

Family Liliaceae in Nepal: Taxonomy, Distribution Pattern and Species Richness

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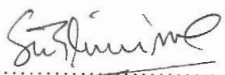
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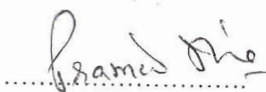
The M.Sc. Dissertation entitled "**Family Liliaceae in Nepal: Taxonomy, Species Richness and Distribution Pattern**" submitted by **Miss Hum Kala Rana** for the partial fulfillment of her Master's Degree in Botany (Plant Systematic and Biodiversity Unit) has been accepted.

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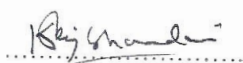
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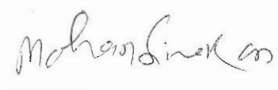
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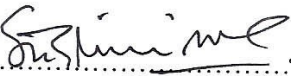
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RECOMMENDATION

It is hereby recommended that the dissertation entitled "**Family Liliaceae in Nepal: Taxonomy, Species Richness and Distribution Pattern**" was carried out by **Miss Hum Kala Rana** under my supervision. This work has been accomplished on the basis of candidate's original research work based on herbarium specimen from different herbaria of the world. This thesis has been submitted for the partial fulfillment of her Master's (M.Sc.) Degree in Botany from Tribhuvan University, Kathmandu, Nepal.

To the best of my knowledge the results of this work have not been submitted for any other degree either in whole or in part at this or at any other University. Therefore, I'm pleased to forward this dissertation for the final approval and acceptance.



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Declaration of Originality

I hereby declare that the work contained in this dissertation is my own, unless otherwise acknowledged and cited. This material has not been submitted, either in whole or in part, for a degree at this or any other institution.

Date: 23rd September 2014



Hum Kala Rana

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ACRONYMS AND ABBREVIATIONS

Amer. Monthly Mag. & Crit. Rev.	The American Monthly Magazine and Critical Review
Ann. Bot.	Annals of Botany
Anno. Check. Fl. Pl. Nepal	Annotated Checklist of Flowering Plants of Nepal.
Bot. Ergben.	Botanische Ergebnisse
Bot. Himal. Mts.	Botany of the Himalayan Mountains
Bot. Mag. (Tokyo)	Botanical Magazine
Bot. Rev.	Botanical review
Bull. Univ. Mus. Univ. Tokyo	The University Museum, the University of Tokyo Bulletin
Bull.	Bulletin
c.	About (approximate)
CDB	Central Department of Botany
cm.	Centimeter
Contr. Gray Herb.	Contributions from Gray Herbarium
E	Royal Botanic Garden, Edinburgh, UK
e.g.	<i>exempli gratia</i> or 'for example'
Ecol. Lett.	Ecology Letters
ed.	Edition
eds.	Editors
Enum. Fl. Pl. Nep.	Enumeration of the Flowering Plants of Nepal
<i>et. al</i>	<i>et alia</i> or 'and others'
Fig.	Figure
Fl. Bhutan	Flora of Bhutan
Fl. Bor.–Amer.	Flora Borealia - Americana
Fl. Brit. Ind.	Flora of British India
Fl. China	Flora of China
Fl. E. Himal.	Flora of Eastern Himalaya
Fl. Germ. Excurs.	Flora Germanica Excursoria
Fl. Himalaya	Flowers of Himalaya
Fl. Orient.	Orient of Florida
i.e.	<i>id est</i> : that is
Icon. Pl.	Icones Plantarum

IUCN	The world Conservation Union
J. Jap. Bot.	Journal of Japanese Botany
J. Linn. Soc., Bot.	Journal of the Linnean Society, Botany
J. Plant Res.	Journal of Plant Resources
KATH	National Herbarium and Plant Laboratories, Godavari
Kew Bull.	Kew Bulletin
Mem. Wern. Nat. His. Soc.	Memories of Wernerian Natural History Society
mm.	Milimeter
Nom. Cons.	Nomen Conservandum (singular); Nomina Conservanda - a plural)
p., pp.	Page, pages
Proc. Californai Acad. Sci.	Proceedings of the California Academy of Sciences
Prod. Fl. Nep.	Prodromous Florae Nepalensis
Sp. Pl.	Species Plantarum
Symb. Sin.	Symbolae Sinicae
Syst. Biol.	Systematic Biology
Syst. Veg.	Systema Vegetabilium
TI	University Museum, University of Tokyo
TUCH	Tribhuvan University Central Herbarium
var.	Variety
Veg. Kingd.	Vegetable Kingdom
Viz.	Videlicet: namely
Vol.	Volume

ABSTRACT

The taxonomy of family Liliaceae is under great dispute among the taxonomists of the world. In the past, the family was considered in loose sense, which included large assemblies of unrelated taxa, many of these are treated now under distinct family. Liliaceae now consists of 15 genera and 600 species in the world.

Present study was conducted to revise the taxa under Liliaceae, and predict their potential distribution along with species richness pattern in Nepal. In total, 19 species belonging to 9 genera and 3 subfamilies (Lilioideae, Streptopoideae and Calochortoideae) were described for Nepal based morphometric evaluation of herbarium specimens deposited at different herbaria (KATH, TUCH, E and TI). Angiosperm Phylogeny Group (APG III) system of classification was used for arranging taxa within the family. Predictive distribution modeling of the three subfamilies was done using occurrence records from herbarium specimens and bioclimatic variables from WORLDCLIM. The model used for the purpose was BIOCLIM of DIVA-GIS 7.5.

The species of family Liliaceae showed ranges of morphological characters, based on which taxa were delineated. The dendrogram obtained based on cluster analysis showed two distinct clusters: cluster 1 as bulbous group (including *Cardiocrinum*, *Fritillaria*, *Gagea*, *Lilium*, *Lloydia* and *Notholirion*) and cluster 2 as rhizomatous group (including *Clintonia*, *Streptopus* and *Tricyrtis*). Predicted current potential distribution of species of three subfamilies indicated that species of two subfamilies Lilioideae and Streptopoideae are potentially distributed in all the phytogeographic regions of Nepal; whereas, the species of subfamily Calochortoideae have potential distribution in eastern and very less in central regions of Nepal. Species of Calochortoideae favors wetter climates than the species of other two subfamilies. Central and western regions were found with highest species richness values than the eastern region of Nepal. Fir forest, oak-laurel forest and alpine mats and pastures are the vegetation types with maximum species richness. Present study showed that vegetative and reproductive morphological characters are of much significance in identifying and delimiting the taxa within the family. Species distribution models provided the current distribution localities of species. These localities can be the new sites for future collections, studies and expeditions.

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CHAPTER 1

INTRODUCTION

1.1 Background

The family **Liliaceae** now consists of fifteen genera and approximately 600 species of flowering plants within the order Liliales (Stevens, 2001 onwards). But in the past, Liliaceae was treated as a moderately large family consisting of about 280 genera and nearly 4,000 species in the world (Cronquist, 1981). The family is named after *Lilium*, the type genus (Simpson, 2006). *Lilium* is Latin for 'lily' and which came from the Greek word *leirion* (lily flower "a classic symbol of purity"). The name 'lily' has historically been applied to a wide variety of plants other than the genus *Lilium* (Hayashi and Kawano, 2000). The lily appears in ancient literatures associated with both sovereignty and virginal innocence, and is mentioned on a number of occasions in the Bible (Dale, 2014). Other symbolic meanings include purity, divinity, glory, love and birth (Dale, 2014).

Liliaceae are generally bulbous geophytes (but also possess other forms of enlarged underground stem) from which grow erect clusters of narrow, grass-like leaves or leafy stems, large flowers with six free and often spotted tepals, six extrorse stamens, and a superior ovary (Simpson, 2006).

Evolutionally, the family is probably the basic monocotyledonous stock, its ancestors having given rise to the majority of contemporary monocots, e.g. the orchids, the palms, the iris and amaryllis families, and possibly also the grasses (Givnish *et al.*, 2006). The family evolved approximately ~65 million years ago during the late Cretaceous to early Paleogene (Vinnersten and Bremer, 2001).

The relationships between members of the family Liliaceae are not always clear. Some botanists have treated many members of the traditional family Liliaceae into separate families or, if they take a broader view of the family, included some groups such as the Agave and Amaryllis (Patterson and Givnish, 2002).

The members of the family are widespread throughout the world, but most common in temperate to subtropical regions, especially East Asia and North America of the northern

hemisphere. They occur mostly in the steppes and mountain meadows. The centre of diversity is considered as S.W. Asia to China (Simpson, 2006).

It is a well known fact that plant species are not homogeneously distributed, each species depends on the existence of a specific set of environmental conditions for its long-term survival (Gaston and Blackburn, 2000). Detailed knowledge of species' ecological and geographic distribution is fundamental for conservation planning and forecasting (Ferrier, 2002; Funk and Richardson, 2002; Rushton *et al.*, 2004), and for understanding ecological and evolutionary determinants of spatial patterns of biodiversity (Rosenzweig, 1995; Brown and Lomolino, 1998; Ricklefs, 2004; Graham *et al.*, 2006).

To predict species' potential distribution, a range of models have been developed. Species distribution models do not predict species geographic occurrences as such, but produce a spatially explicit probability surface that represents habitat suitability in ecological hyperspace after factoring in some specified constraints (sometimes including variable interactions) (Herkt, 2007).

1.2 Statement of the Problem

Liliaceae has been a matter of great dispute among the taxonomists mainly in relation to the placement of taxa within the family (Hutchinson, 1959; Dahlgren *et al.*, 1985; Takhtajan, 1987). Cronquist (1981) and many contemporary authors (Takhtajan, 1980; Thorne, 1992) circumscribed Liliaceae very broadly and included in it some 280 genera and 4,000 species. In recent years, attempts have been made on the delimitation of Liliaceae *s.s.*, based on re-evaluation of morphological traits and various other criteria (Tamura, 1998). Members of the traditional Liliaceae *s.l.* are now re-organized among Liliales and Asparagales in particular (Dahlgren *et al.*, 1985) and seven other families (Rudall *et al.*, 2000). Recently, based on molecular and evolutionary characters, only 15 genera are proposed in the the family Liliaceae *s.s.* (Angiosperm Phylogeny Group, 2009). A more comprehensive understanding of morphology is urgently needed to enable broad evolutionary questions, and there is a particular need for targeted surveys of the morphological variation of particular groups (Stevens, 2001 onwards).

