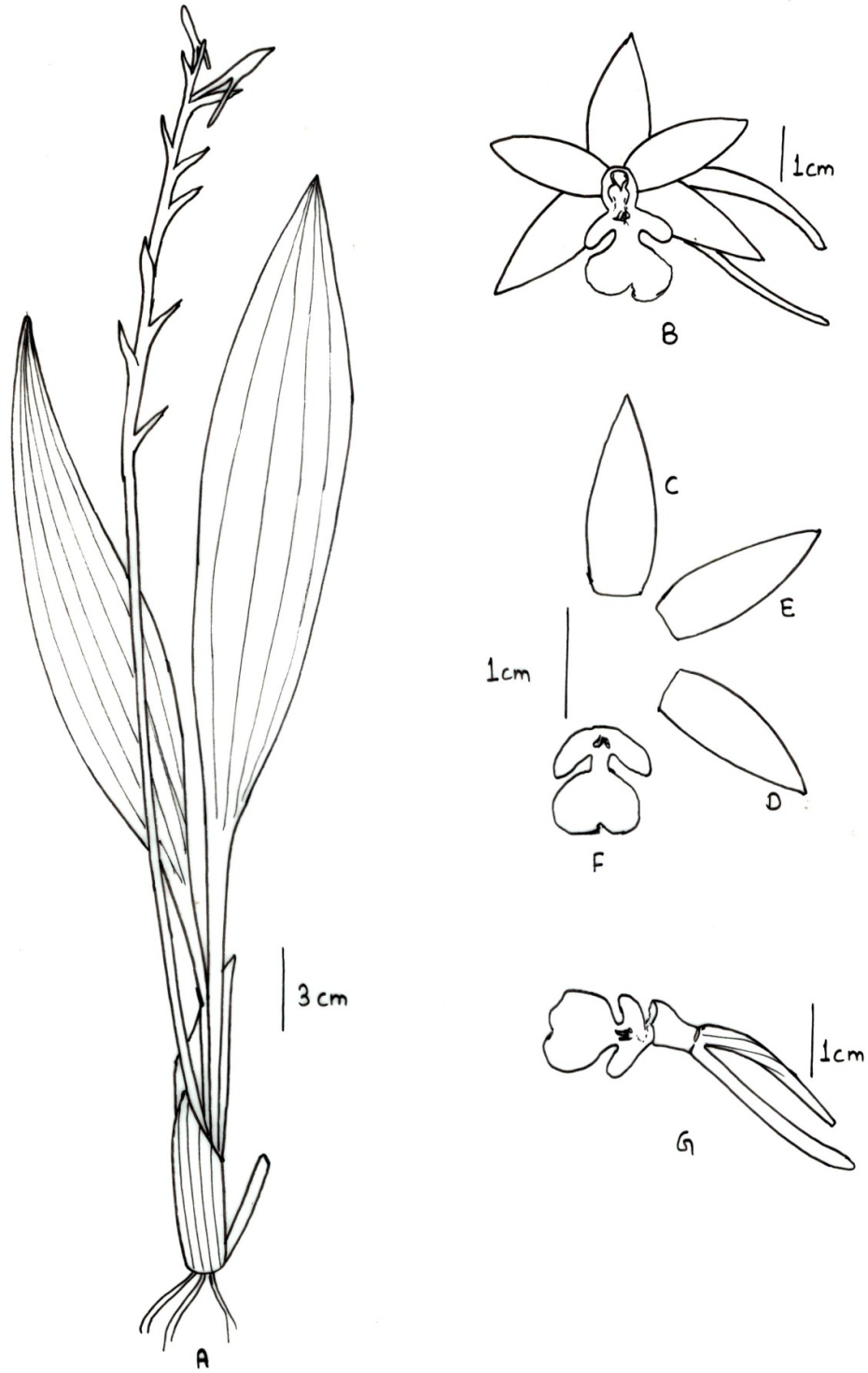
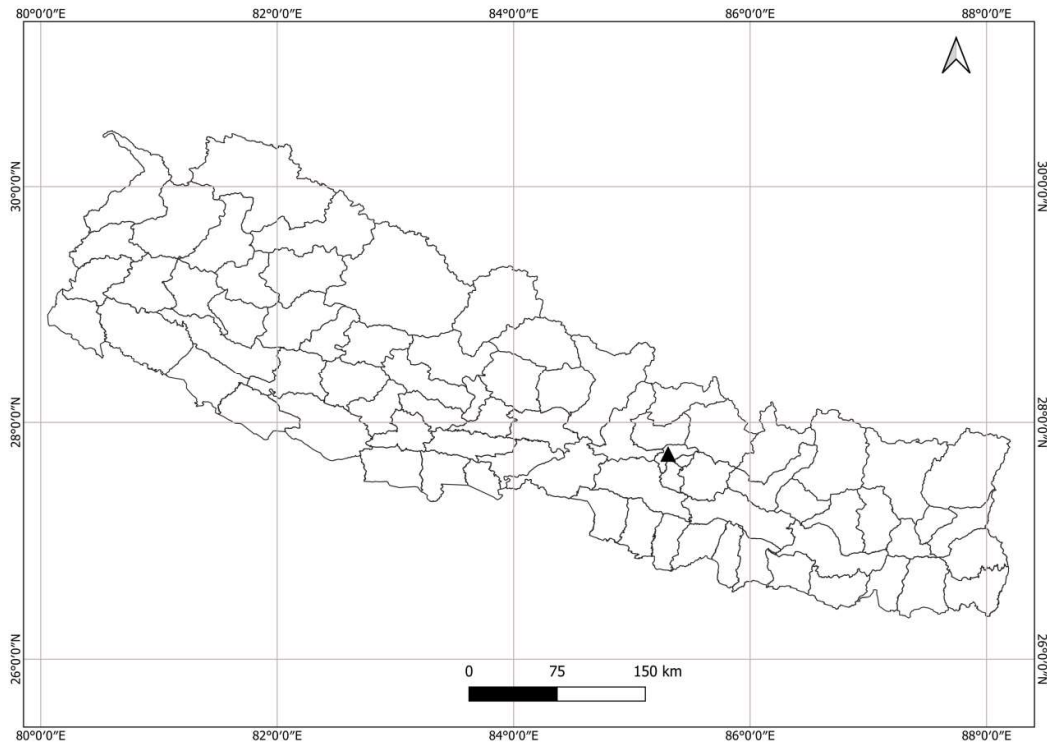


Figure 15: *Calanthe masuca* (D. Don) Lindl. A. Habit sketch. B. Single flower. C. Dorsal sepal. D. Lateral sepal. E. Petal. F. Lip. G. Lip attachment with column. (Wallich, N 7337, K001127194).

Distribution: Nepal: Central (Map 10), Assam, Borneo, China South-Central, China Southeast, East Himalaya, India, Japan, Madagascar, Malaya, Myanmar, Sri Lanka, Taiwan, Thailand, Tibet, Vietnam.



Map 10: Distribution of *C. masuca* (D.Don) Lindl. in Nepal.

Specimen examined:

Virtual specimen: Nepaliae [Nepal], August 1821, *Wallich*, N 7337 (K001127194).

10. *Calanthe plantaginea* Lindl. *Gen. Sp. Orchid Pl.*:250 (1840); *Fol. Orchid.* 6: 9 (1855); *Fl. Brit. Ind.* 5:852 (1890); Hara *et al. Enum. Fl. Pl. Nep.*1:35 (1978); Press *et al. Ann. Ch. Fl. Pl. Nep.*: 210 (2000); Pearce & Cribb *Fl. Bhutan.* 3:289 (2002); Chen *et al. Fl. China.* 25:292-301. (2009); Rokaya *et al. Ann. Ch. Fl. Nep.*:518 (2013); Rajbhandari *Hand. Orchid. Nep.*: 22 (2015); Rajbhandari & Rai *Hand. Fl. Pl. Nep.* 1:80 (2017); Shrestha *et al. Hand. Fl. Pl. Nep.* 1:101 (2018); Shrestha *et al. Fl. Nep.*:78 (2022).

Alismorkis lindleyana (Lindl.) Kuntze *Revis. Gen. Pl.* 2: 650 (1891)

Type specimen: Nepal, 1821, *Wallich*, N. 7346A (Syntype: K001127206).

Plants 30-62 cm tall. Pseudobulb small, broadly conic. Pseudostem 10-24 cm long with 3-4 tubular sheaths, basal white, membranous. Leaves 3-5, basal, ovate-lanceolate, 18-44 ×

2.5-13 cm, distinct petiole, petiole upto 25 cm, acute. Scape usually 1, arising from leaf axil, 24-62 cm, pubescent. Peduncle 6-12 cm long, raceme 10-16 cm long, 7-25 laxly flowered, flowers scented, purple. Sterile bract 1, lanceolate, 0.6-1.2 × 0.2-0.7 cm, pubescent, 1 vein, acute. Floral bracts lanceolate, shorter than pedicel and ovary, 0.5-1.1 × 0.1-0.4 cm, single vein, glabrous, acute. Pedicel and ovary 2-3.5 cm long, slightly pubescent. Sepals subsimilar; dorsal sepal light purple, lanceolate, 1.5-1.8 × 0.4-0.7 cm, 3 veins, glabrous, acute; lateral sepals lanceolate, 1.5-2 × 0.5-0.8 cm, 5 veins. Petals elliptic-lanceolate, light purple, 1-1.8 × 0.2-0.5 cm, 3 veins, glabrous, acute. Lip adnate to entire length of the column, 3-lobed, 0.9-1.8 × 0.8-1.5 cm, purple; side lobes rhomboid obovate, 0.4 × 0.6-0.8 cm, apex obtuse and incurved; mid lobe cuneately reniform or obovate, 0.5-0.6 × 0.6-0.8 cm, disk with three slender ridges or lamellae extending from base to near the apex, apex apiculate; spur cylindrical, long, slender, pubescent, slightly arcuate, equaling or longer than ovary, 2-2.7 cm long. Column glabrous, 7 mm long. (Figure 16).

Altitude: 700 – 2400 m

Ecology: Shady and moist places.

Flowering: March – October

Voucher specimen: **Kathmandu**, Shivapuri, Panimuhan, 1970 m, 27°49'0"N 85°19'55"E, 27 March 2022, *Rina Duwal, Pushpa Shakya & Manisha Simkhada* R101 (ASCOL); **Lalitpur**, Godawari, Naudhara, 1745 m, 27°34'45"N 85°22'43"E, 10 March 2022, *Rina Duwal & Pushpa Shakya* R102 (ASCOL). **Makwanpur**, Chitlang, 21 March 2021, *Rina Duwal, Pushpa Shakya, Ekata Dhakal & Manisha Simkhada* R100 (ASCOL).

(Note*The plant specimens used for studying *C. plantaginea* in this study were collected at the time of educational field visit during semester program).

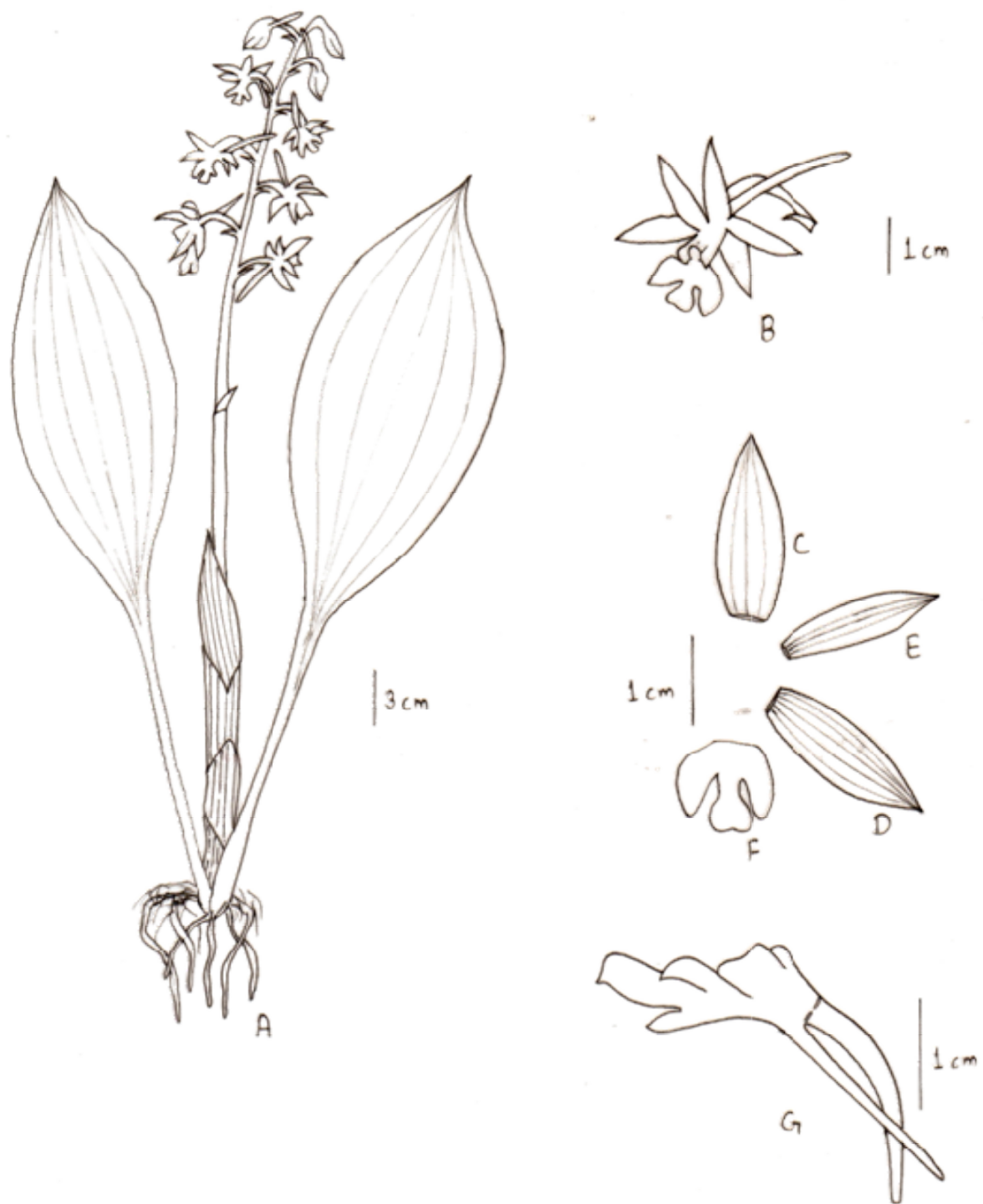
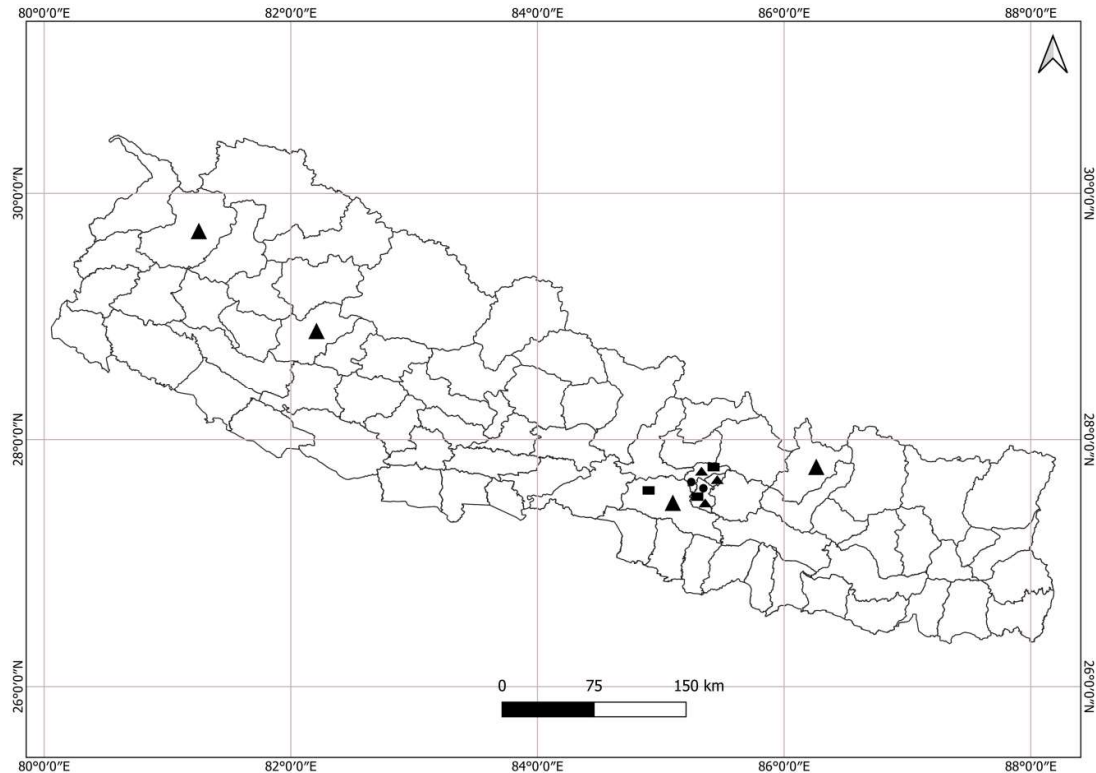