Arrangement of lower taxa is also problematic within the family. Two genera, *Streptopus* and *Scoliopus* previously included in a narrowly-drawn family Uvulariaceae are now treated under subfamily Streptopoideae of the family Liliaceae (Shinwari *et al.*, 1994). The placement of *Calochortus* and *Tricyrtis* in subfamily Calochortoideae is questionable as *Tricyrtis* is linked with the members of subfamily Streptopoideae (Rudall *et al.*, 2000). Previously, the genus *Tricyrtis* (of current subfamily Calochortoideae) has been treated under family Uvulariaceae along with the genera, like *Clintonia*, *Disporium* and *Streptopus* (Noltie, 1994). Similarly, different views exist for the placement of the genus *Lloydia*, which was previously treated as distinct genus later included in *Gagea* (Peterson *et al.*, 2008; Zarrei *et al.*, 2009). Takhtajan (1987) included *Erythronium* and *Tulipa* in subfamily Tulipeae; *Cardiocrinum*, *Lilium*, *Notholirion*, *Nomocharis*, *Fritillaria* and *Rhinopetalum* in subfamily Lilieae; *Medeola* as a monotypic genus of the family Medeolaceae and *Clintonia* tentatively in the separate family Convallariaceae. Tamura (1998), however, recognized two subfamilies in Liliaceae s.s., Medeoloideae (*Clintonia* and *Medeola*) and Lilioideae [*Erythronium*, *Tulipa*, *Gagea* and *Lloydia* (tribe Tulipeae); *Cardiocrinum*, *Lilium*, *Fritillaria*, *Nomocharis* and *Notholirion* (tribe Lilieae)]. In contrast, Angiosperm Phylogeny Group (2009) mentioned three subfamilies within Liliaceae, Lilioideae (tribe Lilieae: *Cardiocrinum*, *Erythronium*, *Fritillaria*, *Gagea*, *Lilium*, *Notholirion* and *Tulipa* and tribe Medeoleae: *Clintonia* and *Medeola*), Streptopoideae (*Pterosartes*, *Streptopus* and *Scoliopus*), and Calochortoideae (*Calochortus* and *Tricyrtis*). Thus, there are still differing views concerning the members of the family Liliaceae, and of the families within the Liliales. These examples show that Liliaceae is one of the difficult families within the order Liliales.

There are only few published accounts concerning the status of the family Liliaceae from the Himalayan region, including South Asia. Hooker (1894), for example, described 35 genera under Liliaceae in “The Flora of British India”. Similarly, Noltie (1994) in “Flora of Bhutan” described 6 genera under Liliaceae. Afroz and Hassan (2008) revised the family Liliaceae for Bangladesh and Gogoi (2010) does the same work for Manipur, India.

There is no country-level account of the family Liliaceae for Nepal. However, some regional- or district-level Flora exists, which enlists the taxa under the family Liliaceae. For example, Malla *et al.* (1976) in “Flora of Langtang” reported 12 genera, Obha *et al.* (2008) in “Flora of Mustang” mentioned 8 genera, Malla *et al.* (1986) in “Flora of Kathmandu Valley” included 10 genera, and Press *et al.* (2000) listed 33 genera under the family Liliaceae in “Annotated

Checklist of Flowering Plants of Nepal”. All these studies reviewed here, treated the taxa within the family based on old classification system. No work has been done taking in consideration to modern Angiosperm Phylogeny Group (APG) classification system. This study has attempted to make a revisionary work of the family for Nepal using modern classification system.

This work has been carried out in the context of ‘Flora of Nepal’. Several attempts have been made to launch the Flora of Nepal Project in national and international levels. During 1996, a collaborative project was developed between the three collaborating countries (Nepal, UK and Japan) to prepare the Flora of Nepal. The first document of Flora of Nepal was Volume 3 published in 2011, comprising the families from Magnoliaceae to Rosaceae. The fourth International Editorial Board meeting of Flora of Nepal held in Japan decided to publish volume 4, 7 and 10 simultaneously within 2015. The volume 10 covers the monocot families of Nepal. The taxonomic account prepared for the family Liliaceae in the present work can be the part of “Flora of Nepal, Vol. 10, and Part 1”.

Any revisionary work will be incomplete if the geographical and ecological limits of the taxa under study are not mentioned. The works done in the past have mentioned only geographical distribution of taxa based on herbarium records and expeditions, thus limiting the species occurrence only to the surveyed regions. Prediction of the spatial pattern of distribution based on past records is crucial for biodiversity conservation and future explorations even to the unexplored or poorly-surveyed areas (Guisan *et al.*, 2006).

Many scientists used BIOCLIM model of DIVA-GIS to predict the species current distribution (e.g., Guisan and Zimmerman, 2000; Elith *et al.*, 2006; Hijmans and Graham, 2006; Parthasarathy *et al.*, 2006; Rajbhandary *et al.*, 2010; Barman *et al.*, 2011) and Babar *et al.* (2012), taking one or few genera and even a whole family. But, no work has focused on the family Liliaceae and its taxa. Thus, the present work also aims to predict the current potential distribution of the family and species rich regions in the study area.

1.3 Objectives

Realizing limited taxonomic work on the family, a taxonomic revision of Liliaceae in Nepal has been undertaken. Emphasis is given on gross morphological (vegetative and

reproductive) characters and geographical distribution modeling of the taxa and richness pattern of the family Liliaceae in Nepal.

Major objectives of the present study are:

1. To undertake taxonomic study of the family Liliaceae in Nepal in particular:
 - To prepare taxonomic treatment of individual taxa including identification keys, illustrations and distribution maps,
 - To delimit taxa within family based on morphological characters,
 - To find character similarity between taxa using cluster analysis.
2. To predict the current potential geographic distribution of three subfamilies of Liliaceae: Lilioideae, Streptopoideae and Calochortoideae.
3. To generate the species richness pattern for the family Liliaceae in Nepal.

1.4 Limitation

Systematic study requires several replicates of good quality plant specimens. Due to non-availability of the herbarium specimens, three species (*Lilium bakerianum*, *L. sherriffiae* and *Notholirion thomsonianum*) were excluded from the study. Some species included in the study were explained on the basis of only one or two specimens.

Similarly, very less work has been done on species distribution modeling for Nepal. Although distribution modeling can not be treated as substitute for detailed empirical field data, including data on demography, abundance and species-environment interactions, its prediction accuracy can be judged based on available information. In the case of Liliaceae, the collection of occurrence records is limited mostly to the sites where field excursions have been made in the past, which may result in the perception that they grow under certain conditions when other areas were simply not examined. Selected parameters may not be sufficient to describe the species habitat requirements. Certain species have specific ecological limitations governing where they are known to occur, which may result in over-prediction of suitable habitat by the model. Distribution model (such as BIOCLIM used here) predicts suitability areas only in the neighbourhood of occurrence records.

CHAPTER 2

LITERATURE REVIEW

2.1 History of Classification of the Family Liliaceae and Lower Taxa

Adanson (1763), described the family Liliaceae in his “*Families Naturelles des Plantes*”, but Jussieu (1789) named it formally as Liliaceae. The grouping was based on the presence of calyx of six equal colored parts, six stamens, a superior ovary, single style, and a trilocular (three-chambered) capsule. Over the long period of taxonomic history of the family, many other genera were added until it became one of the largest families of monocotyledon. Lindley (1846) recognized only 133 genera and 1200 species under Liliaceae. Many other taxonomists, viz., Bentham and Hooker (1862-1883), Engler and Prantl (1887-1915), Bessey (1915), Rendle (1925), and Hutchinson (1934) described Amaryllidaceae (ovary inferior) and Liliaceae (ovary superior) separately under the same order or under separate orders mainly on the basis of ovary position. But, Cronquist (1981), Takhtajan (1980) and Thorne (1992) merged Liliaceae with Amaryllidaceae encompassing about 280 genera and 4,000 species in order Liliales.

Eventually, this polyphyletic taxon was reclassified into several, partly distantly related families; several of them were placed in a large order Asparagales, others in a more narrowly circumscribed Liliales (Dahlgren *et al.*, 1985). With molecular data, the circumscriptions of Liliales and the families of Liliales have been further refined (Rudall *et al.*, 1995, 2000). The order Liliales includes seven families, Liliaceae, Melanthiaceae, Colchicaceae, Smilacaceae, Alstroemeriaceae, Campynemataceae and Luzuriagaceae (Rudall *et al.*, 2000). In the context of a general review of the classification of angiosperms, Liliaceae was subjected to more intense scrutiny. Considerable progress in plant phylogeny and phylogenetic theory enabled a phylogenetic tree to be constructed for all of the flowering plants including Liliaceae, as elaborated by the Angiosperm Phylogeny Group (1998). Angiosperm Phylogeny Group System of Flowering Plant Classification (Angiosperm Phylogeny Group, 1998, 2003 and 2009) treated family Liliaceae in the order Liliales along with other smaller families.

Present study follows APG system of classification (Angiosperm Phylogeny Group, 2009) to arrange taxa within the family. There is now a general consensus of the genera comprising

subfamily Lilioideae [*Amana*, *Cardiocrinum*, *Erythronium*, *Fritillaria* *Gagea* (including *Lloydia*), *Lilium* (including *Nomocharis*), *Notholirion* and *Tulipa*] and the phylogenetic relationships between them (Fay and Chase, 2000; Patterson and Givnish, 2002; Fay *et al.*, 2006). Similarly, genera comprising subfamily Medeoloideae (*Clintonia* and *Medeola*) and their relationships are well supported (Fay *et al.*, 2006). However, the placement of *Tricyrtis*, *Calochortus* and the clade comprising *Prosartes*, *Scoliopus* and *Streptopus* (Streptopeae) in Liliaceae have been more problematic (Patterson and Givnish, 2002; Rønsted *et al.*, 2005; Fay *et al.*, 2006).

Table 1. Subfamilies, tribes and genera of Liliaceae in the world (Stevens, 2001 onwards).

Subfamily	Tribe	Genera
	Medeoleae Benth. (synonyms: Medeolaceae Takht., Medeoloideae Benth.)	<i>Clintonia</i> Raf. <i>Medeola</i> Gronov. ex L.
Lilioideae Eaton	Lilieae Ritgen (synonyms: Erythroniaceae Martinov, Fritillariaceae Salisb., Liriaceae Borkh., Tulipaceae Borkh.)	<i>Cardiocrinum</i> (Endl.) Lindl. <i>Erythronium</i> L. <i>Fritillaria</i> Tourn. ex L. <i>Gagea</i> Salisb., including <i>Lloydia</i> Salisb. ex Rchb. <i>Lilium</i> Tourn. ex L. <i>Nomocharis</i> Franch. <i>Notholirion</i> Wall. ex Boiss. <i>Tulipa</i> L. including <i>Amana</i> Honda
	Calochortoideae Dumort. (synonyms: Calochortaceae Dumort., Compsaceae Horan., <i>nom. illeg.</i> , Tricyrtidaceae Takht., <i>nom. Cons</i>)	<i>Calochortus</i> Pursh <i>Tricyrtis</i> Wall.
	Streptopoideae (synonym: Scoliopaceae Takht.)	<i>Prosartes</i> D. Don <i>Scoliopus</i> Torr. <i>Streptopus</i> Michx.

Note: The genera given in bold are found in Nepal. This present work has treated *Lloydia* as separate genus, even though it is based on APG III system of classification.

Due to the diversity of the originally broadly defined Liliaceae *s.l.*, many attempts have been made to form suprageneric and generic classifications. Tamura (1998) divided Liliaceae into two subfamilies, Lilioideae (two tribes: Tulipeae and Lilieae) and Medeoloideae. Angiosperm phylogeny group recognized three subfamilies (Table 1), one of which is divided into two tribes (Stevens, 2001 onwards). Various authorities [e.g., ITIS, 2012; GRIN, 2014; NCBI, 2014, and Watson and Dallwitz, 1992 onwards (DELTA)] differ on the exact number of genera included in Liliaceae *s.s.*, but generally there are about fifteen to sixteen genera, depending on

whether or not *Amana* is included in *Tulipa* and *Lloydia* in *Gagea*. Currently, Stevens (2001 onwards) listed fifteen genera in the family, arranged as shown in Table 1.

2.2 Phylogeny

The order Liliales diverged from their sister groups in the early Cretaceous >100 mya (Bremer, 2000). The order Liliales diverged ~65 mya into 4 evolutionary clades comprising 7 families (*clade 1*: Alstoemeriaceae, Luzuriagaceae and Colchicaceae; *clade 2*: Campynemataceae; *clade 3*: Melanthiaceae and *clade 4*: Smilacaceae and Liliaceae) (Vinnersten and Bremer, 2001). Smilacaceae are strongly supported as sister to Liliaceae based on *rbcl* study (Janssen and Bremer, 2004).

Phylogenetic analysis based on molecular data showed a tree with two clades in the subfamily Lilioideae of the family Liliaceae; one consisting of 5 genera: *Cardiocrinum*, *Fritillaria*, *Lilium*, *Notholirion* and *Nomocharis* (tribe Lilieae) and second consisting of four genera: *Erythronium*, *Tulipa*, *Amana* and *Gagea* (tribe Lilieae) (Hayashi and Kawano, 2000). *Medeola* and *Clintonia* (tribe Medeoleae) are found to be a distantly related sister group to the rest of Lilioideae (Hayashi and Kawano, 2000; Patterson and Givnish, 2002).

Gao *et al.* (2012) revealed that evolutionary trend of tribe Lilieae did not follow a single direction, but different in each genus. Chromosome diversity and evolution in Lilieae are quite clear in the light of molecular inference.

The genus *Gagea* with its seven sections including the genus *Lloydia* forms *Gagea s.l.* based on DNA sequences and morphological data (Zarrei *et al.*, 2011). Most recently, Gao *et al.* (2012) reconstructed the phylogeny of *Lilium* and *Nomocharis* using two molecular markers and including six species of *Nomocharis*. The results of their study supported previous investigations (Hayashi and Kawano, 2000; Lee *et al.*, 2011) showing the placement of *Nomocharis* within *Lilium*.

The monophyly of subfamily Calochortoideae is also questionable. *Calochortus* and its relatives (i.e., *Tricyrtis*) of Calochortoideae are not monophyletic (Rudall *et al.*, 2000). Even, *Tricyrtis* is linked with the members of subfamily Streptopoideae (Kim *et al.*, 2013).

The subfamily Streptopoideae includes three genera viz., *Streptopus*, *Scoliopus* and *Prosartes* (e.g., Shinwari *et al.*, 1994). These genera even appear linked in morphological analysis (Patterson and Givnish, 2002). Fay *et al.* (2006) found the strongly supported relationships among them based on molecular studies.

2.3 Taxonomy of the Himalayan Liliaceae

The Himalaya constitutes a vast stretches of mountains, which run almost in parallel. This is the world's highest mountain system, which extends nearly about 3000 km (Mani, 1999). Himalaya consists of three major geographical divisions: *Western Himalaya* (comprising northern part of Afganistan upto western border of Nepal), *Cental Himalaya* (including Nepal Himalaya), and *Eastern Himalaya* (extending from North Bengal Hills to Sikkim, Bhutan, Arunachal Pradesh and Northern Myanmar) (Mani, 1978).

The Himalaya is an important area in terms of its position as the centre of different floristic regions (Hara, 1966; Stainton, 1972; Dobremez, 1976; Mani, 1999; Bhujju *et al.*, 2007). A detailed understanding of plant distribution within the region is a key to understanding the biogeography of the Himalayan flora both locally and in a broader context (Bhujju *et al.*, 2007). Biodiversity documentation is of immediate importance not only in Nepal but also in the greater Himalayan region (MFSC, 2009).

Pioneer work on the flora of the eastern Himalayan region was that of Hooker (1894). He divided the family Liliaceae in 3 series, 16 tribes and described 120 species under 35 genera from British India. He placed *Streptopus* into tribe Polygonateae; *Fritillaria*, *Gagea*, *Lilium*, *Lloydia* and *Tulipa* into tribe Tulipeae; *Tricyrtis* into tribe Uvularieae and *Clintonia* into tribe Medeoleae within Liliaceae. Other than these genera of present Liliaceae *s.s.* many other genera, like *Smilax*, *Heterosmilax*, *Asparagus*, *Polygonatum*, *Smilacina*, *Theropogon*, *Tupistra*, *Goniscypha*, *Aspidistra*, *Hemerocallis*, *Dracaena*, *Cordyline*, *Asphodelus*, *Eremurus*, *Chlorophytum*, *Dianella*, *Allium*, *Dipcadi*, *Urgenia*, *Scilla*, *Colchicum*, *Merendera*, *Iphigenia*, *Tofieldia*, *Gloriosa*, *Disporum*, *Trillium* and *Paris* have also been described under the family Liliaceae.

“Flora of Bhutan” (Noltie, 1994) described only 6 genera, *Cardiocrinum*, *Fritillaria*, *Gagea*, *Lilium*, *Lloydia* and *Notholirion*. It placed some genera of past Liliaceae *s.l.* into other families: like *Chlorophytum* into family Anthericaceae, *Hemerocallis* into Hemerocallidaceae,

Pancreatium and *Zeyphyranthes* into Alliaceae. Even *Clintonia*, *Streptopus* and *Tricyrtis* of present Liliaceae *s.s.* are placed separately into the family Uvulariaceae along with *Disporum*.

“Flora of China” (Chen *et al.*, 2000) described 57 genera and 726 species under Liliaceae. The circumscription adopted for Liliaceae *s.l.* is not supported by current phylogenetic analysis. Genera like *Cardiocrinum*, *Clintonia*, *Erythronium*, *Fritillaria*, *Gagea*, *Lilium*, *Lloydia*, *Nomocharis*, *Notholirion* and *Tulipa* are among those which form the part of present Liliaceae *s.s.*

The family Liliaceae had also been revised for Bangladesh, where a total of 34 species with one variant under 16 genera (*Allium*, *Asphodelus*, *Asparagus*, *Crinum*, *Curculigo*, *Eucharis*, *Gloriosa*, *Haemanthus*, *Hemerocallis*, *Hippeastrum*, *Hypoxis*, *Molineria*, *Pancreatium*, *Proiphys* and *Urginea*) have been recorded (Afroz and Hassan, 2008). None of these genera now belongs to Liliaceae *s.s.*

Gogoi (2010) described Liliaceae for Manipur, India. He listed 11 genera viz., *Asparagus*, *Cardiocrinum*, *Dianella*, *Disporum*, *Lilium*, *Maianthemum*, *Polygonatum* and *Streptopus*. Tiwari *et al.* (2010) recorded *Notholirion macrophyllum* (D. Don) Boiss., as new species for Western Himalaya of India.

Many attempts have been made to document the floral diversity of Nepal at regional (e.g., Banerji, 1963; Hara, 1966; Malla *et al.*, 1976; Shrestha, 1982) and national (Hara *et al.*, 1978, 1979, 1982; Akiyama *et al.*, 1998; Malla and Shakya 1998; Press *et al.*, 2000; GoN 2001) levels. These documentations also include the family Liliaceae.

Hara (1966) described 38 species belonging to 18 genera under Liliaceae in “Flora of Eastern Himalaya”. *Aletris*, *Allium*, *Asparagus*, *Campylandra*, *Chlorophytum*, *Disporum*, *Hemerocallis*, *Ophiopogon*, *Paris*, *Peliosanthes*, *Polygonatum* and *Smilacina* are among the genera described whose placement is now in the families other than Liliaceae.

Malla *et al.* (1976) reported 20 species and 12 genera under Liliaceae from Langtang region. The 12 genera were *Alertis*, *Allium*, *Asparagus*, *Clintonia*, *Disporum*, *Fritillaria*, *Gloriosa*, *Lilium*, *Notholirion*, *Paris*, *Polygonatum*, *Smilacina* and *Theropogon*. Among these only *Clintonia*, *Fritillaria*, *Lilium* and *Notholirion* are considered now under Liliaceae.

Obha *et al.* (2008) listed 10 species belonging to 8 genera (*Allium*, *Alertis*, *Asparagus*, *Chlorophytum*, *Lloydia*, *Milula*, *Ophiopogon* and *Polygonatum*) under Liliaceae in “Flora of Mustang, Nepal”. Out of these, only *Lloydia* is circumscribed under Liliaceae *s.s.* in the recent classification system.