Figure 16: *Calanthe plantaginea* Lindl. A. Habit sketch. B. Single flower C. Dorsal sepal. D. Lateral sepal. E. Petal. F. Lip. G. Lip attachment with column. (Rina Duwal & Pushpa Shakya R102, ASCOL).

Distribution: Nepal: West, Central (Map 11), Bhutan, China, India.



Map 11: Distribution of *C. plantaginea* Lindl. in Nepal.

Specimens examined:

Western Nepal: *Sudurpaschim Province:* **Bajhang**, near Dyolekh, 1950 m, 15 April 1984, *P. Pradhan, R. K. Uprety, N. Pradhan & N. Dabadi* 1317 (KATH002281!, KATH002282!, KATH002283!); *Karnali Province:* **Jajarkot**, Kuyapani, 720 m, 3 March 1991, *N. P. Manandhar* 652-91 (KATH!).

Central Nepal: *Bagmati Province:* **Bhaktapur**, Kusumban, 1900 m, 12 March 1975, *D.P. Joshi & K. R. Rajbhandari* 75/520 (KATH002274!, KATH002275!, KATH002276!, KATH002277!); **Dolakha**, Khole, Jungu, 2173 m, 16 June 2018, *S. Karki & A.P. Dhital* J18 (KATH086689!); near Deurali, 2250 m, 6 March 2017, *Sangram Karki* D03 (TUCH!); **Kathmandu**, Manichur Danda, 2100 m, 13 March 1975, *D. P. Joshi & K. R. Rajbhandari* 75/571 (KATH!); Shivapuri Janbhir, 1828 m, 16 March 1970, *T. B. Shrestha & Shakya* 11614 (KATH!); Shivapuri, 2133 m, 6 April 1965, *T. B. Shrestha* 2701 (KATH!); Sundarijal, 1700 m, 18 March 1975, *D.P. Joshi & K. R. Rajbhandari* 75/704 (KATH002278!, KATH002279!, KATH002280!); [**Kathmandu**], Bhumithan-Tareveer, 1219 m – 2438 m, 5 October 1978, *M. Amatya & T. Bhattacharya* 13945

(KATH!); **Kathmandu**, Sumbhunath [Swayambhu], July 1821, *N. Wallich* 7346A (K001127206); **Kathmandu**, 27-35°E 85-23°N, 29 May 1969, *H. Hara et al.* 10002485 (TI); 27-35°E 85-23°N, 1800 m, 7 March 2003, *T. Watanabe & K. J. Malla* 10004412 (TI); **Lalitpur**, Phulchoki, 7000 ft [2133 m], 4.12.2022 BS, *P. Pradhan* 4261 (KATH!); Sungure Dhara, Phulchoki, 1219 m, 5 March 1967, *R. K. Manandhar & party* 6820 (KATH!); Godawari Botanical Gaen, 1500 m, 22 March 1967, *D. H. Nicholson* 3038 (KATH!); Godawari, 18 March 1975, *Stainton, J.D.A.* 7312 E00296619; **Makwanpur**, Palung, 1800 m, 29 May 1986, *N. K. Bhattarai* 86/254 (KATH!).

11. *Calanthe puberula* Lindl. *Gen. Sp. Orchid Pl.*:252 (1833); *Fol. Orchid.* 6: 2 (1855); *Fl. Brit. Ind.* 5:848 (1890); King & Pantl. *Ann. Roy. Bot. Gard. Calcutta* 8: 166 (1898); Hara *et al. Enum. Fl. Pl. Nep.*1:35 (1978); Press *et al. Ann. Ch. Fl. Pl. Nep.*:210 (2000); Pearce & Cribb *Fl. Bhutan.* 3:289 (2002); Chen *et al. Fl. China.* 25:292-301. (2009); Rokaya *et al. Ann. Ch. Fl. Pl. Nep.*:518 (2013); Rajbhandari *Hand. Orchid. Nep.* :22 (2015); Rajbhandari & Rai *Hand. Fl. Pl. Nep.* 1:80 (2017); Shrestha *et al. Hand. Fl. Pl. Nep.* 1:101 (2018); Shrestha *et al. Fl. Nep.*:78 (2022).

Alismorkis puberula (Lindl.) Kuntze *Revis. Gen. Pl.* 2: 650. 1891

Calanthe amoena W. W. Sm. *Notes Roy. Bot. Gard. Edinburgh* 13: 191 (1921)

Type specimen: India, Sylhet, *De Silva, F.* 7342 (Holotype: K001127201)

Plants 18-44 cm tall. Pseudobulb narrowly cylindrical, small, 2 × 1.5 cm. Pseudostem 4-6 cm long with 3-4 tubular sheaths. Leaves 4-5, basal, lanceolate, oblong, 14-37 × 3.5-6.5 cm, glabrous, acute to acuminate. Scapes 1-3, arising from leaf axil, longer than the leaves, 13-41 cm long, pubescent. Peduncle 5.5-6.8 cm long, raceme 6-14 cm long, laxly 4-13 flowered. Sterile bracts 2 or more than 2, tubular, 1.3-2.7 × 0.3-0.6 cm, 5 veins, pubescent, acute. Floral bracts lanceolate, shorter than pedicel and ovary, 1.2-3 × 0.2-0.5 cm, 3 veins, pubescent in outer surface, acuminate. Pedicel and ovary 2-2.3 cm long, densely pubescent. Sepals different; dorsal sepal ovate-lanceolate, 1.2-1.5 × 0.4-0.5 cm, pubescent, 5 veins, acuminate; lateral sepal falcate, oblique, 1.3-1.8 × 0.4-0.7 cm, pubescent, 5 veins, acuminate. Petals thin, linear, 0.9-1.3 × ca. 0.1 cm, single vein, acute. Lip adnate to base of column, 1-1.5 cm long, 3-lobed; side lobes oblong falcate, margin entire; midlobe elliptic to obovate, apical margin irregularly fringed, disk without callus, acute, spurless. Column short, thick, 7 mm long, glabrous. (Figure 17).

Altitude: 1800 – 2700 m

Ecology: Moist, shady and cool place under forest floor.

Flowering: May-August, December (Fruiting)

Notes: The lateral sepals of this species are unique from remaining other species for being oblique, falcate in shape. And this shape is infact different from its own dorsal sepal.

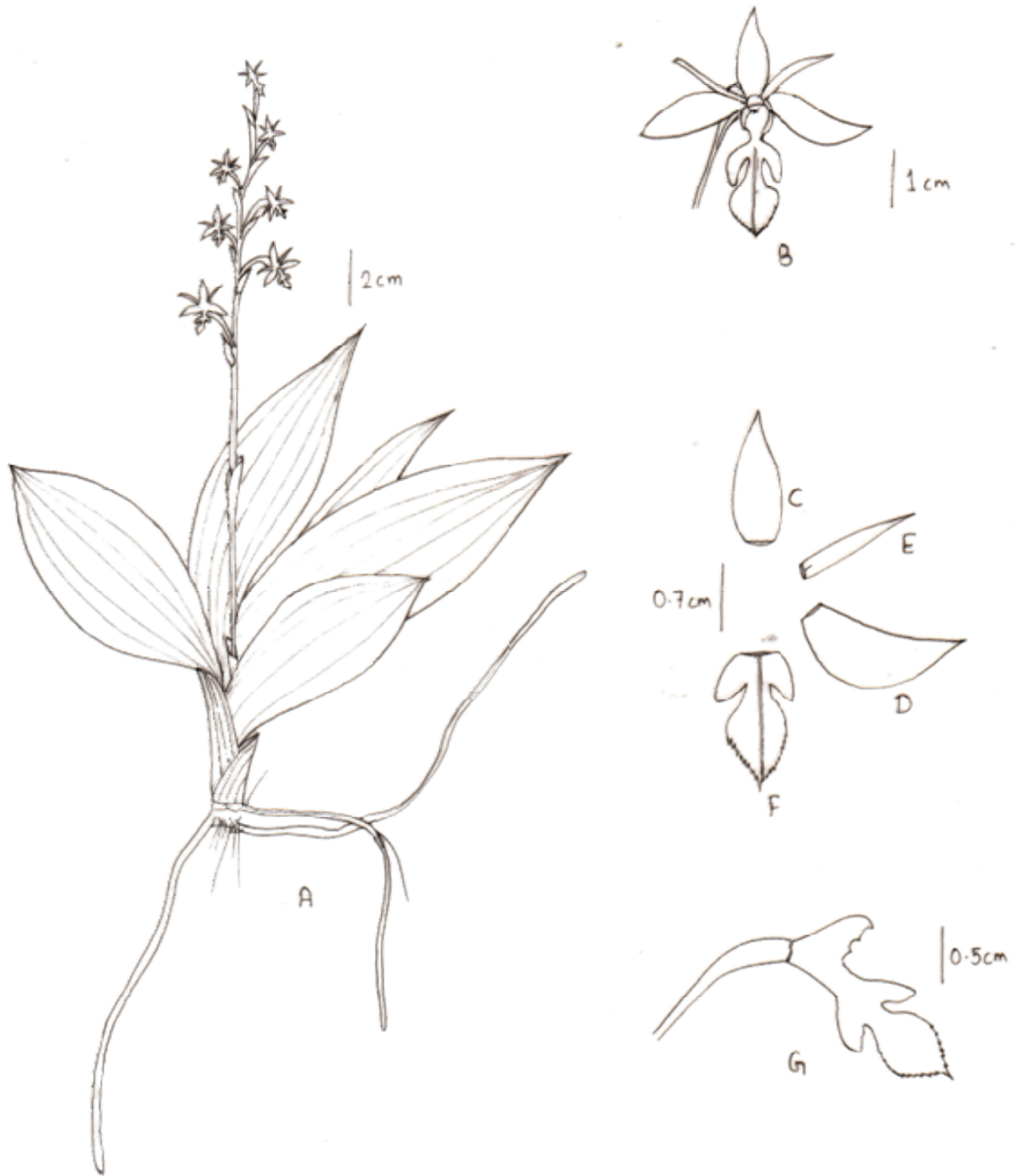
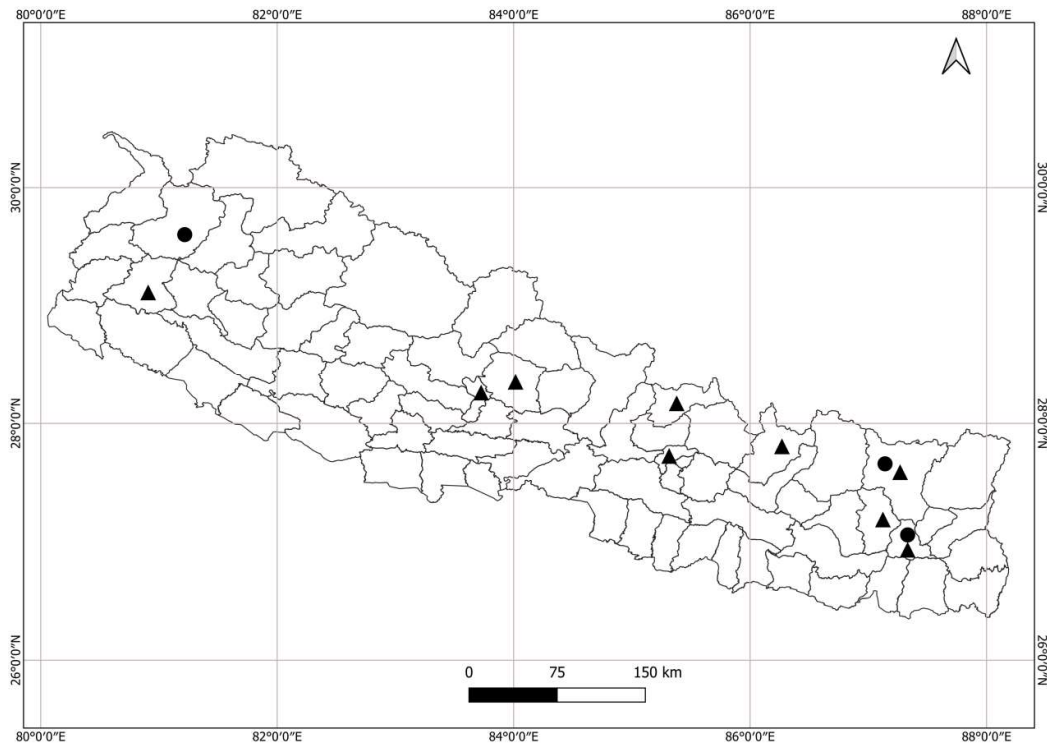


Figure 17: *Calanthe puberula* Lindl. A. Habit sketch. B. Single flower. C. Dorsal sepal. D. Lateral sepal. E. Petal. F. Lip. G. Lip attachment with column. (P.R. Shakya & Adhikari 588, KATH002286).