In “Flora of Kathmandu Valley” (Malla *et al.*, 1986), 16 species belonging to 10 genera (*viz.*, *Allium*, *Asparagus*, *Cardiocrinum*, *Campylandra*, *Chlorophytum*, *Disporum*, *Lilium*, *Ophiopogon*, *Paris* and *Polygonatum*) were included in the family Liliaceae. Out of these only *Cardiocrinum* and *Lilium* are now circumscribed under Liliaceae *s.s.*

Press *et al.* (2000) listed 97 species of the family Liliaceae belonging to 33 genera in “Annotated Checklist of Flowering Plants of Nepal”. These genera include: *Aloe*, *Aletris*, *Asparagus*, *Campylandra*, *Cardiocrinum*, *Chlorophytum*, *Clintonia*, *Dianella*, *Disporum*, *Dipcadi*, *Fritillaria*, *Gagea*, *Helonias*, *Hemerocallis*, *Iphigenia*, *Lilium*, *Lloydia*, *Maianthemum*, *Notholirion*, *Ophiopogon*, *Paris*, *Peliosanthes*, *Polygonatum*, *Smilax*, *Streptopus*, *Theropogon*, *Tofieldia*, *Tricyrtis*, *Trillidium*, *Tupistra* and *Urginea*. Out of these, only 9 genera (*Cardiocrinum*, *Clintonia*, *Fritillaria*, *Gagea*, *Lilium*, *Lloydia*, *Notholirion*, *Streptopus*, and *Tricyrtis*) are remaining in the present Liliaceae *s.s.*

2.4 Distribution and Ecology

Members of the family Liliaceae are widely distributed, but are mainly concentrated in the temperate regions of the Northern Hemisphere (Fig. 1). The family Liliaceae expanded from North America to Eurasia sometime ~30-40 mya (Vinnersten and Bremer, 2001).

Genera like *Tulipa* and *Gagea* are examples of ornamental geophyte biomorphological types representing continental thermoperiodic zones (Irano-Turanian region). They are characterised by cessation of underground growth at high temperatures in early summer and requiring low winter temperatures for spring flowering (Kamenetsky and Okubo, 2012). While some genera are shade-dwelling, such as the Medeoleae, and Streptopoideae, *Tricyrtis*, and *Cardiocrinum*, others prefer a more open habitat (Simpson, 2006).

Liliaceae is ecologically diverse family and its members bloom at various times from spring to late summer (Patterson and Givnish, 2002). The plants produce colorful and showy flowers with large amounts of nectar and pollen that attract insects which pollinate them

(entomophily), particularly bees and wasps (hymenopterophily), butterflies (psychophily) and moths (phalaenophily) (Sharma, 2009). Generally, the seeds are dispersed by wind and water. But, some species, e.g., *Gagea* have seeds with an aril structure that are dispersed by ants (myrmecochory) (Patterson and Givnish, 2002).

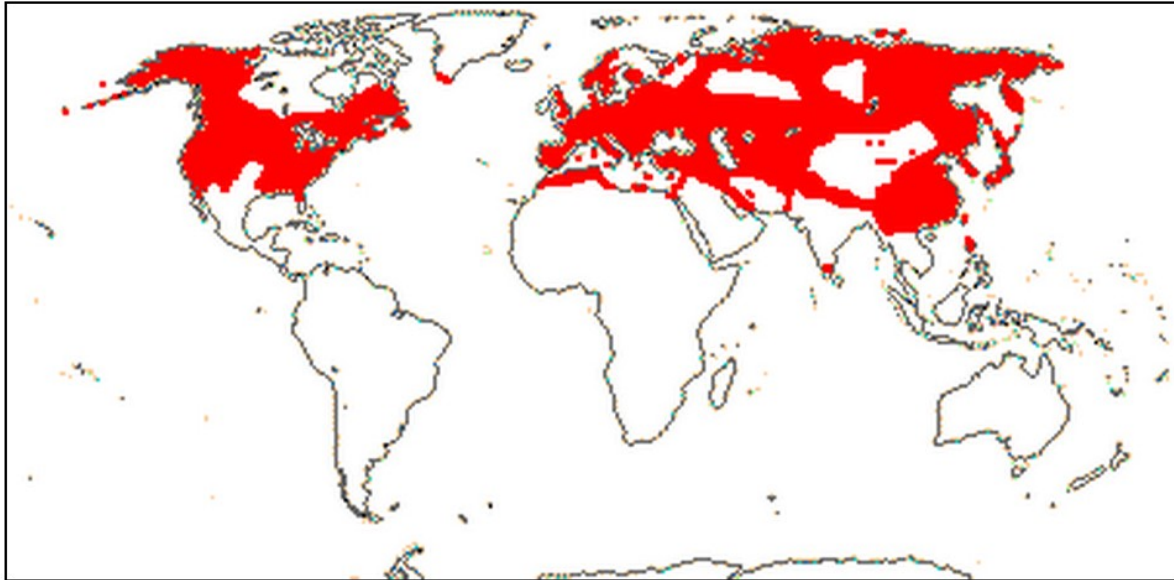


Fig. 1 Worldwide distribution of family Liliaceae (*Source*: Stevens, 2001 onwards).

The members of family Liliaceae are subjected to a wide variety of diseases and pests, including insects, such as thrips, aphids, beetles and flies. In addition, they are also affected by fungi, viruses and vertebrates, such as mice and deer (UC IPM, 2014). Scarlet lily beetle (Japanese red lily beetle, *Lilioceris lili*) has been identified as an important horticultural and garden pest and other *Lilioceris* species which attack *Fritillaria* and *Lilium* (Phillips, 1996). Species of genus *Lilium* are food plants for the *Cosmia trapezina* moth. Tulips are affected by a fungus pest called *Botrytis tulipae* (Phillips, 1996; Garber, 1989).

2.5 Economic Importance

The family Liliaceae contain many members with economic importance. Notable among them are species of *Fritillaria*, *Lilium*, *Tulipa* and *Tricyrtis*. The members of the family Liliaceae (particularly, *Fritillaria cirrhosa*, *Lilium nepalense* and *Lilium wallichianum*) are also valued in Nepal as medicine and food (Ghimire *et al.*, 2008; Kunwar *et al.*, 2006). *Fritillaria cirrhosa* and *Lilium nepalense* are also traded from Nepal to overseas herbal

market. Considering their increasing exploitation for trade, Conservation Assessment Management Prioritization Workshop (CAMP) held in Nepal has listed *Fritillaria cirrhosa* and *Lilium nepalense* as threatened medicinal plants under threat categories ‘Vulnerable’ and ‘Data Deficient’, respectively (Tandon *et al.* 2001). Both of these species are also included in National Register of Medicinal Plants (IUCN, 2004).

Tulipa, *Fritillaria*, and *Lilium* of subfamily Liliaeae and *Tricyrtis* of subfamily Calochortoideae are grown as ornamental plants worldwide (Chen *et al.*, 2000). Within these genera, a wide range of cultivars have been developed by breeding and hybridisation.

Tulipa and *Lilium* also form a significant part of the cut flower market. They are generally used in outdoor gardens and other displays; even they are often induced to bloom indoors, particularly during the winter months (Majka and LeSage, 2008).

Bulb extracts of *Fritillaria* are used in traditional Chinese medicine under the name *chuan bei mu*. It is used for curing many types of cough, particularly chronic cough, cough associated with difficult expectoration, and cough with blood-streaked sputum. Its secondary use is as a lymphatic decongestant to reduce swellings, nodules, fibrocystic breasts, goiter, and swollen lymph glands. In China, it is also used for thyroid and lung cancer (Turner and Kuhnlein, 1983; Yeum *et al.*, 2007).

Bulbs of *Lilium* and *Fritillaria* and Leaves of *Clintonia* are used as food in china and other parts of Asia (Yanovsky, 1936; Turner and Kuhnlein, 1983).

The bulbs of some species are poisonous to household pets (bulb toxicosis) if eaten and may cause serious complications in household pets, such as renal failure in cats from Lilies, particularly *Lilium longiflorum* (Easter lily) (Volmer, 1999; Piirila *et al.*, 1999). Easter lily also causes IgE-Mediated asthma, and allergic diseases of the skin and mucosa (Piirila *et al.*, 1999).

CHAPTER 3

MATERIALS AND METHODS

3.1 Taxonomic Study

The present research is primarily based on study of herbarium specimens housed at different herbaria in the world, but more particularly from E (UK), TI (Japan), KATH and TUCH (both Nepal) (acronyms in accordance with Holmgren *et al.*, 1990). In the course of study, numerous collections were also made in different parts of Nepal. High resolution photographs were examined from E and scanned herbarium specimens of some species were also downloaded from Flora of Nepal Database TI.

All the available specimens of respective species were examined and their vegetative and reproductive morphological characters were recorded in an excel datasheet. The morphological characters were examined with the help of stereomicroscope and compound microscope. The dissected parts of herbarium studied were kept in small packet and attached in the respective herbarium sheets. Measurements of characters were mainly done on mature parts. The characters recorded during the morphological study were then compared and a set of characters which were unique and best described the species were chosen for the descriptions and also to produce dichotomous keys. The final descriptions were then checked and updated with all the available specimens.

Original author citations and synonyms of each taxon were included in the final description. In addition, altitudinal range, ecology, flowering and fruiting period and flower colour of the plants were noted from secondary information given in the herbarium sheet.

Lists of herbarium specimens examined were also included in chronological order for each developmental region of the country.

Free hand sketches were prepared for all the species based on herbarium specimens examined. The illustrations included habit sketch, floral parts as well as fruit parts if available. Photographs were taken as far as possible and were included wherever necessary. Distribution maps of all species were produced using ArcGIS Version 9.3, based on co-

ordinate points of collection localities. Exact localities of plant collections have been incorporated for each species.

3.2 Cluster analysis

Cluster analysis was performed based on gross morphological (vegetative and reproductive) characters to find maximum similarity among the species. In total, 19 vegetative and reproductive characters were used to perform cluster analysis for 19 species of Liliaceae *s.s.* The characters were chosen based upon their consistency traced in the study. Both two-state and multi-state codings were done as per the requirement during analysis. Character coding followed Evans *et al.* (2000).

The characters were unordered and all had given equal weightage. The output of the cluster analysis was based on phenotypic similarity and obtained in the form of dendrogram. Hierarchical cluster analysis was done using Statistical Software SPSS 16.0 for windows. For clustering method, nearest neighbor option was used (Evans *et al.*, 2000; Gajurel, 2008).

3.3 Phenology

Phenology is the study of periodic events in the life cycle of plant and animal. In particular, it is the periodic behaviour of the plant species in response to changing climatic condition, as well as habitat factors. In this study, flowering and fruiting phenological events were considered based on herbarium record. Different life cycle events of plant are very sensitive to small variations in climate, especially to temperature. Phenological records can be a useful proxy for predicting temperature variations.