Distribution: Nepal: West, Central, East (Map 12), Bhutan, China, India, Japan, Myanmar, Veitnam.



Map 12: Distribution of *C. puberula* Lindl. in Nepal.

Specimens examined:

Western Nepal: *Sudurpaschim Province:* **Doti**, Kapthad [Khaptad], 2600 m, 15 July 1976, *H. Tabata, K. R. Rajbhandari & K. Tsuchiya* 1294 (KATH019227!); [**Bajhang**], Dhuli, 29°46'N 81°15'E, 2700 m, 14 May 1973, *Dobremez, J. F.* 2213 (E00614272).

Central Nepal: *Gandaki Province:* **Kaski**, Panchase forest, 1900 m, 16 August 2017, *P. Bhandari, K. Shrestha, G.T. Magar & D. Pathak* 10008P (KATH038034!), Panchase danda, 2300 m, 15 August 2002, *A. Subedi, R. P. Chaudhary & L. R. Shakya* 980 (TUCH!); [**Parbat**], Chitray, 2255 m, 4 August 1979, *S. Dahal & N. Dawadi* 866 (KATH!). *Bagmati Province :* **Dolakha**, Khole Jungu, 2300 m, 28 August 2018, *S. Karki* J81 (KATH093097!); **Kathmandu**, Tarebir Bhanjyang (Shivapuri), 7000ft [2133 m], 3 August 1966, *S.B. Malla* 4968 (KATH002284!); **Rasuwa**, Ramche-Dhunche, 2000 m, 18 July 1971, *P. R. Shakya & Adhikari* 588 (KATH002285!, KATH002286!).

Eastern Nepal: *Province 1:* [**Bhojpur**], near Gogane, 1910 m, 8 July 1988, *M. N. Subedi* 889090 (KATH!); [**Dhankuta**], Hile Manichur, 6000ft [1828 m], 31 July 1967, *S. B.*

Malla 9572 (K, KATH!, BM000514405); **Sankhuwasabha**, Manebhanjyang – Chichila, 27°20'N 87°10'E, 1930 m, 28 July 1990, *M. Minaki, C. Yonebayashi, F. Miyamoto, H. Takayama, H. Sugita, H. Yagi, M. N. Subedi & H. Ikeda* 9010054 (KATH!, E00104559, TI); 1850 m, 7 August 1988, *M. Suzuki, N. Naruhashi, S. Kurosoki, Y. Kadota, M. N. Subedi, M. Minaki, S. Noshiro & H. Ikeda* 8810208 (KATH!); Tashigaun-Sedua, 87°15'E 27°35'N, 2160 m, 1 August 1988, *M. Suzuki, N. Naruhashi, S. Kurosoki, Y. Kadota, M. N. Subedi, M. Minaki, H. Ikeda & S. Noshiro* 8821146 (KATH!, E00104093); after Chichila, 1870 m, 4 August 1988, *M. N. Subedi* 8890718 (KATH!); Bhotebas Gogane-Chichila, 87°10'E 27°25'N, 1850 m, 8 July 1988, *M. Suzuki, N. Naruhashi, S. Kurosoki, Y. Kadota, M. N. Subedi, M. Minaki, S. Noshiro & H. Ikeda* 8850201 (KATH!, E00104097, TI); around Chichila, 1910 m, 29 July 1990, *M. Minaki, C. Yonebayashi, F. Miyamoto, H. Takayama, H. Sugita, H. Yagi, M. N. Subedi & H. Ikeda* 9070080 (KATH!); Chichila, 1900 m, 13 December 1998, *D. Karkee* 822 (KATH!); 27-24°E 87-13°N, 8 July 1988, *M. Suzuki, N. Naruhashi, S. Kurosoki, Y. Kadota, M. N. Subedi, M. Minaki, S. Noshiro & H. Ikeda* 8820252, (KATH!, E00104096, TI); 27-37°E 87-16°N, 1 August 1988, *M. Suzuki, N. Naruhashi, S. Kurosoki, Y. Kadota, M. N. Subedi, M. Minaki, S. Noshiro & H. Ikeda* 8821146, (KATH!, E00104093, TI); 1950 m, 27-25°E 87-10°N, 30 July 1990, *M. Minaki et al.* 9048939 (TI); 1850 m, 27-24°E 87-13°N, 8 July 1988, *M. Suzuki et al.* 8810208 (TI); 1800 m, 27-24°E 87-11°N, 28 July 1990, *M. Minaki et al.* 9020183 (TI); 1975 m, 27-24°E 87-11°N, 28 July 1990, *M. Minaki et al.* 9070079 (TI); 9 May 1973, *Dobremez, J. F.* 2140, E00614271.

12. *Calanthe tankervilleae* (Banks) M.W. Chase, Christenh. & Schuit. *Phytotaxa* 472:165 (2020). *Mus. Bot.* 2:177 (1856); Hara *et al. Enum. Fl. Pl. Nep.* 1:53 (1978); Press *et al. Ann.Ch. Fl. Pl. Nep.*:223 (2000); Pearce & Cribb *Fl. Bhutan* 3:305 (2002); Rokaya *et al. Ann. Ch. Fl. Nep.*:542 (2013); Rajbhandari *Hand. Orchid. Nep.* :88 (2015); Rajbhandari & Rai *Hand. Fl. Pl. Nep.* 1:140 (2017); Shrestha *et al. Hand. Fl. Pl. Nep.* 1:144 (2018); Shrestha *et al. Fl. Nep.* :78 (2022).

Bletia tankervilleae (Banks) R. Br., *Bot. Mag.* 44:t.1924 (1817)

Limodorum tancarvilleae L'Heritier, *Sert. Angl.* 28. (1789)

Phaius tankervilleae (Banks) Blume, *Mus. Bot.* 2:177 (1856)

Type specimen: lectotype: LINN-HS 1403-1

Plant 40-64 cm tall. Pseudobulb conic. Pseudostem not distinct, tubular sheaths 3-4, 3.5-14 cm long. Leaves 2-3, lanceolate, 40-60 × 2.5-3cm, distinct petiole, acute. Scape usually 1, arising from the side of the leaf axil, 43-61 cm long, pubescent. Raceme ca. 21 cm long, laxly 7- 10 flowered. Sterile bract more than 2, tubular, 4-4.5 cm long, more than 5 veins, acute. Floral bracts linear-lanceolate, longer than pedicel and ovary, 3-5 × 0.3-0.6 cm, more than 5 veins, glabrous, acuminate. Pedicel and ovary 1.5-2 cm long, glabrous. Sepals similar; dorsal sepal lanceolate, 3-3.5 × ca. 0.5 cm, more than 5 veins, acute; lateral sepals 2.3-2.5 × 0.5-0.7 cm. Petals oblong 2.5 × 0.4 cm, more than 5 veins, acute. Lip free from column, 3-lobed, 2.5 cm long; lateral lobes short, margin undulate, apex rounded; mid-lobe orbicular or transversely oblong, margin slightly undulate, apex truncate and emarginate or rounded; disk usually with 2 or 3 ridges, densely pubescent; spur hooked, 0.1-0.2 cm long, pubescent. Column 2-2.2 cm. (Figure 18).

Altitude: 200 m

Ecology: Forest floor

Flowering: June

Notes: The description is based on the 3 herbarium specimens of same collection number deposited at KATH. There are no herbarium specimens belonging to this species deposited in international herbaria which are collected from Nepal. The number of vein is single in the petal from the ventral side. The floral bracts in the examined herbarium are longer than the pedicel and ovary and it is linear-lanceolate in shape. According to the virtual examination of type specimen, the floral bracts are smaller than pedicel and ovary and it is lanceolate in shape. However this specimen can further be studied and examined in detail.

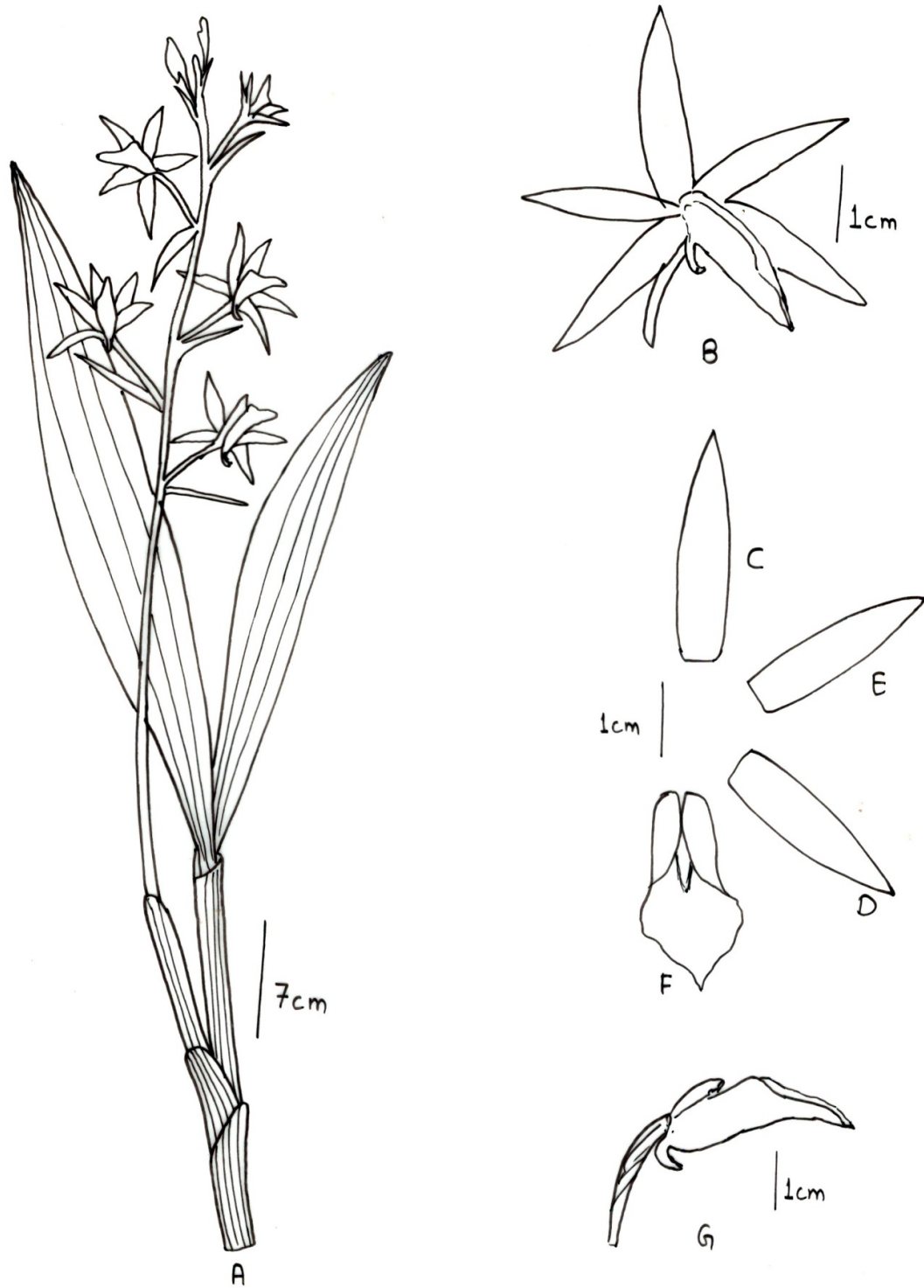
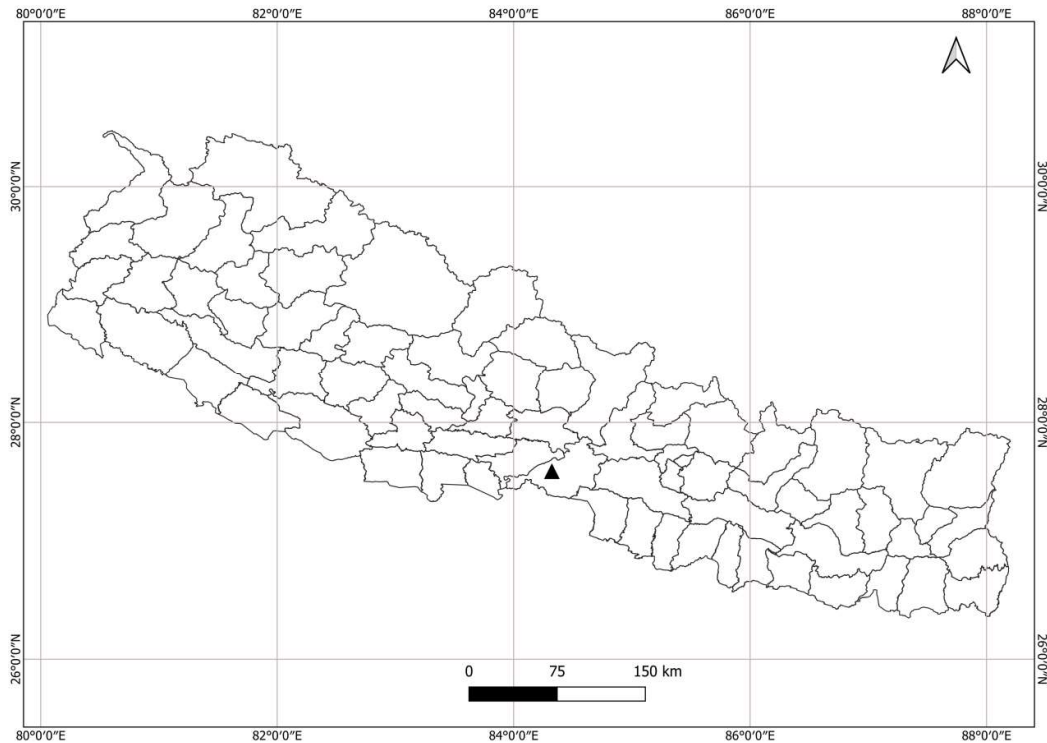


Figure 18: *Calanthe tankervilleae* (Banks) M.W. Chase, Christenh. & Schuit. A. Habit sketch. B. Single flower. C. Dorsal sepal. D. lateral sepal. E. Petal. F. Lip. G. Lip attachment with column. (R. Uprety 29, KATH003048).

Distribution: Nepal: Central (Map 13), Assam, Bangladesh, Cambodia, China, East Himalaya, India, Japan, Jawa, Laos, Myanmar, New Guinea, Philippines, Taiwan, Thailand, Tibet, Vietnam, West Himalaya.



Map 13: Distribution of *C. tankervilleae* (Banks) M.W.Chase, Christenh. & Schuit. in Nepal.

Specimen examined:

Central Nepal: *Bagmati province:* **Chitwan**, 200 m, 21 June 1987, R. Uprety 29 (KATH003048!, KATH003049!).

13. *Calanthe tricarinata* Lindl. *Gen. Sp. Orchid Pl.*:252 (1840); *Fol. Orchid.* 6: 2(1855); *Fl. Brit. Ind.* 5:847 (1890); King & Pantl. *Ann. Roy. Bot. Gard. Calcutta* 8:166 (1898); Hara *et al. Enum. Fl. Pl. Nep.*1:35 (1978); Press *et al. Ann. Ch. Fl. Pl. Nep.* 211 (2000); Pearce & Cribb *Fl. Bhutan.* 3:291 (2002); Chen *et al. Fl. China.* 25:292-301. (2009); Rokaya *et al. Ann. Ch. Fl. Nep.*:519 (2013); Rajbhandari *Hand. Orchid. Nep.*:23 (2015); Rajbhandari & Rai *Hand. Fl. Pl. Nep.* 1:81 (2017); Shrestha *et al. Hand. Fl. Pl. Nep.* 1:101 (2018); Shrestha *et al. Fl. Nep.*:78 (2022).

Alismorchis tricarinata Kuntze *Revis. Gen. Pl.* 2: 650. 1891

Calanthe lamellate Hayata *Icon. Pl. Formosan.* 4: 70 (1914)

Calanthe occidentalis Lindl. *Fol. Orchid.* 6: 3 (1855)

Type specimen: Nepal, 1821, *Wallich, N. 7339* (Holotype: K001127196).

Plants 30-75 cm tall. Pseudobulb broadly ovoid, 1.5 cm in diameter. Pseudostem 15 cm with 3 or 4 tubular sheaths, basal white, membranous, upper green, 2.5-15 cm long. Leaves 3-4, basal, lanceolate, 22-52 × 5-10 cm, distinct petiole, acute. Scapes 1 or 2, arising from leaf axil, longer than the young leaves, 30-60 cm long. Peduncle 9.5 cm long, surface shiny, pubescent, slightly pinkish stripes present, raceme 16 cm long, 6-20 laxly flowered. Sterile bract 1, lanceolate, 0.6-1.7 × 0.2-0.6 cm, slightly pubescent in outer surface, 3 veins, acute. Floral bracts lanceolate, concave, shorter than pedicel and ovary, 0.7-1.7 × 0.2-0.4 cm, 3 veins, slightly pubescent, acute. Pedicel and ovary 1.5-2.5 cm long, pubescent. Sepals subsimilar; dorsal sepal light green, later turns to yellow, ovate-lanceolate, 1.2-2 × 0.4-0.8 cm, glabrous or pubescent in outer surface, 5 veins, acute; lateral sepals lanceolate, 1.4-2 × 0.3-0.8 cm. Petals elliptic-lanceolate, green, later turns to yellow, 1-1.9 × 0.3-0.6 cm, glabrous, 3 veins, acute. Lip adnate to base of the column, reddish brown, decurved, 3 lobed; side lobes short, broad, rounded with undulate edges; mid lobe broadly oblong with undulate edges and upper surface with 3 large fleshy lamellae, apex emarginated and mucronate in sinus; spurless. Column short, 6 mm long, slightly pubescent at base. (Figure 19).

Altitude: 2300 – 3300 m

Ecology: Moist and shady places on the slopes and forest floor.

Flowering: March-October

Voucher specimens:

Kavrepalanchok, Parthali, 2568 m, 27°32'17"N 85°28'18"E, 15 Aug 2022, *Rina Duwal, Pushpa Shakya, Nabina Kasichhwa & Kusum Shrestha* R103 (ASCOL); 2260 m, 27°32'17"N 85°28'20"E, 16 Aug 2022, *Rina Duwal, Pushpa Shakya & Nabina Kasichhwa* R104 (ASCOL).

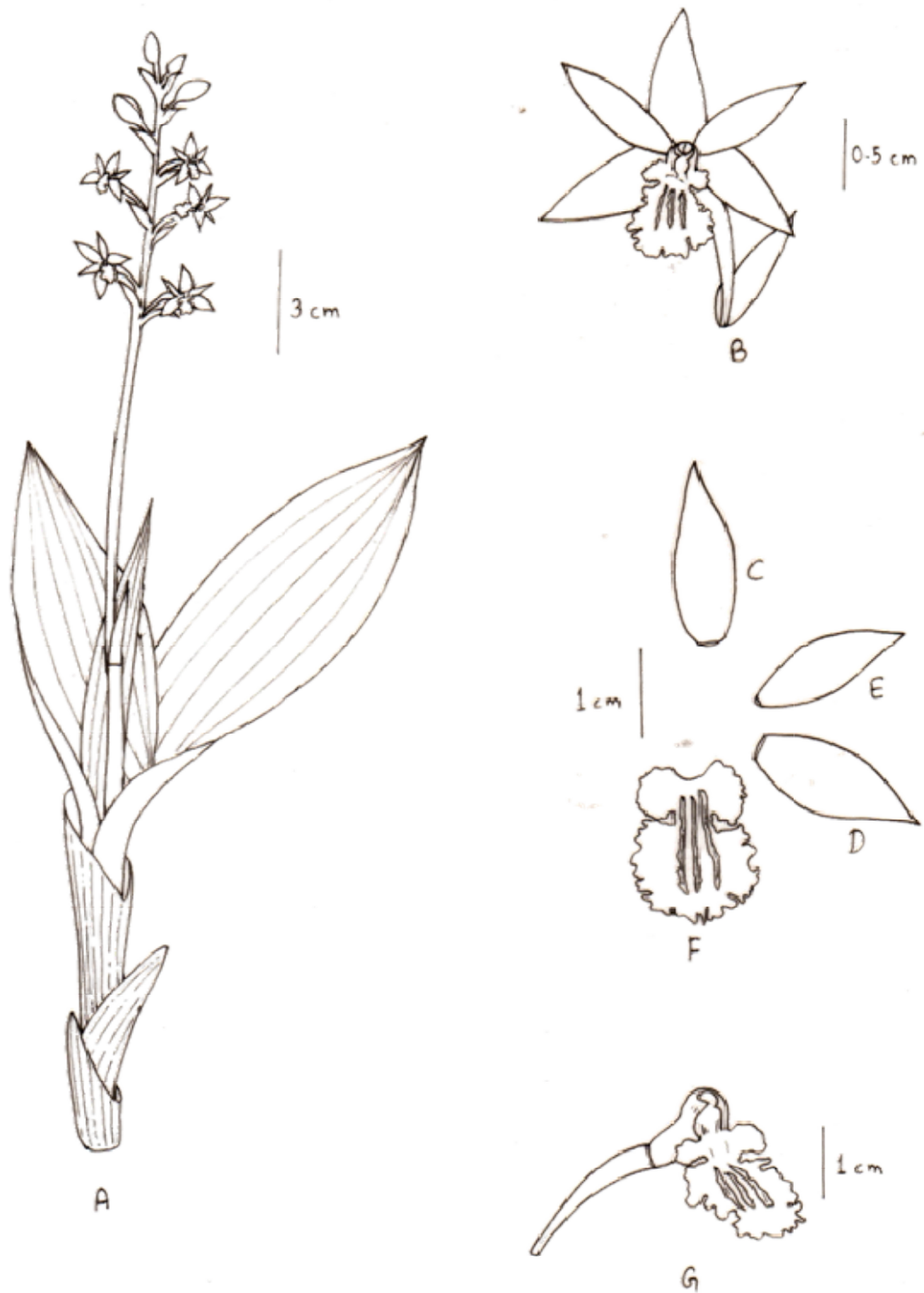
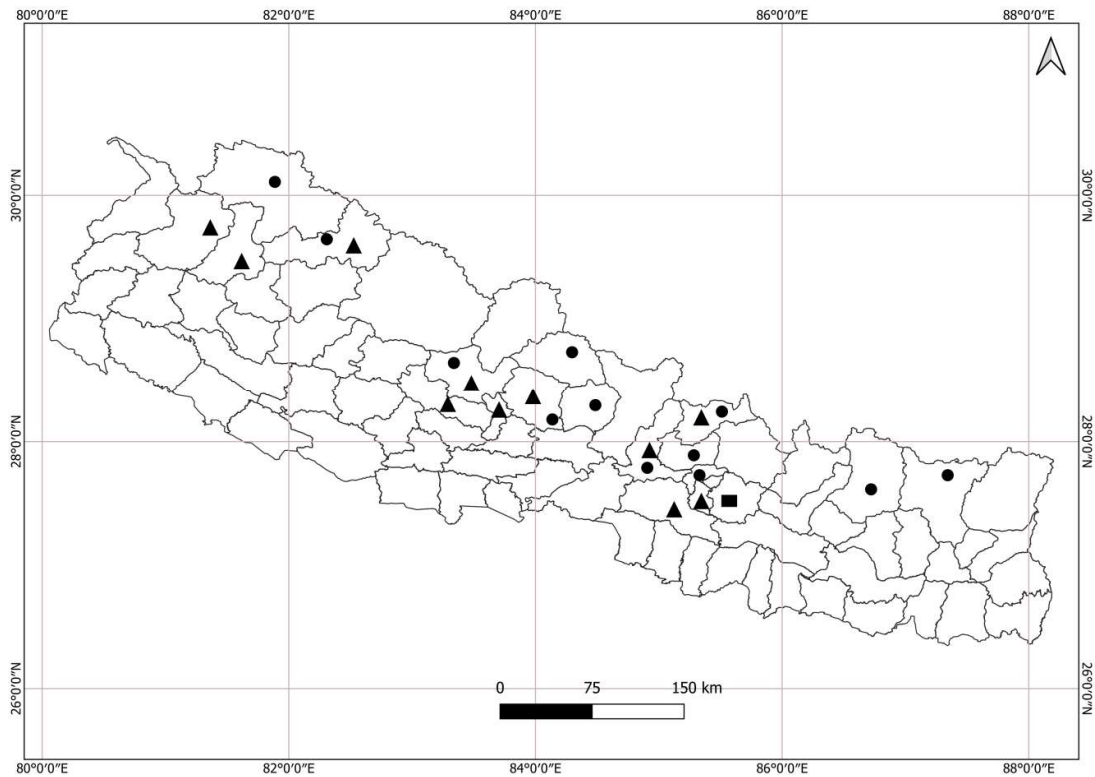


Figure 19: *Calanthe tricarinata* Lindl. A. Habit sketch. B. Single flower. C. Dorsal sepal. D. Lateral sepal. E. Petal. F. Lip. G. Lip attachment with column. (Rina Duwal *et al.* R103, ASCOL).

Distribution: Nepal: West, Central, East (Map 14), Bhutan, China, India, Japan, Korea, Myanmar, Pakistan, Taiwan, Thailand, Vietnam.



Map 14: Distribution of *C. tricarinata* Lindl. in Nepal.

Specimens examined:

Unknown location: Hindung, 2300 m, 28°12'N 85°5'E, 6 May 1974, *Yon, Berna* 77 (E00624096); Tiri, 2600 m, 28°39'N 83°38'E, 21 May 1974, *Dobremez, J. F.* 3218 (E00624097); 9-10,000ft, 13 October 1927, *Sir Clive Wigram* s.n. (E00694040); Bosaon, 29 July 1937 (E00694037); Salaphu to Jogi supha, 3000 m, 17 July 1976, *D. P. Joshi & S. K. Dhungana* 76/3803 (KATH!); Bhorlang (Chipu Danda), 2316 m, 21 August 1969, *S. B. Malla*, 16028 (KATH002293!); Above Hundung, 2350m, 24 May 1973, *Shakya & Bhattacharya* 2285 (KATH!); Nepalia, July 1821, *N. Wallich* 7339 (K001127196).

Western Nepal: Karnali Province : [**Humla**], Between Chankheli Lagna and Darma, 7-8000 ft, 20 May 1952, *O. Polunin, W. R. Sykes & L. H. J. Williams* 4135 (E00694038); **Mugu**, between Ghurchi lagna and Pina, 29°28'34"N 82°8'21"E, 2950 m, 7 June 2008, *C.A. Pendry, S. Baral, S. Noshiro, S. Rajbhandary, P.P. Kurmi, B. Dell, & B. Adhikari* JRS A82 (KATH!, E00397489); Rara lake, 2956 m, 3 April, *S.B. Malla* 10784 (KATH002287!); Ghurchi lekh, 2800 m, 29 May 1980, *P.R. Shakya & B. Roy* 5437

(KATH002288!, KATH002289!, KATH002290!). *Sudurpaschim Province* : **Bajhang**, Srivabhar, 5500ft [1676 m], 30 October 1991, *C.M. Joshi* 2493 (KATH!); Gorkhali lekh, 3300 m, 1.9. 1990, *N. K. Bhattarai* 90/1231 (KATH!); **Bajura**, Khaptad, 2950 m, 23 June 1991, *N. K. Bhattarai* 91/1000 (KATH!). *Surmasarowa-Takundada*, 2500 m, *J.F. Dobremez* DBR NEP 2140 (KATH!); near Dhuli, 8300ft [2529 m], 21 May 1965, *T. B. Shrestha* 4135 (KATH!).