3.4 Species Distribution Modeling

3.4.1 Data sources: climatic and species data

Locality records (in total, 218) for 19 enumerated species (classified into 3 subfamilies *viz.*, Lilioideae, Streptopoideae, Calochortoideae) of family Liliaceae were used for distribution modeling. These locality records were obtained from the herbarium specimens housed at

different herbaria (KATH, TUCH, TI and E). A set of 19 climatic variables for Nepal (Appendix 1) were extracted from WORLDCLIM (<http://www.worldclim.org/>) (Hijmans *et al.*, 2005). WORLDCLIM contains climatic data at a spatial resolution of 2.5 arc sec (~5 Km²) obtained by interpolation of climatic station records from 1950-2000. The variables were derived from monthly precipitation and maximum and minimum temperature.

3.4.2 Data cleaning

The initial record of presence points were 355, after removing the multiple collections record. The presence points were georeferenced using ArcGIS 9.3 and duplicate records were removed within each 2 min grid cell (separately for species of 3 subfamilies) to obtain least spatial autocorrelation. Finally, 164 collection points for subfamily Lilioideae (16 species), 42 for Streptopoideae (2 species) and 12 for Calochortoideae (single species) were obtained.

3.4.3 Distribution modeling

Ecological and biogeographical studies in which the present distribution of organism is analyzed with regard to the characteristics of the physical environment, involving modeling and predictions of distributions have been carried out for many types of organism, especially with the application of DIVA-GIS (e.g., Guisan and Zimmerman, 2000; Elith *et al.*, 2006; Delanoy and Damme, 2006; Hijmans and Graham, 2006; Parthasarathy *et al.*, 2006; Zafra-Calvo *et al.*, 2010; Hou *et al.*, 2010; Rajbhandary *et al.*, 2010; Barman *et al.*, 2011; Babar *et al.*, 2012). Species distributions can be modeled better using geographical co-ordinates and climatic variables as an explanatory variable (Bahn and McGill, 2007). In this study BIOCLIM model of DIVA-GIS 7.5 (a free Geographic Information System) was used for distribution modeling of 3 subfamilies (comprising 19 species) of Liliaceae using 19 climatic variables derived from WORLDCLIM.

BIOCLIM uses presence only data for distribution modeling. It attempts to identify suitable and unsuitable areas or niches in which the organism is likely to occur, or could survive if it was introduced, based on climatic features of the data point locations. This model was implemented using the WORLDCLIM 2.5 arc min resolution database of 19 bioclimatic variables. BIOCLIM predicts suitability areas only in the neighbourhood of occurrence records.

The environmental suitability for each species was ranked under five classes (Table 2). The places not suitable for the species were displayed in white. Areas with various classes of suitability for the species were shown from dark green to red color.

The dark green color means lower suitability (0-2.5 percentile) while red (20-30 percentile) indicates place with higher suitability of species present occurrence.

For each grid cell of the map, percentile value is assigned, which range from zero (low) to the theoretical maximum of 50 (very high). Locations where the values lie within the 2.5-30 percentile of the climate envelope are traditionally classified as ‘core’ regions of species occurrence. Excellent distribution of species belonging to subfamilies is shown by the region with 20-30 percentiles.

Table 2. Species richness classes with suitability value.

Color	Class	Suitability (Percentile)
	Not suitable	>0
	Low	0-2.5
	Medium	2.5-5
	High	5-10
	Very high	10-20
	Excellent	20-30

3.4.4 Species richness

Richness gradient in Nepal for the family Liliaceae was estimated by overlaying the overall potential range map predicted by BIOCLIM in DIVA-GIS 7.5. For this purpose, neighborhood option with 9×9 neighborhood size was selected. Estimated richness of species was then interpreted on the basis of vegetation type in Nepal. Number of species occurring in any habitat not only depends on the climatic variables, but also on local ecological conditions as defined by the composition of dominant vegetation. Thus, to find the pattern of species richness in various vegetation types, species richness map was overlaid by the GIS layer of ecology.

CHAPTER 4

RESULTS

4.1 Range of Morphological Characters in the Family Liliaceae

4.1.1 Habit and habitat

The members of the family Liliaceae are characterized as perennial, herbaceous, bulbous (*Fritillaria*, *Gagea*, *Lilium*, *Lloydia*, *Notholirion*) or rhizomatous (*Streptopus*, *Tricyrtis*, *Clintonia*) geophytes. Plant height ranges from c. 2 cm (*Lloydia serotina* var. *parva*) to upto 3.5 m (*Cardiocrinum giganteum*) tall. They are mostly erect, but sometimes sub-erect.

4.1.2 Bulb and rhizome

Most taxa of the family are characterized by bulbs (*Cardiocrinum*, *Fritillaria*, *Gagea*, *Lilium*, *Lloydia*, *Notholirion*) and some with tuberous rhizome (*Streptopus*, *Tricyrtis*, *Clintonia*). Bulbs may be covered with tunics (*Fritillaria*, *Lloydia*, *Notholirion*) or naked (*Lilium*). In *Notholirion*, bulb bears many bulbils (Fig. 2).

4.1.3 Stem or erect shoot

Stem is mostly in the form of erect or sub-erect leafy shoot (*Lilium*, *Fritillaria*, *Notholirion*, *Streptopus*). Stem is reduced in some taxa (*Clintonia*). Stem is branched (*Streptopus simplex*) or unbranched (*Lloydia*, *Lilium*, *Fritillaria*, *Gagea*).

4.1.4 Leaves

Leaves are simple, entire, linear (*Fritillaria*, *Notholirion*, *Gagea*), linear-lanceolate (*Lilium*), oval (*Cardiocrinum*) to filiform (*Lloydia*) (Fig. 3); mostly parallel veined, but occasionally net veined (*Cardiocrinum*). Leaves are arranged alternately or spirally, but sometimes are in whorl (3 or more attached at one node, e.g. *Lilium*, *Fritillaria*), sheathed in basal rosette (*Clintonia*) or cauline. Mostly, the leaves are sessile (*Streptopus*, *Tricyrtis*, *Notholirion*,

Fritillaria), but sometimes petiolate (*Cardiocrinum*, *Clintonia*). Some taxa are characterized by cordate leaf base (*Cardiocrinum*, *Streptopus* and *Tricyrtis*).

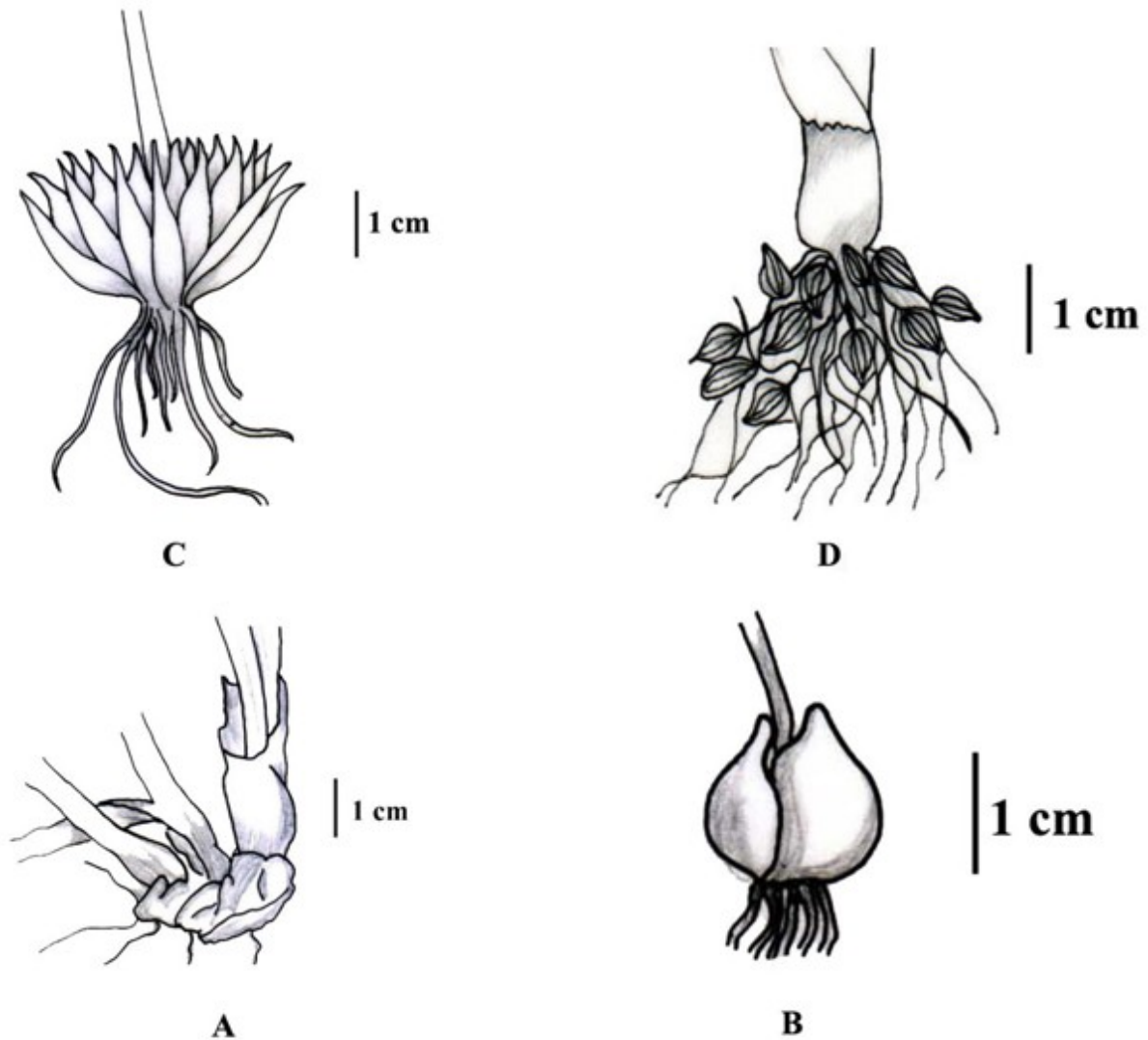


Fig. 2 Types of modified stem in Liliaceae: **A.** Rhizome (*Clintonia udensis*); **B.** Bulb with tunics (*Fritillaria cirrhosa*); **C.** Bulbs without tunics (*Lilium nanum*); **D.** Bulbils (*Notholirion bulbuliferum*).