Central Nepal: Gandaki Province: Baglung, Lamula, 1350 m, 28 May 1992, *N. P. Manandhar & S. K. Acharya* 451- 92 (KATH!); **Kaski**, Panchase top to Bhanjyang, 2300 m, 17 April 2018, *P. Bhandari* P1607 (KATH037995!); [**Kaski**], Chipli, north of Pokhara, 8000 ft, 18 April 1954, *Stainton, Sykes & Williams* 4908 (E00694042); [**Kaski**], Dulhi, Seti Khola, 2500 m, 14 May 1973, *Maire, A.* AMA 948 (E00634730); [**Lamjung**] Lamjung Himal, 16 July 1954, *Stainton, Sykes & William hiuzs* s.n. (E00694039); [**Manang**], Burungdi Khola, 7500ft, 21 May 1954, *Stainton, Sykes & Williams* 5364 (E00694041); [**Manang**], Mersiandi Valley, 8200ft, 27 May 1950, *D. G. Lowndes* 902 (E00694043); Lalopani, 8000 ft, 03/06/1971, *C. Barclay & P.M. Syngé* 2455 (K); **Myagdi**, Ghorepani-Tatopani, [28-24°E 83-42°N] 2740 m, 27 July 1996, *T. Hoshino, M. Amano, H. Koba, N. Miyoshi, K. R. Rajbhandari, M. Sato, P. Shrestha & S. Takatsuki* 9668034 (KATH026348, TI); 2740 m, 28-24°E 83-42°N, 27 July 1996, *T. Hoshino et al.* 9668134 (TI); [**Myagdi**] Near Gurjakhani, 9000 ft [2743], 18 July 1954, *Stainton, Sykes & Williams* 3534 (E00694036); **Parbat**, Ulleri, 2400 m, 21 July 1974, *D.P. Joshi & T. K. Bhattacharya* 1800174 (KATH002291!). *Bagmati Province* : **Dhading**, Ganesh Himal, 2600 m, 1992, *W. J. Baker, T. A. Buskitt, J. T. Miller & R. Shrestha* 10 (KATH!); **Kathmandu**, 27-35°E 85-23°N, 29 May 1969, *H. Hara et al.* 69823 (TI); 27-35°E 85-23°N, 29 May 1969, *H. Hara et al.* 10002486 (TI); 27-35°E 85-23°N, 29 May 1969, *H. Hara et al.* 10002487 (TI); **Lalitpur**, Nayadanda (Phulchoki), 2529 m, 16 June 1967, 6890 (KATH!); Phulchoki, 2400 m, 23 May 1967, *D. H. Nicolson* 3360 (KATH!, BM000514388); **Makwanpur**, Daman, 2439 m, 5 June 1972, *T. B. Shrestha* 17206 (KATH!); Hetauda, March 1961, *P. N. Suwal & S. B. Rajbhandary* 260 (KATH!); **Nuwakot**, Tungapang, 2400 m, 18 June 1981, *Wiert, Jaques* 540 (E00624095); **Rasuwa**, Dhunche - Syabru, [28-07°E 85-18°N], 2360 m, 23 May 1985, *M. Suzuki & S. Noshiro* 8541009 (KATH!, TI); 2900 m, 28-15°E 85-16°N, 30 June 1970, *H. Kanai & P. R. Shakya* 10002488 (TI).

Eastern Nepal: *Province 1: Solukhumbu*, 2450 m, 27-35°E 86-41°N, 2 August 1997, *M. Wakabayashi et al.* 9720099 (TI); **Sankhuwasabha**, 1870 m, 27-25°E 87-10°N, 8 July 1988, *M. Suzuki et al.* 8850177 (TI).

14. *Calanthe trulliformis* King & Pantl. *J. Asiat. Soc. Bengal* 64: 337; King & Pantl. *Ann. Roy. Bot. Gard. Calcutta* 8: 168 (1898); Hara *et al. Enum. Fl. Pl. Nep.* 1:35 (1978); Press *et al. Ann. Ch. Fl. Pl. Nep.* 211 (2000); Pearce & Cribb *Fl. Bhutan.* 3:293 (2002); Rokaya *et al. Ann. Ch. Fl. Pl. Nep.*:519 (2013); Rajbhandari *Hand. Orchid. Nep.* :23 (2015); Rajbhandari & Rai *Hand. Fl. Pl. Nep.* 1:81 (2017); Shrestha *et al. Hand. Fl. Pl. Nep.* 1:101 (2018); Shrestha *et al. Fl. Nep.*:79 (2022).

Calanthe nipponica Makino

Type specimen: India, Lachang Valley, 7000ft, July 1895, *Pantling R.* 168 (Isotype: K000810896).

Plants 35-68 cm tall. Pseudobulb oblong. Pseudostem 4-6 cm long, with 2 or 3 tubular sheaths. Leaves 2-5, basal, linear, 23-38 × 1.5-2.5 cm, petiole like base sheathing, acute to acuminate. Scape 1, arising from leaf axil, 42-60 cm long, longer than the adult leaves. Peduncle 7-12 cm long, pubescent, raceme 9-16 cm long, 5-23 laxly flowered. Sterile bract usually 1, linear-lanceolate, 2-2.2 × 0.4-0.6 cm, 5 veins, glabrous, acuminate. Floral bracts linear, equal or longer than the pedicel and ovary, 1.6-3 × 0.2-0.4 cm, 5 veins, glabrous or slightly pubescent in outer surface, acute to acuminate. Pedicel and ovary green, 1.3-2 cm long, pubescent. Sepals similar, lanceolate, 1.3-1.6 × 0.2-0.4 cm, 5 veins, acuminate. Petals lanceolate, 1-1.5 × 0.1-0.2 cm, 3 veins, acute. Lip adnate to entire length of the column, bright yellow, glabrous, 0.5 × 0.4 cm, unlobed, triangular in shape with the irregularly dented sides, disk with 2 lamella; spur short, cylindrical, smaller than the pedicel and ovary, 0.1 cm long, slightly pubescent. Column short. (Figure 20).

Altitude: 1700 – 2800 m

Ecology: Moist and rocky shady slopes.

Flowering: May – August

Notes: King & Pantling (1898) have admitted that this species is allied to *C. puberula* which differs only in having the sessile leaves and a unlobed lip.

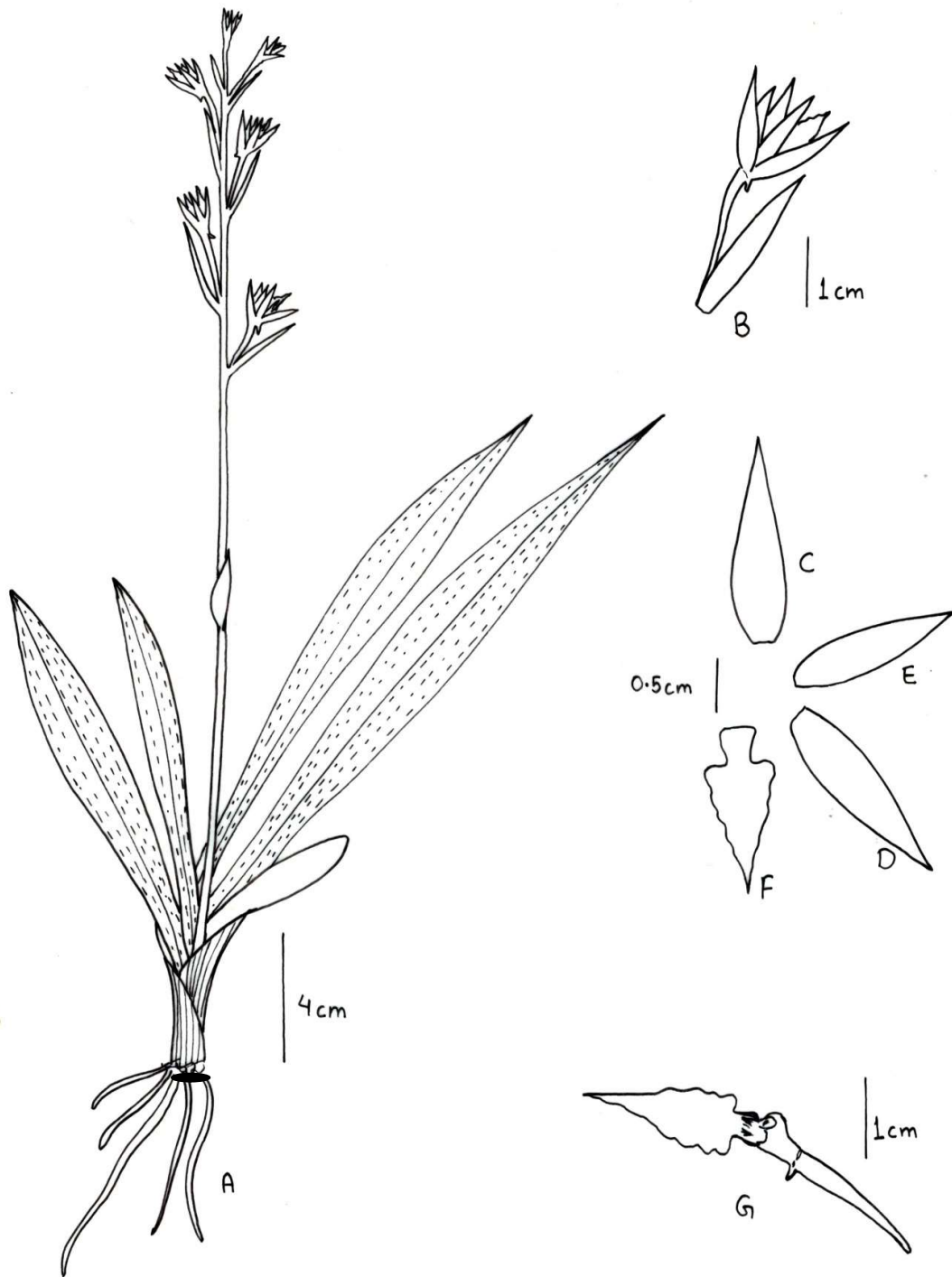
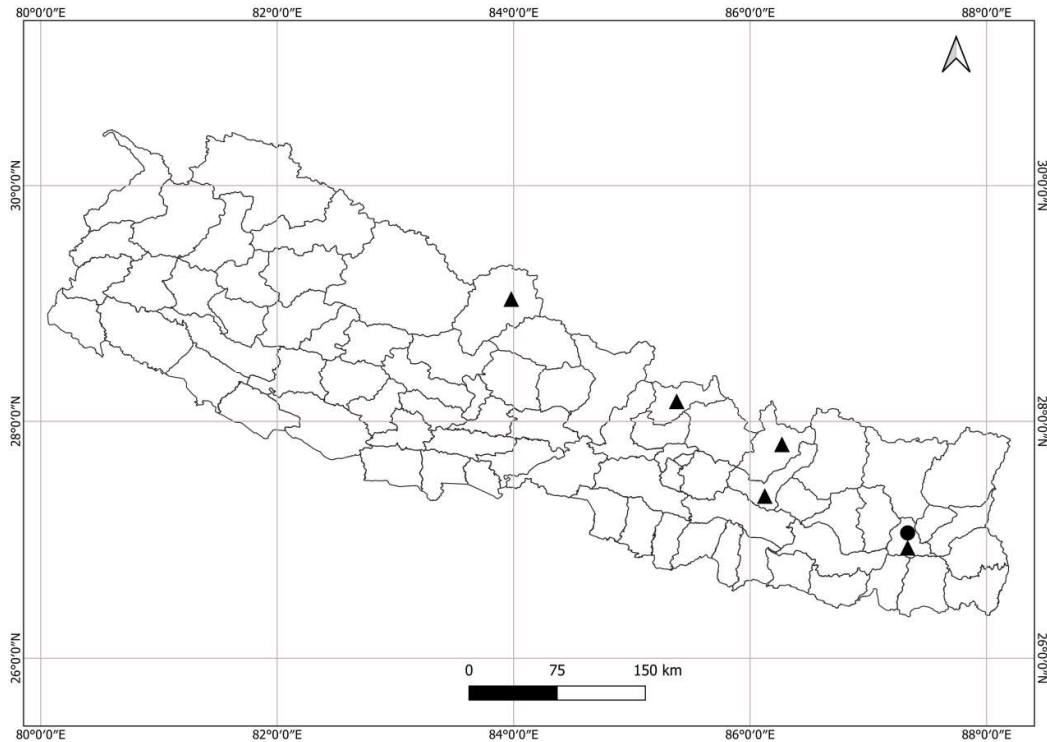


Figure 20: *Calanthe trulliformis* King & Pantl. A. Habit sketch. B. Single flower. C. Dorsal sepal. D. Lateral sepal. E. Petal. F. Lip. G. Lip attachment with column. (P.R. Shakya *et al.* 617, KATH002295).

Distribution: Nepal: Central, East (Map 15), Bhutan, China, Myanmar.



Map 15: Distribution of *C. trulliformis* King & Pantl. in Nepal.

Specimens examined:

Central Nepal: *Bagmati Province* : **Dolakha**, Panikharka, Jungu, 2296 m, 28 August 2018, S. Karki & A. P. Dhital J19 (KATH086696!); **Ramechhap**, Shivalaya, 5900 ft [1798 m], 31 July 1978, P. R. Shakya, P. Pradhan, H. K. Sainju & N. Shrestha 617 (KATH002295!); **Rasuwa**, Syabru bensi, 28°09'N 85°20'E, 1755 m, 18 May 2001, S. Akiyama, M. Amano, C. Mouri, M. N. Subedi, H. Tsukaya & K. Yonekura 20100274 (KATH!). *Gandaki Province:* **Mustang**, Ghasa, 2500 m, 25 July 1976, D.P. Joshi & S. K. Dhungana 76/3938 (KATH002294!). **Eastern Nepal:** Bhuje jungle, 2800 m, 30 August 1977, S. K. Dhungana 925 (KATH!); *Province 1:* **Dhankuta**, 27-10°E 87-25°N, 7 July 1972, H. Kanai et al. 726095 (TI).

15. *Calanthe woodfordii* (Hook.) M.W.Chase, Christenh. & Schuit. *Phytotaxa* 472: 166 (2020). *Gen. Sp. Orchid. Pl.*:127 (1830-1840); King & Pantl. *Ann. Roy. Bot. Gard. Calcutta* 8: 107 (1898); Hara *et al. Enum. Fl. Pl. Nep.* 1: 53 (1978); Press *et al. Ann. Ch. Fl. Pl. Nep.* 223 (2000); Pearce & Cribb *Fl. Bhutan.* 3:303 (2002); Rokaya *et al. Ann. Ch. Fl. Pl. Nep.* :542 (2013); Rajbhandari *Hand. Orchid. Nep.* :88 (2015); Rajbhandari & Rai *Hand. Fl. Pl. Nep.* 1:140 (2017); Shrestha *et al. Hand. Fl. Pl. Nep.* 1:144 (2018); Shrestha *et al. Fl. Nep.* :79 (2022).

Bletia woodfordii Hook., *Bot. Mag.* 54:t. 2719 (1827)

Limodorum flavum Blume., *Bijdr. Fl. Ned. Ind.*(8): 375 (1825)

Phaius maculatus Lindl., *Gen. Sp. Orchid. Pl.*: 127 (1831)

Type specimen: Nepal, *Wallich, N.* 3748 (**Holotype:** K000974262)

Plants 15-78 cm tall. Rhizome indistinct. Pseudobulbs ovoid-conic. Leaves 3-5, developing from stem, lanceolate, yellow spots on surface, 8.5-37.5 × 3-8.5 cm, petiole like base, acute to acuminate. Scape usually 1, arising from the side of the stem bearing leaves, 14-45 cm long; rachis 6-28 cm long, laxly 6-8 flowered. Sterile bracts more than 2, tubular, 3.3-6.2 × 0.8-1 cm, slightly pubescent, more than 5 veins, acute. Floral bracts linear-lanceolate, concave at base, 2.5-5 × 0.5-1.2 cm, more than 5 veins, glabrous, acute. Pedicel and ovary 2-3 cm, glabrous. Sepals similar, ovate-lanceolate, 2.4-4 × 0.6-1.5 cm, more than 5 veins, apex obtuse. Petals oblong, 2.4-4 × 0.6-1.5 cm, more than 5 veins, apex obtuse. Lip free from column, 2.5-4.5 × 2.2-4.5 cm, obovate, shallowly 3-lobed; lateral lobes subobovate, margin undulate, apex rounded-truncate; mid-lobe orbicular, undulate-crisped, apex emarginate; disk with 3 or 4 brown ridges; spur slightly curved, conic, 0.5-0.8 × 0.2 cm. Column 15-20 mm. (Figure 21).

Notes: This species is the only species with the profuse and regular yellow spots on the leaf. And this description is based on virtually examined herbarium specimen. The specific collected location of this species was not mentioned in the herbarium sheet.

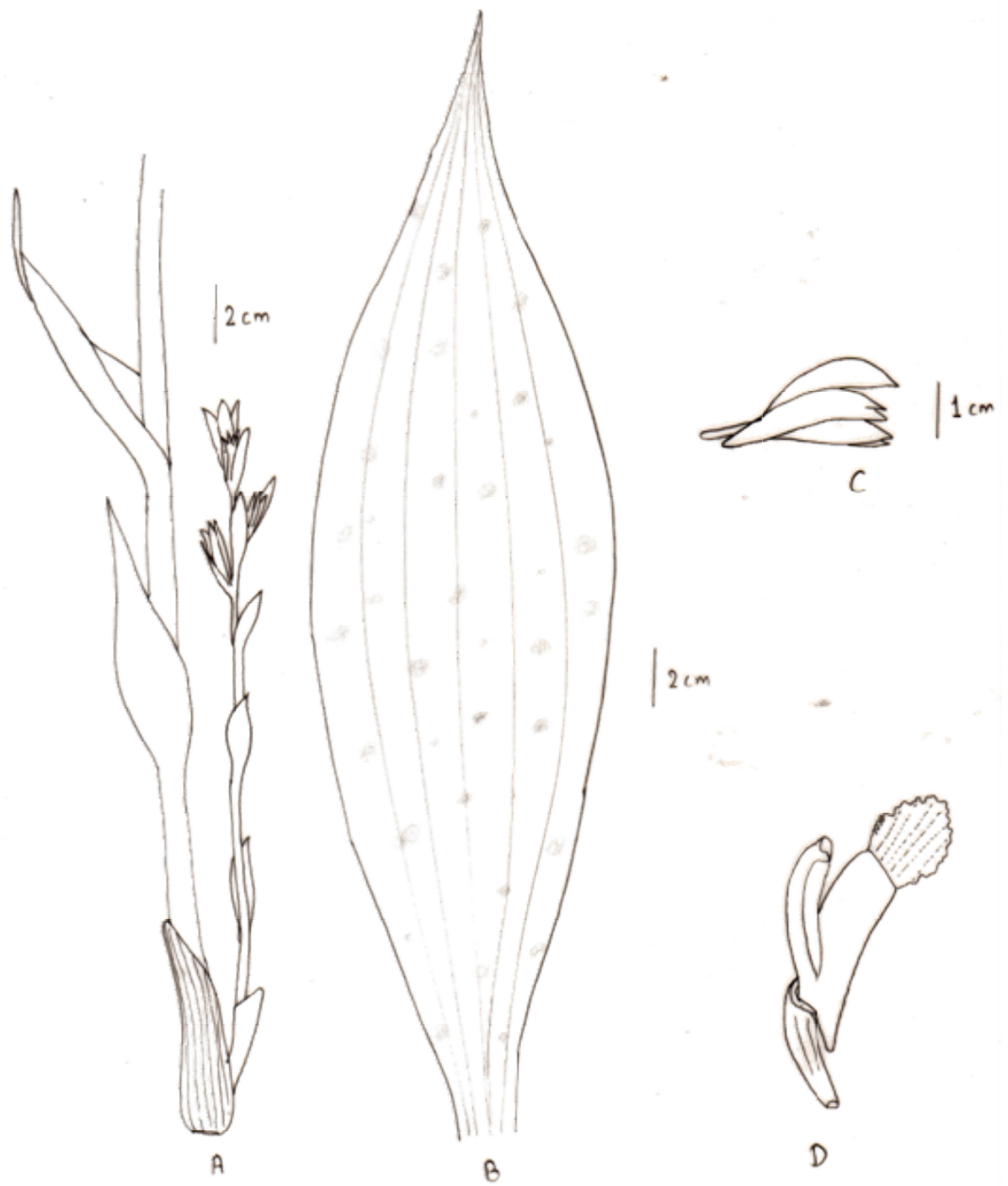
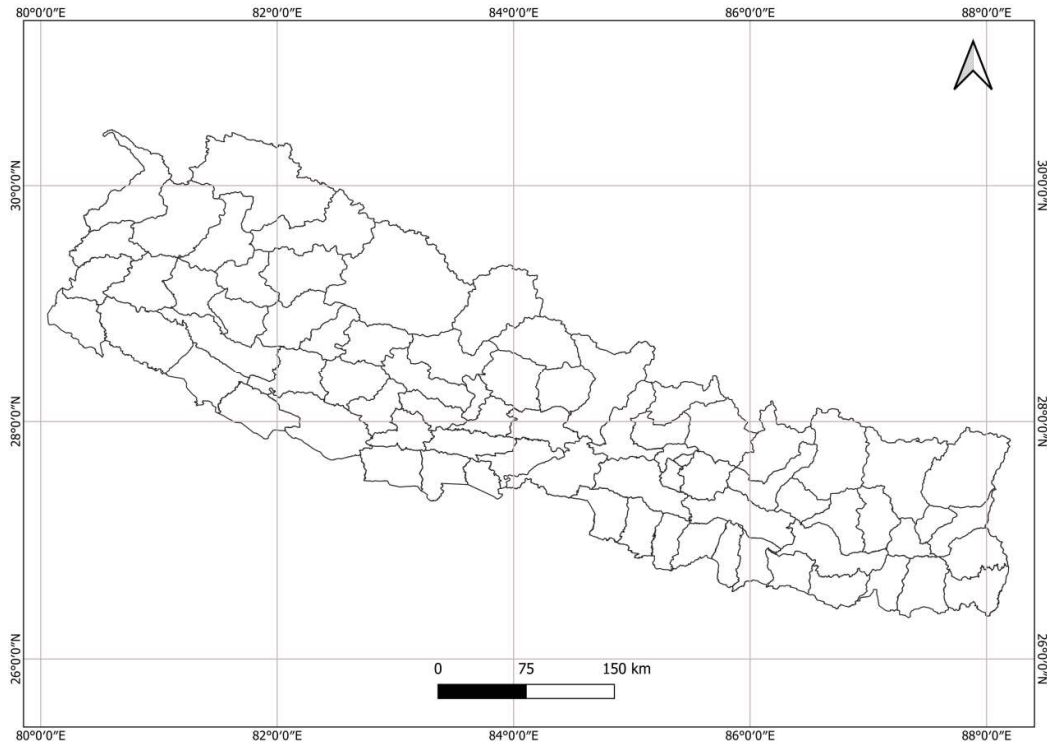


Figure 21: *Calanthe woodfordii* (Hook.) M.W. Chase, Christenh. & Schuit. A. Inflorescence and stem. B. Leaf. C. Single flower. D. Lip attachment with column. (Wallich, N. 3748, K).

Distribution: Nepal (Map 16), E Himalaya, SE Asia, C Asia.



Map 16: Distribution of *C. woodfordii* (Hook.) M.W.Chase, Christenh. & Schuit. in Nepal.

Specimen examined:

Nepal, 1821, *Wallich, N. 3748* (K000974261, K000974262, K000974170, K001119935).

4.2.5 Doubtfully recorded species

1. *Calanthe biloba* Lindl., *Fol. Orchid.*, (1854).

Note: This species in Nepal was first mentioned in Hara *et al.* (1978) the cited specimen was from east Nepal and the specimen is deposited at K. There is no authentic herbarium specimens of this species deposited at other international herbarium. Also there is no collection and deposition of this species in Nepal till date.

2. *Calanthe himalaicum* Raskoti, *Phytotaxa* 394: 257-266 (2019).

Note: This species collected from Nepal was recorded as the new species of orchid to the world in 2019 with its deposition in KATH. The species was collected by Bhakta Bahadur Raskoti in 11 August 2011 (24 August 2011 in the protologue) with the collection number 0019, at an altitude of 2200 m from Wagalek, Doti District.

In the protologue, the author has mentioned that the pedicel and ovary of the species is glabrous but the examination of type specimens clearly showed that the pedicel and ovary is pubescent. The illustration drawn in the protologue has a reference that it is drawn from the type specimen, but the type specimen is different from the illustration and photographs presented in the protologue. Also there is difference in the morphology of inflorescence. The illustration and photographs in the protologues has the flowers that almost are very closer with each other. But there is a gap of 1.8-3.5 cm in between the flowers in the type specimen.

Furthermore the protologue gave the size of pseudostem of this species as; 3 cm long and 8 cm in diameter. The value of length and breadth given is inappropriate because the examination of type specimen showed the length of pseudostem to be ca. 5 cm long and 0.5 cm in diameter. Therefore, this species need further more examination.

3. *Calanthe metoensis* Z.H. Tsi & K.Y. Lang, *Acta Phytotax. Sin.* 16(4): 129 (1978).

Note: This species has been collected by Bhakta Bahadur Raskoti, with the collection number 0081, at altitude of 2000 m on the way to Maipokhari, Illam and deposited at KATH. The herbarium specimen contains only one flower which was pasted in the rachis improperly. On the examination of that flower it was found that it is very different from the actual species. The specimen was not appropriate for the detail study since it contained a single flower not belonging to the plant.

4.3 Cladistic analysis

The data matrix for the phylogenetic analysis of species is shown in Table 10.

Table 10: Data matrix for cladistic analysis of *Calanthe* species.

Species	Characters										
	0	1	2	3	4	5	6	7	8	9	10
<i>Spathoglottis ixioides</i> (outgroup)	0	0	0	0	1	-	1	1	0	1	3
<i>C. alpina</i>	0	1	2	0	1	2	1	0	1	0	1
<i>C. arcuata</i>	0	1	0	0	1	1	1	0	1	0	0
<i>C. brevicornu</i>	0	1	1	0	1	1	1	0	1	1	1
<i>C. chloroleuca</i>	0	1	3	0	1	0	1	1	1	1	0
<i>C. davidii</i>	0	1	0	1	0	1	1	0	1	1	0
<i>C. densiflora</i>	1	0	1	1	0	1	0	1	1	1	1
<i>C. griffithii</i>	0	1	1	0	1	1	1	1	1	1	1
<i>C. mannii</i>	0	1	1	0	1	0	1	1	1	1	0
<i>C. masuca</i>	0	1	2	0	1	1	1	1	1	1	0
<i>C. plantaginea</i>	0	1	3	0	1	0	1	1	1	1	0
<i>C. puberula</i>	0	1	1	1	1	1	1	1	0	1	1
<i>C. tankervilleae</i>	0	2	1	1	1	3	0	0	1	1	2
<i>C. tricarinata</i>	0	1	1	0	1	1	1	1	0	1	1
<i>C. trulliformis</i>	0	1	0	0	0	2	1	0	1	0	0
<i>C. woodfordii</i>	1	2	1	1	0	3	0	0	1	1	2

From the cladistic analysis a singlemost parsimonious cladogram and other cladogram from Bootstrap method were generated with the L= 35, CI= 54 and RI= 65 (Figure 22 and Figure 23).

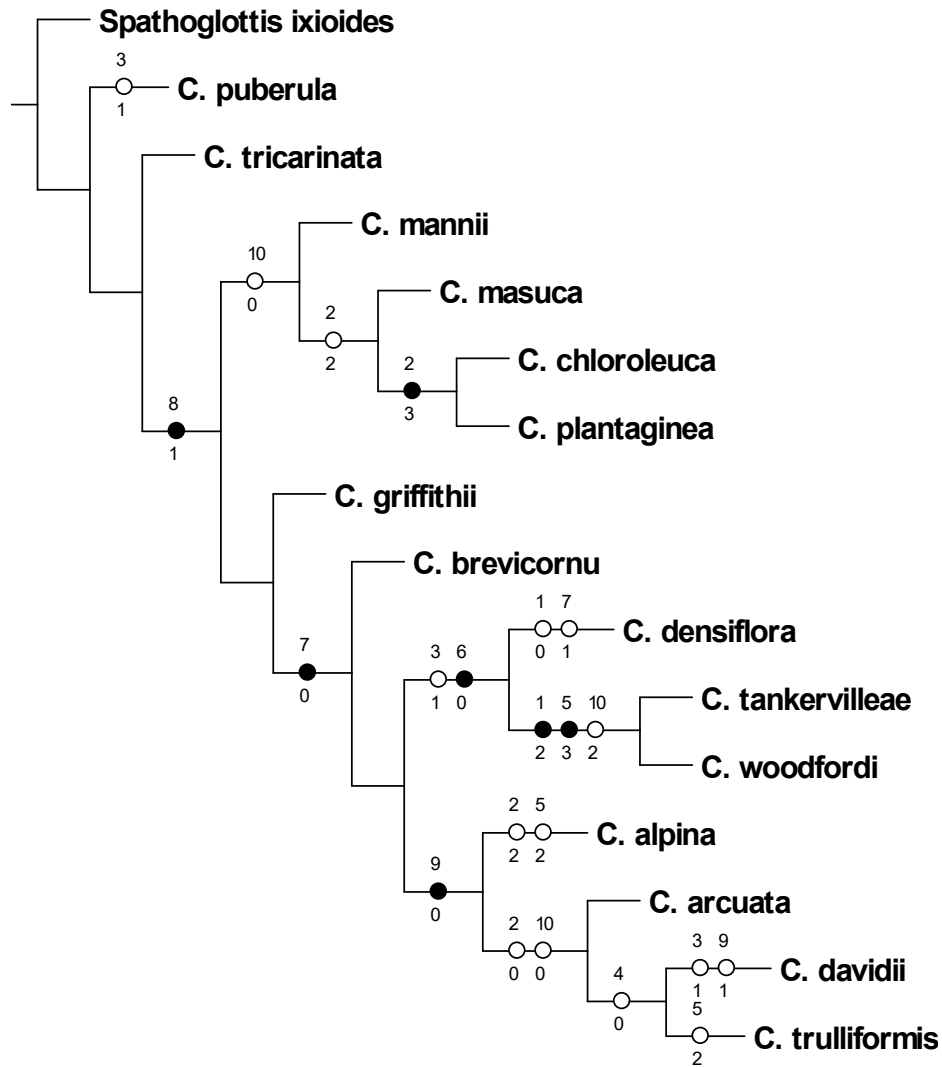


Figure 22: A singlemost parsimonious tree from Winclada analysis.