4.1.5 Inflorescence

In some taxa of the family, flowers are solitary, terminal or axillary (*Fritillaria cirrhosa*, *Lilium nanum*, *L. wallichianum*, *L. oxypetalum*, *Lloydia delicatula*, *L. yunnanensis*, *Streptopus parasimplex* and *S. simplex*); in others, flowers are 2-many in number and aggregated in racemes (as in *Cardiocrinum giganteum*, *Lloydia flavonutans*, *L. longiscapa*,

Notholirion spp. and *Tricyrtis maculata*) or in umbels (*Clintonia*) (Fig. 4). Some taxa are characterized by leafless scape (*Clintonia*, *Gagea* and *Lloydia*).

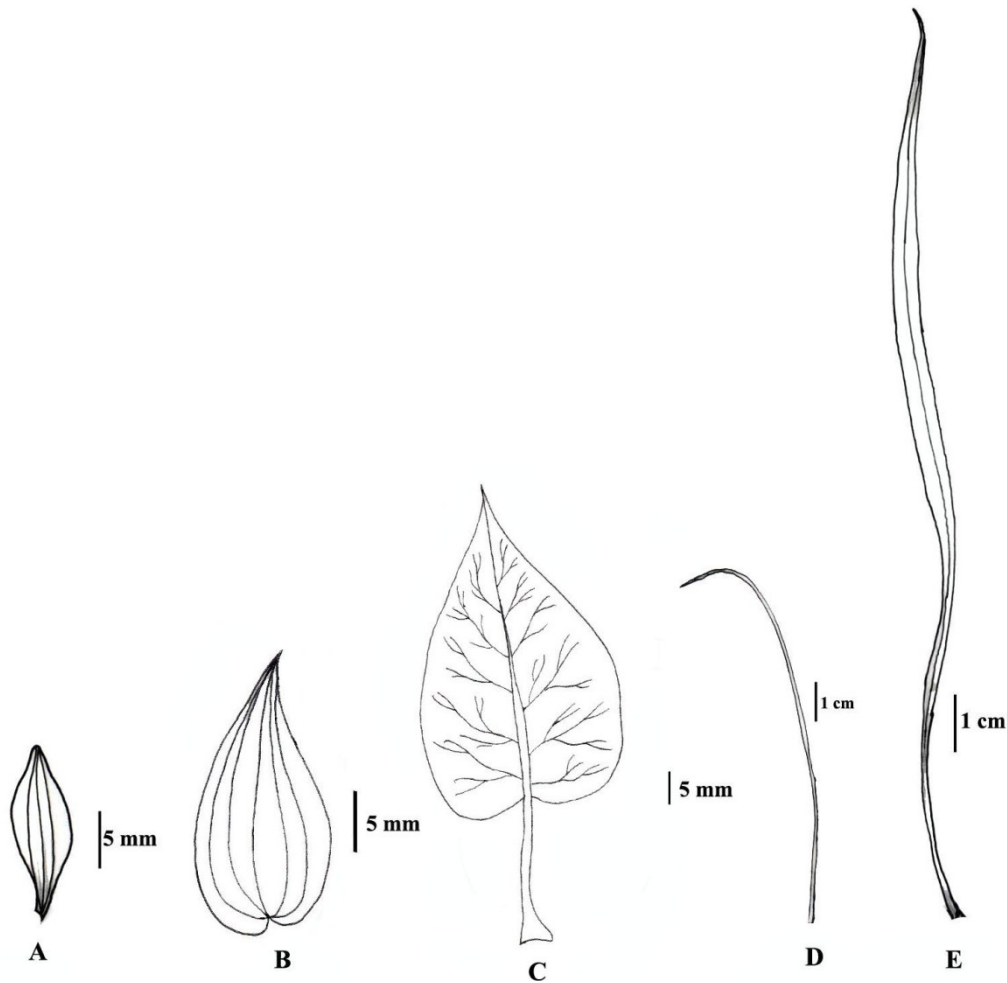


Fig. 3 Types of leaves in Liliaceae: **A.** Lanceolate (*Lilium nepalense*); **B.** Oblanceolate (*Streptopus simplex*); **C.** Ovate (*Cardiocrinum giganteum*); **D.** Filiform or linear (*Lloydia longiscapa*); **E.** Linear lanceolate (*Gagea elegans*).

4.1.6 Flower

The flowers are hermaphroditic, actinomorphic (*Lloydia*) or weakly zygomorphic (*Lilium*), trimerous. Bracts may or may not be present; if present are leaf-like as in *Lilium*, or filiform as in *Lloydia*. Flower size varies from c. 6 mm (*Lloydia serotina* var. *parva*) to upto 20 cm (*Lilium nepalense* and *L. wallichianum*). Flowers are variously coloured.



Fig. 4 Types of inflorescence in Liliaceae: **A.** Single solitary or axillary flower (*Lilium nanum*); **B.** Racemose (*Notholirion macrophyllum*); **C.** Umbellate (*Clintonia udensis*).

4.1.7 Perianth

The perianth is undifferentiated and biseriate, formed from six tepals arranged into two separate whorls of three parts. The tepals are petaloid with striations or markings in other colours or shades. Perianth is either homochlamydeous (all tepals equal, *Clintonia* and *Gagea*) or dichlamydeous (two separate and different whorls, *Cardicrinum*, *Fritillaria*, *Lilium*, *Lloydia*, *Streptopus* and *Tricyrtis*). Usually, nectar is produced in perigonal nectarines at the base of tepals (*Fritillaria*, *Lilium* and *Lloydia*).

4.1.8 Androecium

Stamens occur in two trimerous whorls, with free filaments; usually filaments are epiphyllous and diplastemonous; with (*L. flavonutans*, *L. longiscapa* and *Lloydia tibetica*) or without

(other than above three species) hairs. The attachment of the anthers to the filament may be either (pseudo-)basifixed (*Fritillaria*, *Gagea*, *Lloydia* and *Streptopus*) or dorsifixed (*Lilium*, *Notholirion* and *Tricyrtis*) (Fig. 5).

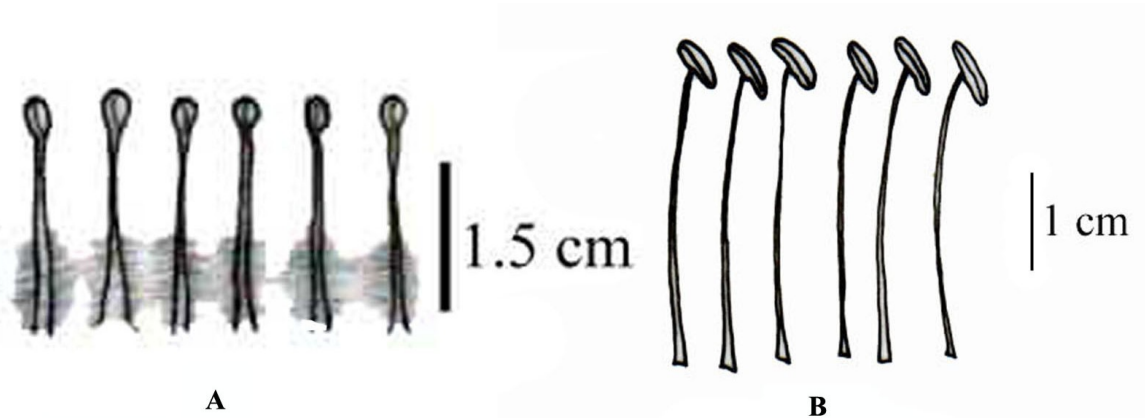


Fig. 5 Types of stamens in Liliaceae: **A.** Stamens with hairy filaments (*Lloydia longiscapa*); **B.** Stamens with glabrous filaments (*Notholirion macrophyllum*).

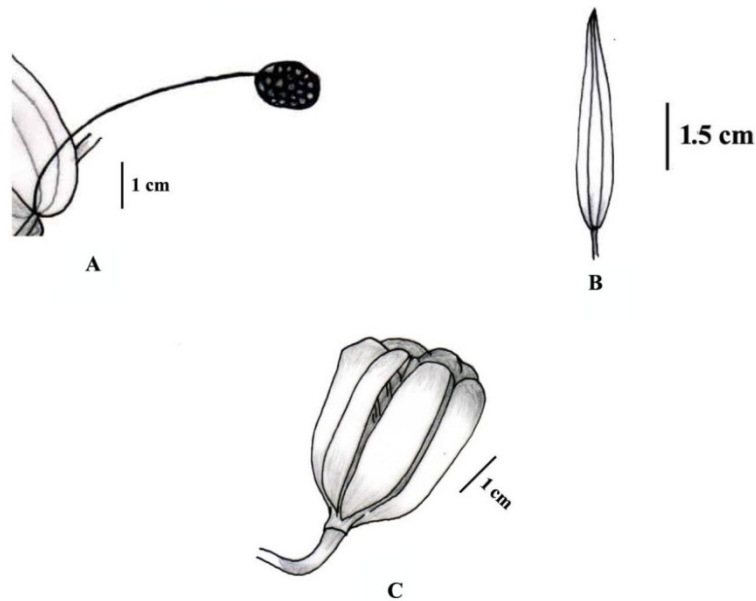


Fig. 6 Types of fruits in Liliaceae: **A.** Berry (*Streptopus simplex*); **B.** Septicidal capsule (*Tricyrtis maculata*); **C.** Loculicidal capsule (*Lilium nepalense*).

4.1.9 Gynoecium

Gynoecium is 3 carpelled, syncarpous. Ovary is superior and trilocular in all taxa; whereas, shape varies from ellipsoid (*Clintonia*), ovoid (*Streptopus*) to cylindric (*Cardiocrinum*, *Lilium*, *Notholirion*). Style is single, with 3-lobed or capitate stigma.

4.1.10 Fruit and seed

Mostly, the fruit type (Fig. 6) among the members is loculicidal capsule (*Cardiocrinum*, *Gagea*, *Fritillaria*, *Lloydia*, *Lilium*, *Notholirion*), but occasionally septicidal (*Tricyrtis*), and some produce berries (*Clintonia*, *Streptopus*). The seeds may be flat, discoid (*Fritillaria*, *Lilium*, *Notholirion*), oblong-elliptic (*Tricyrtis*), narrowly ovate (*Lloydia*), reniform (*Cardiocrinum*), ellipsoid or globose (*Clintonia*, *Streptopus*); and with (*Cardiocrinum*, *Fritillaria*, *Lilium*, *Lloydia*) or without (*Clintonia*, *Gagea*, *Notholirion*, *Streptopus*) wings.