The legends; 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 respective character state. The characters with their character state and respective code are as follow.

Scape length (0): longer than leaf = 0, shorter than leaf = 1. Scape development (1): arising directly from rhizome = 0, arising from leaf axil = 1, arising from side of leaf axil = 2. Leaf shape (2): linear = 0, lanceolate = 1, elliptic = 2, ovate-lanceolate = 3. Sterile bract no. (3): one = 0, more than one = 1. Floral bract size (4): longer than pedicel and ovary = 0, shorter than pedicel and ovary = 1. Floral bract veins (5): one = 0, three = 1, five = 2, more than five = 3. Pedicel and ovary surface (6): glabrous = 0, pubescent = 1. Sepals similarity (7): similar = 0, different = 1. Spur (8): absent = 0, present = 1. Lip lobe

(9): unlobed = 0, 3-lobed = 1. Lip attachment with column (10): attached to entire length of column = 0, attached to base of column = 1, free from column = 2, not distinct = 3.

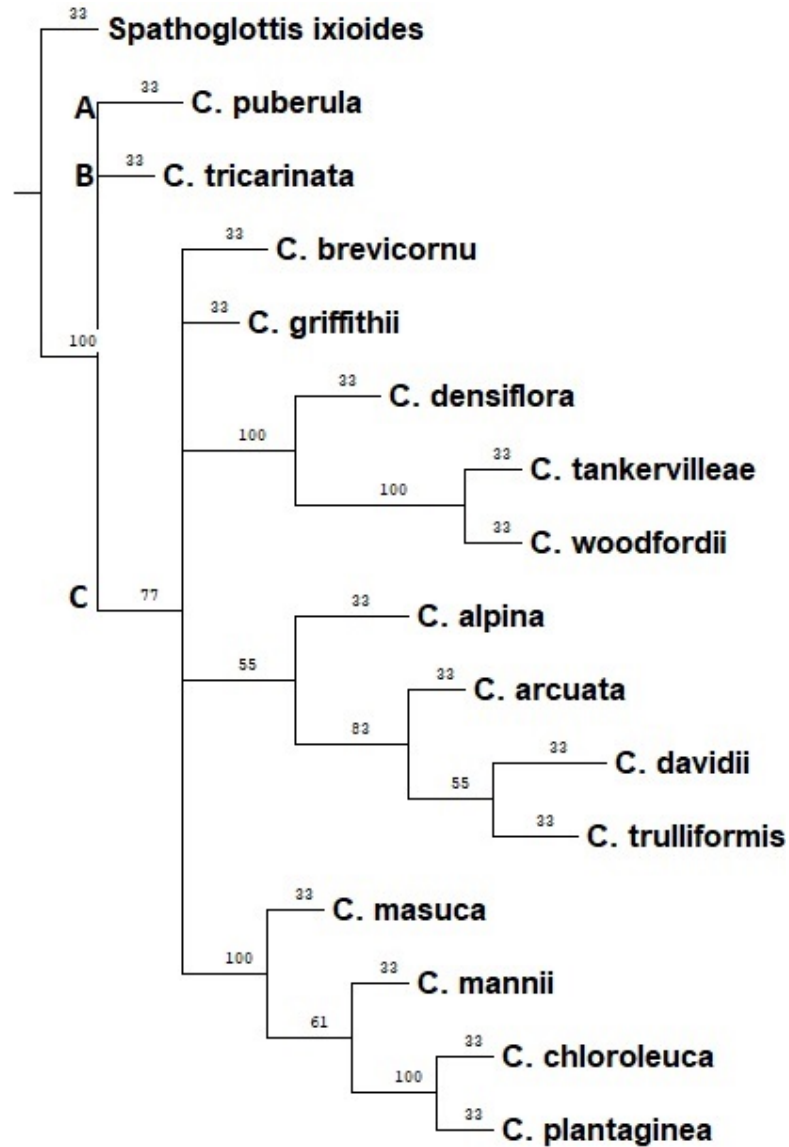


Figure 23: Cladogram by using Bootstraps method.

The single parsimonious cladogram is shown in Figure 22. In the Bootstrapped cladogram (Figure 23), three major clades; clade A, clade B and clade C are formed from the branch of the outgroup. Clade A is formed by a single species *Calanthe puberula*. Clade B is also formed by single species *C. tricarinata*. The third clade, clade C contains the remaining 13 species and this clade C is separated from clade A and clade B due to presence of spur

in the lip. The Booststrapped values are indicated in the nodes with the highest value of 100.

The clade C is further divided into 5 subclades. The subclade 1 consists of single species; *C. brevicornu*, subclade 2 is also formed by single species; *C. griffithii*. The subclade 3 is subdivided into two sub-subclades, the first one formed by single species; *C. densiflora* and other formed by two species; *C. tankervilleae* and *C. woodfordii*. The species *C. densiflora* has its scape development from the rhizome directly while *C. tankervilleae* and *C. woodfordii* show nonhomoplasly in this case for having their scape development from side of leaf axil; also these two species show nonhomoplasly in having more than 5 veins in their floral bracts. And they are homoplasious with each other in having their lip which is free from column.

The subclade 4 of clade C, consists of 4 species; *C. alpina*, *C. arcuata*, *C. davidii* and *C. trulliformis*. These all species have the unlobed lip except *C. davidii*. In this subclade also, *C. alpina* forms an individual branch as it has elliptic leaf and others have linear leaf. Similarly 3 species; *C. arcuata*, *C. davidii* and *C. trulliformis* show homoplasly in having their lip attached to entire length of the column. Furthermore, *C. davidii* and *C. trulliformis* show homoplasly in having the floral bracts longer than pedicel and ovary.

The subclade 5 also consists of 4 species; *C. chloroleuca*, *C. mannii*, *C. masuca* and *C. plantaginea* and all of these have the lip which is attached to the entire length of the column. The two species *C. chloroleuca* and *C. plantaginea* are closely related because they have ovate-lanceolate leaves present in them and *C. masuca* have elliptic leaf.

4.4 Distribution

4.4.1 Horizontal Distribution

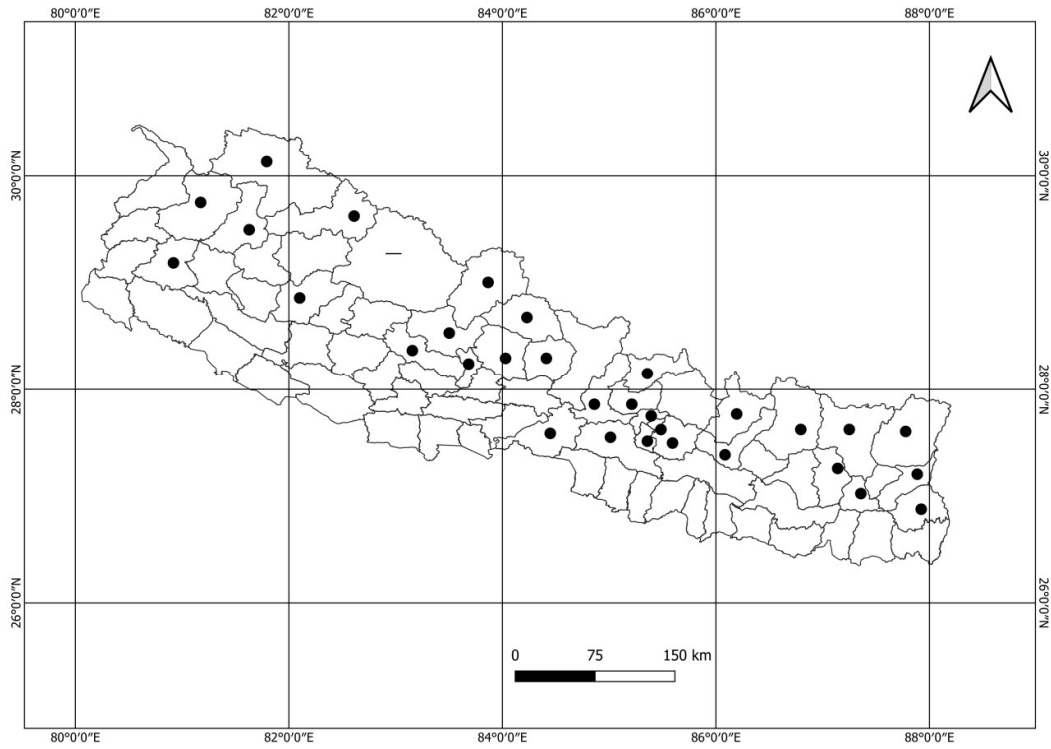
From the study of herbarium it was found that 15 species of *Calanthe* are inhabitant in Nepal. And three of them; *C. alpina*, *C. puberula* and *C. tricarinata* are distributed in all 3 regions (West, Central and East) of Nepal. *C. plantaginea* is recorded only from West and Central region of Nepal. While *C. brevicornu*, *C. mannii* and *C. trulliformis* are recorded from Central and East region. And *C. arcuata*, *C. davidii*, *C. densiflora*, *C. masuca* and *C. tankervilleae* are present only in Central region of Nepal. Similarly, *C. chloroleuca* and *C. griffithii* are recorded only from East region of Nepal. Whereas there

is no such species that is present only in West region of Nepal. The exact distribution of *C. woodfordii* in Nepal is not recognised.

Table 11: Horizontal Distribution of *Calanthe* in Nepal.

S.N.	Species	West	Central	East
1	<i>Calanthe alpina</i>	\$ @	\$ @	\$ @
2	<i>C. arcuata</i>		\$	
3	<i>C. brevicornu</i>		\$ # @	\$
4	<i>C. chloroleuca</i>			\$
5	<i>C. davidii</i>		@	
6	<i>C. densiflora</i>		\$	
7	<i>C. griffithii</i>			\$
8	<i>C. mannii</i>		\$ # @	\$ @
9	<i>C. masuca</i>		\$*	
10	<i>C. plantaginea</i>	\$	\$ # @	
11	<i>C. puberula</i>	\$ @	\$ #	\$ @
12	<i>C. tankervilleae</i>		\$	
13	<i>C. tricarinata</i>	\$ @	\$ @	\$ @
14	<i>C. trulliformis</i>		\$	\$ @
15	<i>C. woodfordii</i>			

‘\$’, ‘#’ 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 ‘*Flora of Kathmandu Valley*’.



Map 17: Distribution map showing the districts with *Calanthe R. Br.* in Nepal.

According to Map 17, the genus *Calanthe* is collected and distributed in 31 districts of Nepal. This map is made from distribution data extracted from the herbarium specimens.

4.4.2 Vertical Distribution

The vertical distribution (Table 12) was noted from the national and international herbaria (KATH, TUCH, BM, E, K and TI). However, the exact location of species collected is not given in BM. From the study, it was found that the *Calanthe* is present in the altitudinal range from 200 m to 3300 m in Nepal with the majority at the range of 1500 m to 2400 m in subtropical and temperate region.

Table 12: Vertical distribution of the species of *Calanthe* in Nepal.

S. N.	Species	Vertical distribution (m)
1	<i>Calanthe alpina</i> Hook. f. ex. Lindl	1900-3000
2	<i>C. arcuata</i> Rolfe	2000
3	<i>C. brevicornu</i> Lindl.	2000-2700
4	<i>C. chloroleuca</i> Lindl.	2100-2400
5	<i>C. davidii</i> Franch	2100
6	<i>C. densiflora</i> Lindl.	1400
7	<i>C. griffithii</i> Lindl.	2200
8	<i>C. mannii</i> Hook. f.	2000-2300
9	<i>C. masuca</i> (D.Don) Lindl.	1500-2100
10	<i>C. plantaginea</i> Lindl.	700-2400
11	<i>C. puberula</i> Lindl.	1800-2700
12	<i>C. tankervilleae</i> (Banks) M.W.Chase, Christenh. & Schuit	200
13	<i>C. tricarinata</i> Lindl.	2300-3300
14	<i>C. trulliformis</i> King & Pantl.	1700-2800
15	<i>C. woodfordii</i> (Hook.) M.W.Chase, Christenh. & Schuit	

4.4.3 Flowering season

The flowering season of *Calanthe* starts from the month of March and ends in November. The overall flowering season of *Calanthe* is shown in Figure 24. According to Figure 24, the peak flowering season of *Calanthe* is May to August and during this time more than half of Nepalese *Calanthe* blooms. The flowering is not reported in January, February and December.

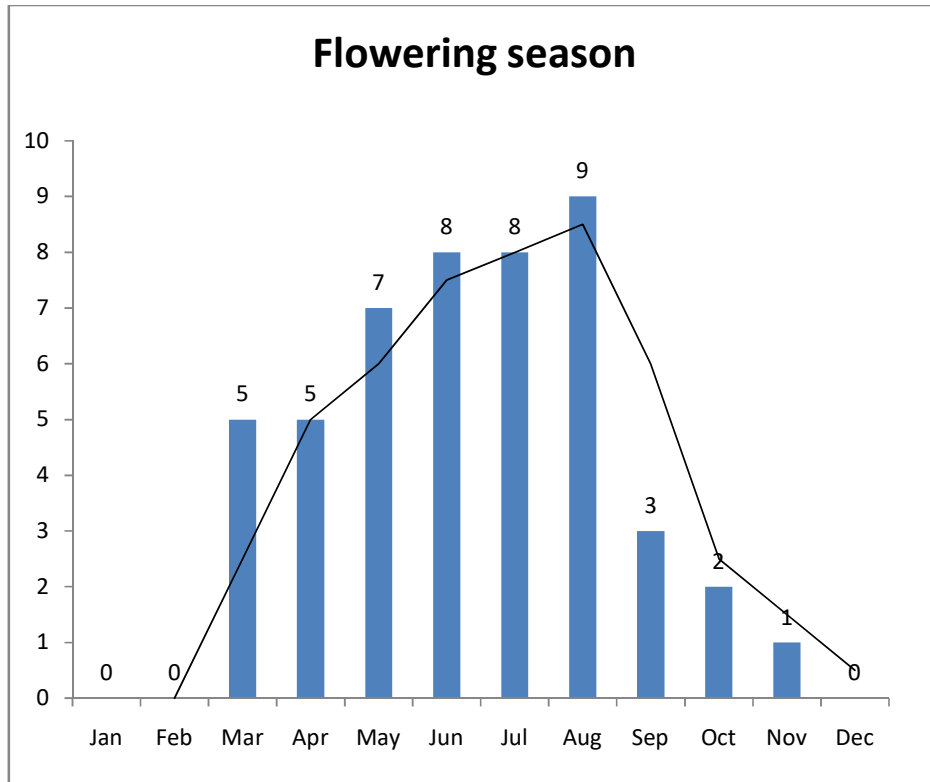


Figure 24: Flowering Season of *Calanthe* R. Br.