4.2 Taxonomic Treatment

LILIACEAE Jussieu

Herbs perennial, with a rhizome, bulb or corm. Leaves basal and/or cauline, alternate, opposite or whorled, parallel or rarely reticulate veined. Inflorescence a raceme, spike, umbel, reduced panicle or flowers solitary. Flowers bisexual, actinomorphic, rarely zygomorphic; bracts present or absent; bracteoles present or absent. Perianth petaloid, 6-merous, in 2 whorls; tepals free or united. Stamens 6, rarely 3, free or adnate to perianth, anthers usually 2-loculed, basifixed or dorsifixed and versatile, introrse or extrorse. Carpels usually connate for most or all of their length, ovary superior, usually 3-loculed rarely 1-loculed. Nectaries present or absent. Fruit a capsule or berry.

Worldwide about 15 genera and nearly 600 species, occurring mostly in temperate and subtropical regions. Only 11 genera and 24 species in Nepal (based on APG system).

Note: In the present study, *Lilium bakerianum*, *L. sherriffiae* and *Notholirion thomsonianum* were excluded due to lack of specimens in herbaria. These species have been reported from eastern region of Nepal only. *Tulipa* is an exotic genus and its varieties are cultivated as ornament, therefore it was also excluded from the study. Single species of genus *Nomocharis* (*N. nana*) has been treated as synonym of *Lilium nanum*. Only 19 species have been studied in detail with 2 forma and 2 varieties.

Key to subfamily

- 1. a. Flowers terminal; fruit cluster of berries on leafless scape or a capsule.....2
- b. Flowers axillary; fruit a berry occurring singly on leafy stem.....**II.Streptopoideae**
- 2. a. Stem usually branched; fruit septicial capsule.....**III.Calochortoideae**
- b. Stem unbranched; fruit berries or loculicidal capsule.....**I.Lilioideae**

I. LILIOIDEAE Eaton

Herb perennial, bulbous (Lilieae) or rhizomatous (Medeoleae). Stem unbranched. Leaves simple, variously shaped, usually with parallel or reticulate (*Cardiocrinum*) venation. Inflorescence single flowered, many flowered raceme or umbel-like. Flowers usually large and showy, solitary or terminal, bracteate or ebracteate. Tepals 6, with nectaries at base. Stamens 6; anthers basifixed or dorsifixed. Ovary 3-loculed; style simple; stigma shortly lobed. Fruit a loculicidal capsule or a berry.

Key to tribe

- Plant bulbous; fruit a loculicidal capsule.....**A. Lilieae**
- Plant rhizomatous; fruit berries.....**B. Medeoleae**

A. LILIEAE Ritgen

Synonymy: **Erythroniaceae** Martynov, **Fritillariaceae** R.A. Salisbury, **Liriaceae** Borkhausen, **Tulipaceae** Borkhausen

Herb perennial, bulbous. Stem unbranched. Leaves simple, arranged alternately, linear to lanceolate, sometimes ovate, usually parallel venation, or sometimes reticulate venation sessile or petiolate. Inflorescence single flowered, or many flowered raceme. Flowers usually large and showy, solitary or terminal, bracteate or ebracteate. Tepals 6, with nectaries at base. Stamens 6; anthers basifixed or dorsifixed. Ovary 3-loculed; style simple; stigma shortly lobed. Fruit a loculicidal capsule. Seeds flattened.

Worldwide eight species. Six native genera and one exotic genus (*Tulipa*) are found in Nepal.

Key to genera

1. a. Flowers borne on leafless scape; leaves basal only, filiform.....2
 b. Flowers borne on leafy stem; leaves linear to lanceolate or ovate.....3
2. a. Inflorescence a single flower, or a few flowered raceme; flower drooping.....
 5. **Lloydia**
 b. Inflorescence a single flowered or many flowered umbel; flower erect.....3. **Gagea**
3. a. Leaves petiolate, blade ovate, reticulate venation.....1. **Cardiocrinum**
 b. Leaves sessile, blade linear to lanceolate, parallel venation.....4
4. a. Leaf apex cirrhose.....2. **Fritillaria**
 b. Leaf apex blunt or subacute.....5
5. a. Bulb covered with tunics; bulbils many; seeds wingless.....6. **Notholirion**
 b. Bulb not covered with tunics; bulbils absent; seeds winged.....4. **Lilium**

1. **Cardiocrinum** Lindl., Veg. Kingd. 205 (1846)

Herb perennial, bulb with scales. Stem leafy, erect, simple. Leaves simple, entire, petiolate, ovate, base cordate, veins dichotomously branched. Inflorescence many flowered raceme. Flower drooping, tubular-funnelform, white or pinkish with purplish or reddish veins, complete, actinomorphic, bracteolate. Tepals 6, free. Stamens 6; filaments flat; anthers dorsifixed. Ovary cylindrical; style elongate; stigma slightly 3-lobed. Fruit a capsule.

Worldwide three species. One species in Nepal.

Cardiocrinum giganteum (Wall.) Makino., Bot. Mag. (Tokyo) **27**: 125 (1913); Hooker in Fl. Brit. Ind. **6**: 349 (1896); Hara in Fl. E. Himal. 406 (1966); Hara in Enum. Fl. Pl. Nep. **1**: 71 (1978); Noltie in Fl. Bhutan **3** (1): 104–105 (1994); Press *et al.* in Ann. Check. Fl. Pl. Nep. 184 (2000); Chen *et al.* in Fl. China **24**: 62–63 (2000); Rajbhandari in Cat. Nep. Fl. Pl. **1**: 16–29 (2010) (Fig. 7).

Basionym: *Lilium giganteum* Wall.

Type specimen: Kathmandu, Napalia (Sheopore), *Wallich* 5075, Oct 1821. **Syntype:** BM, K-W.

Bulb scaly upto 10 cm diameter. Stem with purple streaks, 0.9 m to 1.5 m tall, fistular, 3.8-10 cm in diameter at base. Basal leaves in rosette, ovate, acuminate, deeply cordate at base, stem leaves more acuminate, less cordate, 30-45 × 20-25 cm, veins dichotomously branched, margin entire; petiole 20-30 cm. Inflorescence many flowered raceme; pedicels short, 0.7-1 cm; bracteoles 18.5 × 2.5 cm. Flowers white or pinkish with purple or reddish veins, drooping or horizontal, tubular. Tepals narrowly oblanceolate, 12-14 × 2-3.5 cm, inner slightly broader than outer. Filaments 4.5-9 cm; anthers 4-8 cm. Ovary cylindrical, 2.2-3.4 cm, style 3-5 cm; stigma 3-lobed, short, rounded. Capsule oblong, 5-5.5 × 2-3.5 cm. Seeds reniform, winged.

Distribution range: Nepal (Fig. 8), W Himalaya, E Himalaya, Tibetan Plateau, Assam-Burma, E Asia.

Altitude: 1200–3650 m.

Ecology: Coniferous, broad-leaved or mixed forests, hillsides, wet and shady places under dense forest canopy, sometimes found on open or exposed slope.

Flowering: May–July.

Fruiting: July–October.

Specimens examined

Western Nepal: Humla, on way to Darma, 7890 ft, 9th July 1968, Dr. Malla, 14185 (KATH). Parbat, Ulleri–Nayathanti, 2600 m, 21st July 1974, Joshi and Bhattacharya, 74/1831 (KATH); Banthanti–Gorepani Deorali, 2650–3170 m, 12th July 1983, H. Obha, H. Kanai, M. Wakabayashi, M. Suzuki and S. Akiyama, 8330361 (E). **Central Nepal:** Lalitpur, Phulckoki, 2743 m, 3rd July 1986, 10574 (KATH). **Sindhupalchok,** Melamchi, 2500 m, 16th June 1986, N.K. Bhattarai, 86/371 (KATH). **Eastern Nepal:** Solukhumbu, Kharikhola–Copra–Pangonba, 1960–2710 m, 28th July 1995, F. Miyamoto, M. Ikeda, C.M. Joshi, K. Arai and T. Kamatsu, 9592129 (KATH). **Sankhuwasabha,** Namche Kharka, 2280 m, 10th June 1994, P.R. Sharma and K.K. Dangol, 10049 (KATH). **Taplejung,** Syamba–Manabhara (Deurali 1)–Manabhara (Deurali 2)–Bhirkuna, 1610–2570–2600–1980 m, 20th May 1992, M. Suzuki, K.R. Rajbhandari, S. Noshiro, S. Akiyama, H. Koba and N. Acharya, 9240222 (TI); Angikhola, 2300 m, 12th June 1998, M. Suzuki, K.R. Rajbhandari, S. Noshiro, S. Akiyama, H. Koba and N. Acharya, 9255639 (KATH) (see Appendix 2 for more details).