5. DISCUSSION

The present study confirms the number of species to be 15 (excluding *C. biloba*) in the genus *Calanthe* in Nepal which encompasses the description of plant species with their type, synonym, distribution, ecology and flowering. In this study the species of previously called genus '*Phaius*' has been studied along with the genus *Calanthe* after their merge by Chase *et al.* (2020).

In the case of life form, all the species of *Calanthe* are terrestrial, perennial herb in nature. There is no distinct variation in the life forms. The species occurs mostly near water resources, dense, shady and humid forest floor specially *Tsuga*, *Castanopsis*, and *Pinus* forest. Most of the species attain the height of 30-50 cm. The tallest species is *C. tricarinata* reaching upto 75 cm and shortest species is *C. griffithii* of 20-25 cm tall. All the species generally occurs closely with each other in ground. Rasmussen (1995) has also said that very large number of minute sized orchid seeds are produced which help in local centralization and dense coverage around the mother plant. Leaves are simple, usually basal but develop from side of stem in *C. woodfordii*.

In the previous revisionary work of the genus *Calanthe*, sterile bract is completely ignored. But this study shows that, sterile bracts also holds the characteristics that are taxonomically important and helps in delimitation of species. In majority of species only one sterile bract is present at base of inflorescence but 2 or more than two sterile bracts are found to be present in *C. davidii*, *C. densiflora*, *C. puberula*, *C. tankervilleae* and *C. woodfordii*. King & Pantling (1898) have noted that the inflorescence is produced on an undeveloped pseudobulb in this genus which also bears the young leaves. 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 which usually develops from the leaf axil or side of stem. The sepals and petals of all the species are upright except *C. davidii* whose sepals, petals and floral bracts are reflexed. The pedicel and ovary are not specifically distinct, but *C. arcuata* have arcuate ovary. Dressler (1993) also explained that the pedicel and ovary in orchids can hardly be differentiated at the flowering because of the slender ovary.

The lip of the *Calanthe* is the most important part for the delimitation of the species. The lobes, colour, lip margin, callus, spur and its attachment with the column are the

taxonomically superior character for species delimitation in *Calanthe*. The 3-lobed lip is present in *C. brevicornu*, *C. chloroleuca*, *C. davidii*, *C. densiflora*, *C. griffithii*, *C. mannii*, *C. masuca*, *C. plantaginea*, *C. puberula*, *C. tankervilleae*, *C. tricarinata* and *C. woodfordii*. The unlobed lip is present in *C. alpina* with the fimbriate margin, *C. arcuata* and *C. trulliformis*. The callus or ridges are the extra structures present in the disk of lip in species of *Calanthe* which are the another key factor for delimitation of species. The shape, form and number of these structures vary greatly among the species.

In the generic level, it was confirmed that the genus is polyphyletic in origin (Xiang *et al.* 2014, Yukawa & Cribb 2014, Zhai *et al.* 2014). In this study, the species are studied for the cladistic study. The closeness relation is studied among the species. Altogether 11 characters were used for the phylogenetic analysis. The characters for the study could give more exact interpretation as Heath *et al.* (2008) has said that the increase in the number of overall characters in the analysis improves the accuracy of phylogenetic analysis.

From the study it was found that the species of *Calanthe* in Nepal are distributed in all three regions; west, central and east. The wide distribution is in the Central Nepal. While, there is less distribution of *Calanthe* in West and East Nepal. This distribution is inserted in a map according to the location of the species collected from natural habitat in Nepal. So, it is clear that the species of *Calanthe* has been collected in massive amount only from Central Nepal. The west and east Nepal are comparatively less explored regions. From Map 17, it can be concluded that the distribution of *Calanthe* is extremely less in the terai region of Nepal, only one district from that region is known to have natural habitat of *Calanthe* and which is *C. tankervilleae*. In overall, the genus has been collected from 31 districts of Nepal. From the Table 11, it is clear that the *Calanthe* species are more distributed in the subtropical and temperate regions of Nepal. The tropical and subalpine region of Nepal has a single species of *Calanthe* distribution and there is complete absence of this species in high altitude area the alpine region. According to Djordjevic & Tsiftsis (2022), the number of terrestrial orchid species increases with decreasing latitude which means that the orchid diversity are more specific in southern parts.

6. CONCLUSION

The genus *Calanthe* is terrestrial orchid which is characterized by the presence of plicate, linear to broad leaves, showy and mostly large flowers, 8 pollinia in 2 groups. The present study confirmed the presence of 15 species of *Calanthe* in natural habitat in Nepal.

There is more similarity in the morphology among the species, in fact it is difficult to identify the species in non-flowering season. But, this fact is not reliable in case of reproductive structures of this genus. There is wide variation and distinction among the floral characters like colour, size and number of flower in scape. With all this characters the most important and distinguishing character of this genus occurs in lip. Lip is either lobed or unlobed among the species and the unlobed lip is present in *C. alpina* and *C. trulliformis*. From this study, the lip of *C. arcuata* in examined specimen is also found to be unlobed. The presence of callus or lamellae in disk is most common among the species, only the number, size, form and texture of these structure vary between the species. The number of callus is only one in *C. griffithii*, 2 in *C. densiflora*, and 3 in *C. arcuata*, *C. brevicornu*, *C. manni*, *C. plantaginea* and *C. tricarinata*. While, there is absence of callus or such structure in a disk of *C. puberula*. Among this entire species, *C. davidii* is unique in some features like; presence of reflexed sepals, petals and floral bracts, mid lobe of a lip divided into two broad lobules.

The phylogenetic analysis is interpreted through the cladogram by using 11 different characters. It is confirmed that *C. Chloroleuca* and *C. plantaginea* are closely related species supported by ovate-lanceolate leaf. Similarly, *C. tankervilleae* and *C. woodfordii* are the closely related species which are supported by the lip free from column. And these two species are closely related to *C. densiflora* in terms of having more than one sterile bracts. The present cladistic study is for the species and it can hardly gives any conclusion regarding the genus. However, this study has clearly portrayed the closeness between the species of this genus present in Nepal.

From the present study, it is also concluded that more collections and distribution of this genus has been made from Central region of Nepal. In case of vertical distribution, it is found that the genus is present at the range from 200 - 3300 m in Nepal, *C. tankervilleae* is the species collected from the lowest altitude and *C. tricarinata* is the species collected from highest altitude in Nepal till the date. The majority of species are distributed in the temperate region and May to August is the peak flowering season of this genus.

7. RECOMMENDATIONS

The present study is based on the herbarium specimens examination in KATH and TUCH along with virtual examination of herbarium specimens from the international herbaria.

Some of the recommendations are listed as follow:

1. This study is priorly based on morphological characters of the genus *Calanthe* and for the further study the molecular study can be performed to resolve the taxonomic limitations.
2. The plant material in herbarium sheets should be traced in such a way that it does not loose any of its part so, cutting and compulsory collection of the pseudobulbs or lower plant parts in paper folders can be the best option for future study. This will help in direct study and observation of all the characters of a plant from the same herbarium sheets and also increase the stability of the study.
3. Some of the herbarium specimens do not contain the important floral parts in the herbarium sheets. This leads in incomplete information for the direct study of the plant especially at the time, when there is only one herbarium specimen deposited in the herbarium. It is recommended that the plant material should be properly traced in the sheets without removing any of plants part which have taxonomic value.
4. The plant collection team and collectors should also explore the western and eastern Nepal equally.
5. 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.

8. REFERENCES

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(<http://apps.kew.org/herbcat/navigator.do>)
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 (<https://www.nhm.ac.uk>)
 (<https://powo.science.kew.org>)
 (<https://www.tropicos.org>)
 (<https://plants.jstor.org>)


 (<https://www.biodiversitylibrary.org>)
 (www.worldfloraonline.org)

ANNEX

Annex 1: Permission letter by Ministry of Forest and Environment to collect fresh plant material.

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

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४-२२१७४४
फ्याक्स: ४-२२७३७४



प्राप्त पत्र संख्या र मिति:
पत्र संख्या: ०६३/१०
च. नं.: १७४

(कृपया पत्रोत्तरमा प्राप्त पत्र संख्या र मिति उल्लेख गर्नुहोला।)
बबरमहल
काठमाडौं, नेपाल
मिति : २०७९/०५/०५

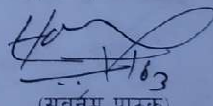
विषय: अनुसन्धान अनुमति सम्बन्धमा।

श्री रिना दुवाल
भक्तपुर, नेपाल।

प्रस्तुत विषयमा त्रिभुवन विश्वविद्यालय, विज्ञान तथा प्रविधि अध्ययन संस्थान, अमृत क्याम्पस, काठमाण्डौ मार्फत स्नातकोत्तर तह चौथो सेमेष्टरमा अध्ययनरत तपाईंले "Taxonomic Revision of the genus *Calanthe* R.Br. (Orchidaceae) in Nepal" को विषयमा अध्ययन अनुसन्धानका लागि अध्ययन अनुमति उपलब्ध गराइदिनु हुन भनि मिति २०७९/०३/२९ गते यस विभागमा दिनु भएको निवेदन साथ प्रपोजल प्राप्त भयो। सो सम्बन्धमा मिति २०७९/०४/२३ गते वसेको प्राविधिक समितिको निर्णय अनुसार उक्त अनुसन्धानबाट नगरकोट, चन्द्रागिरी, काभ्रे तथा फुलचोकी क्षेत्रमा phylogenetic relationship of the species within genus, distribution patterns of different species of this genus and status & species diversity of this genus लगायतका विषयमा जानकारी प्राप्त हुने भएकोले संकलित नमूनाहरूको विश्लेषण नेपालमा नै हुने गरी प्रपोजलमा उल्लेखित Methodology (study of herbarium specimens, live plant collection and description) अनुसार तर्पसिलको शर्तहरूको अधिनमा रही डिभिजन वन कार्यालयसँग समन्वय गरि वि.सं.२०८० सम्मका लागि अनुसन्धान गर्नु हुन निर्देशानुसार अनुरोध छ।

शर्तहरू

१. अनुसन्धानकर्ताले वन ऐन २०७९ तथा वन नियमावली २०७९, राष्ट्रिय निकुञ्ज तथा वन्यजन्तु संरक्षण ऐन, २०२९ र नियमावली २०३० तथा यस मातहतका नियमावलीहरूको पूर्ण पालना गर्नुपर्नेछ।
२. अनुसन्धान कार्य डिभिजन वन कार्यालयसँगको समन्वयमा गर्नुपर्नेछ।
३. संकलित नमूनाहरू (विरुवा) को परिक्षण कार्य अमृत क्याम्पसको प्रयोगशालामा गर्नुपर्नेछ।
४. अनुसन्धानको क्रममा प्राप्त भएको जैविक विविधता संरक्षणसँग सम्बन्धित संवेदनशिल सूचनाहरू गोप्य राख्नु पर्नेछ। अनाधिकृत रूपमा त्यस्ता सूचनाहरू कसैलाई पनि उपलब्ध गराउन पाइने छैन।
५. अनुसन्धान कार्य समाप्त भए पश्चात एक प्रति रिपोर्ट/प्रतिवेदन (कागजी तथा विचुतिय) यस विभागमा अनिवार्य रूपमा बुझाउनु पर्नेछ।
६. तोकिएका शर्तहरूको पालना नगरिएमा विभागले कुनै पनि समयमा अनुसन्धान अनुमति रद्द गर्न सक्नेछ।


(सर्वनम पाठक)
सहायक वन अधिकृत

बोधार्थ

श्री डिभिजन वन कार्यालय, काठमाण्डौ, भक्तपुर, ललितपुर, काभ्रे। : जानकारी तथा आवश्यक सहयोगका लागि अनुरोध छ।

श्री अमृत क्याम्पस, काठमाण्डौ। : संकलित नमूना (विरुवा) तहाँ क्याम्पसको प्रयोगशालामा राखि यस विभागमा जानकारी दिनुहुन।

Annex 2: Type specimens of *Calanthe* species



Holotype of *C. alpina* Hook.f. ex Lindl.
(K)



C. arcuata Rolfe (K)



Syntype of *C. brevicornu* Lindl. (K)

Annex 3: Type specimens continue



Isotype of *C. davidii* Franch. (P)



Syntype of *C. densiflora* Lindl. (K)



Syntype of *C. griffithii* Lindl. (K-LINDL)
(Photo provided by Dr. Lokesh Ratna Shakya)



Syntype of *C. mannii* Hook.f. (K)

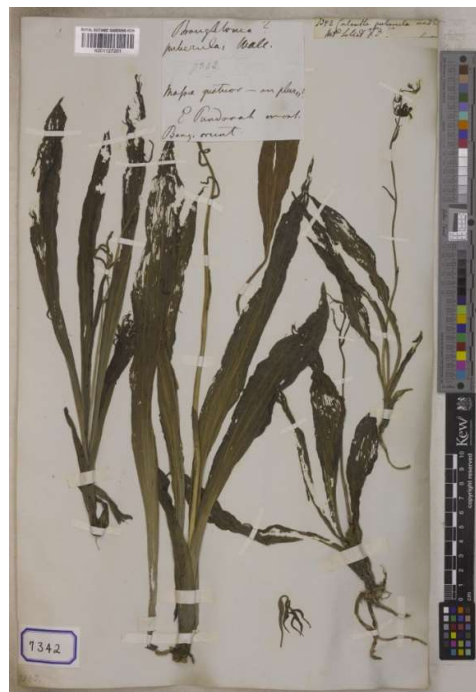
Annex 4: Type specimens continue



Holotype of *C. masuca* (K)



Syntype of *C. plantaginea* (K)



Holotype of *C. puberula* (K)



Lectotype of *C. tankervilleae* (Banks)
M.W. Chase, Christenh. & Schuit. (LINN-
HS)

Annex 5: Type specimens continue



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



Isotype of *C. trulliformis* King & Pantl. (K)



Holotype of *C. woodfordii* (Hook.)
M.W. Chase, Christenh. & Schuit. (K)

Annex 6: Fresh plant in the field (Photos by Rina Duwal)



C. brevicornu Lindl.



C. mannii Hook.f.



C. plantaginea Lindl.



C. tricarinata Lindl.