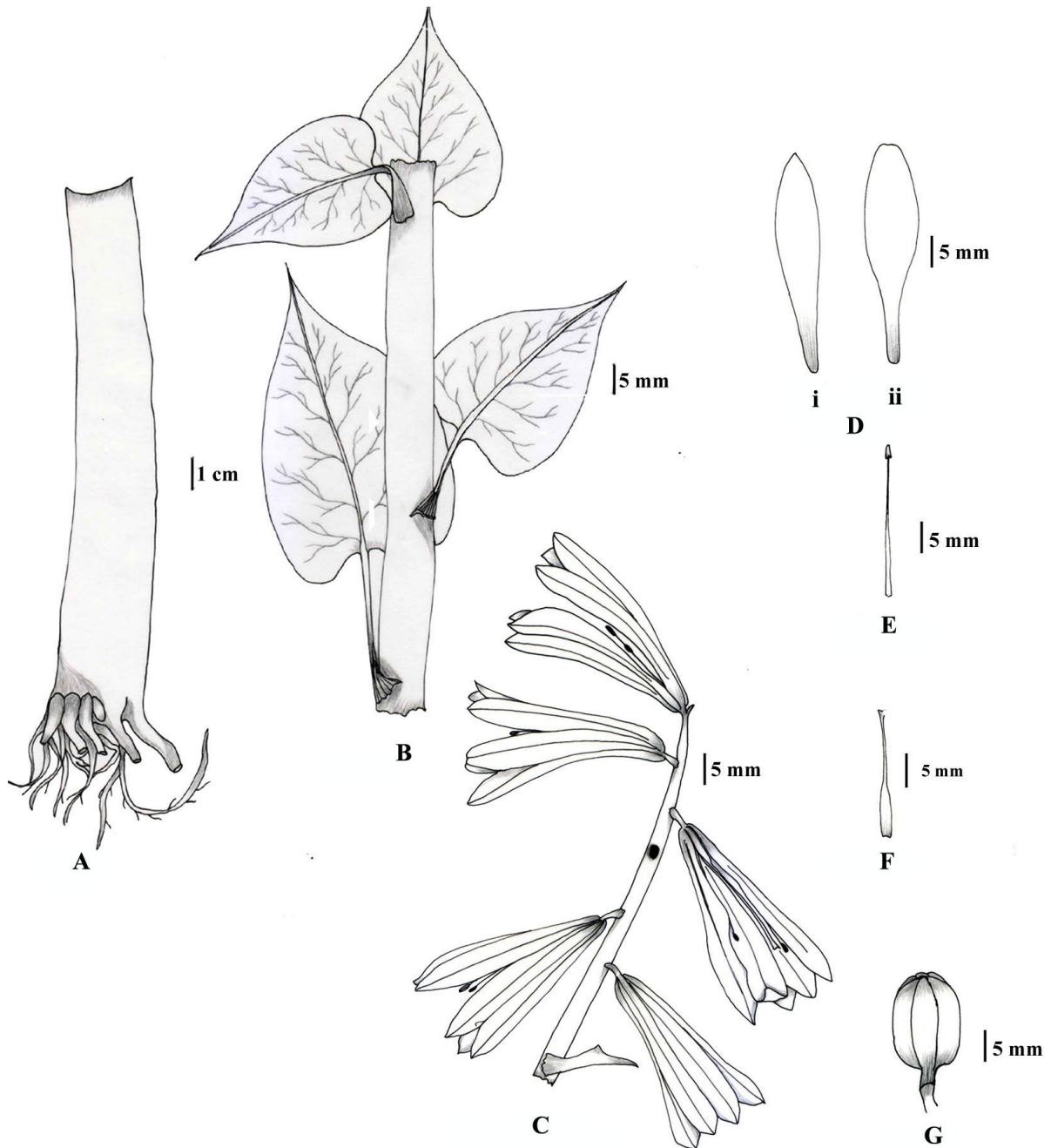


Fig. 7 *Cardiocrinum giganteum* (Wall.) Makino; **A.** Stem (based on M. Bakabayashi, M. Amano, M. Mori, K.R. Rajbhandari and K. Shinozaki, 97/30392 KATH); **B.** Leafy twig (based on F. Miyamoto, M. Ikeda, C.M. Joshi, K. Arai and T. Kamatsu, 9592129 KATH); **C.** Flowering twig (based on M. Suzuki, K.R. Rajbhandari, S. Noshiro, S. Akiyama, H. Koba and N. Acharya, 9255639 KATH); **D.** Tepals: i) Outer and ii) Inner, **E.** Stamens and **F.** Carpel (based on Noshiro, S. Akiyama and N. Acharya, 9240787 KATH); **G.** Fruit (based on M. Bakabayashi, M. Amano, M. Mori, K.R. Rajbhandari and K. Shinozaki, 97/30392 KATH).

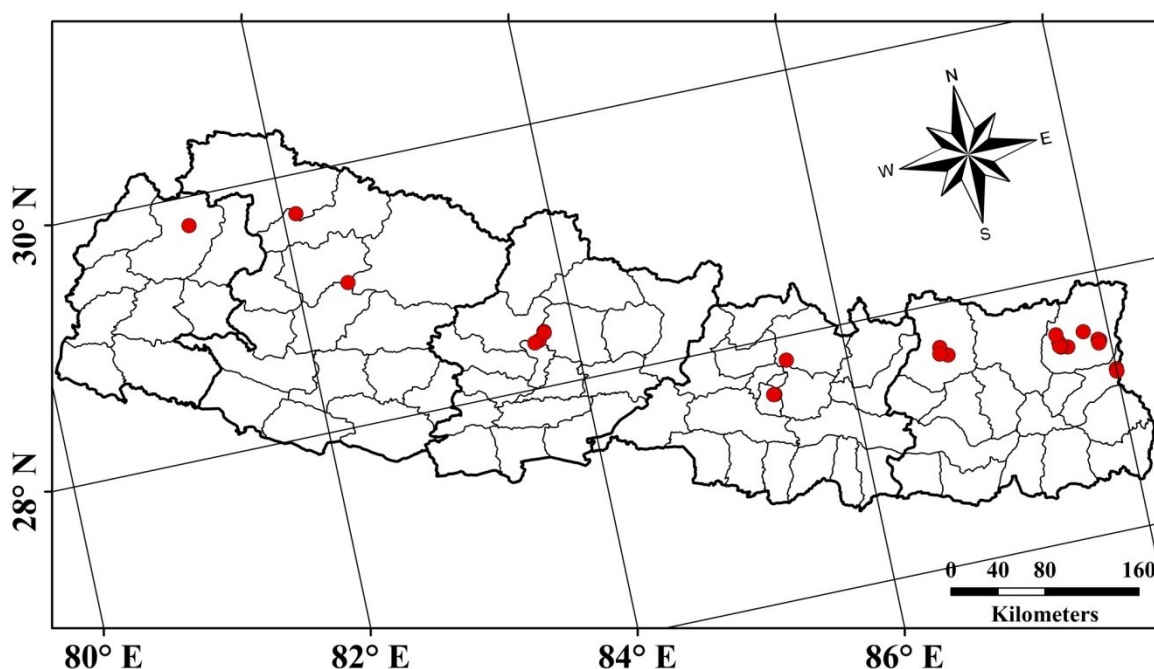


Fig.8. Distribution of *Cardiocrinum giganteum* in Nepal based on herbarium record.

2. *Fritillaria* L., Sp. Pl. 1: 303 (1753)

Herb perennial, bulbiferous. Bulb usually of 2 very thick scales, sometimes 3 or more, covered with thin papery tunic. Stem leafy, erect, simple. Leaves opposite, spirally arranged or whorled, linear to lanceolate, apex sometimes cirrhose. Flower borne singly, drooping, campanulate often chequered with light and dark colours, complete, actinomorphic. Tepals 6, free, each with nectary adaxially. Stamens 6, inserted at base of tepals; anthers basifixed. Ovary cylindric; style short; stigma 3-lobed. Fruit capsule.

Worldwide about 130 species. One species in Nepal.

Fritillaria cirrhosa D. Don., Prodr. Fl. Nepal. 51 (1825); Hooker in Fl. Brit. Ind. 6: 353 (1896); Hara in Fl. E. Himal. 407 (1966); Hara in Enum. Fl. Pl. Nep. 1: 72 (1978); Noltie in Fl. Bhutan 3 (1): 107-108 (1994); Press *et al.* in Ann. Check. Fl. Pl. Nep.: 184 (2000); Chen *et al.* in Fl. China 24: 57 (2000); Rajbhandari in Cat. Nep. Fl. Pl. 1: 21 (2010) (Fig. 9).

Fritillaria cirrhosa var. *bonatii* (H. Léveillé) S.C. Chen; *F. cirrhosa* var. *viridiflava* S.C. Chen; *Lilium bonatii* H. Léveillé

Type specimen: Rasuwa, Gossain Than, Gardener (*in Herb Wallich*) s.n., Aug 1819.

Holotype: BM.

Bulb of 2 thick fleshy scales, 1.2-1.5 × 2 cm, covered with whitish papery tunics. Stem leafy, simple, erect, (8-)13-75 cm. Leaves opposite or in whorl of 3 or 4, linear to linear-lanceolate, 5-12 × 0.3-0.7(-1.5) cm, entire, apex cirrhose, lowest leaves broader, paired, blunt tipped. Inflorescence 1-3 flowered, subtended with leaf like bracts; pedicel, 1-3.5 cm. Flower drooping, yellowish green spotted with purple, campanulate. Tepals oblong-elliptic, inner wider than outer, inner 3-5.5 × 1.2-2.5 cm, outer 3-5.5 × 1.5-2.5 cm; basal nectaries present. Filaments 1.5-1.9 cm, anthers basifixed, 0.5-1 cm. Ovary cylindric, 5-8 mm long; style 1-1.2 cm; stigma 3-lobed. Capsule loculicidal, oblong, 1.3-1.8 × 1-1.2 cm. Seeds pear-shaped, narrowly winged.

Distribution range: Nepal (Fig. 10), E Himalaya, Tibetan Plateau, E Asia.

Altitude: 3000–4600 m.

Ecology: Coniferous forest, alpine scrub, meadows, moist places, rock crevices.

Flowering: May–August.

Fruiting: August–October.

Specimens examined

Western Nepal: *Darchula*, South of Dhuli, 10500 ft, 21st May 1965, T.B. Shrestha, 4137 (KATH). *Bajhang*, Near Khaptad, 9900 ft, 1st May 1965, T.B. Shrestha, 4054 (KATH). **Central Nepal:** *Gorkha*, Between Sama and Samdo, 3550 m, 2nd June 1983, P.R. Shakya, M.K. Adhikari and M.N. Subedi, 7716 (KATH); Uhiva VDC, 3640 m, 28th Sep 1994, Olsen, 221 (KATH). *Rasuwa*, Chandanbari–Lauribinayak, 2980 m, 11th July 2006, B.B. Kunwar, 332 (TUCH); Below Lauribinayak, 2900 m, 10th September 2013, H.K. Rana, RAS201 (TUCH). *Dolakha*, Near Na, 4000 m, 19th May 1979, N.P. Manandhar and M.K. Adhikari, 1637 (KATH). **Eastern Nepal:** *Solukhumbu*, Seto Pokhari–Chhomalang base camp, 4810–4495 m, 17th August 1995, F. Miyamoto, M. Amano, H. Ikeda, C.M. Joshi, K. Arai and T. Komatsu, 9584188 (KATH). *Sankhuwasabha*, Khongma (kauma)–Shipton Pass (Keke la)–Tutu La–Cha ding Kharka–Numbuk (Mumbuk), 3500–4120–3500 m, 17th July 1988, M. Suzuki, N. Naruhashi, S. Kurosaki, Y. Kadota, M.N. Subedi, M. Minaki, S. Noshiro and H. Ikeda, 88104465 (KATH). *Taplejung*, Topkegola–Chaun Kharka–Shinsade Kharka–Topkegola, 3590–3590 m, 16th May 1992, M. Suzuki, K.R. Rajbhandari, S. Noshiro, S. Akiyama, H. Koba and N. Acharya, 9262105 (KATH) (see Appendix 2 for more details).

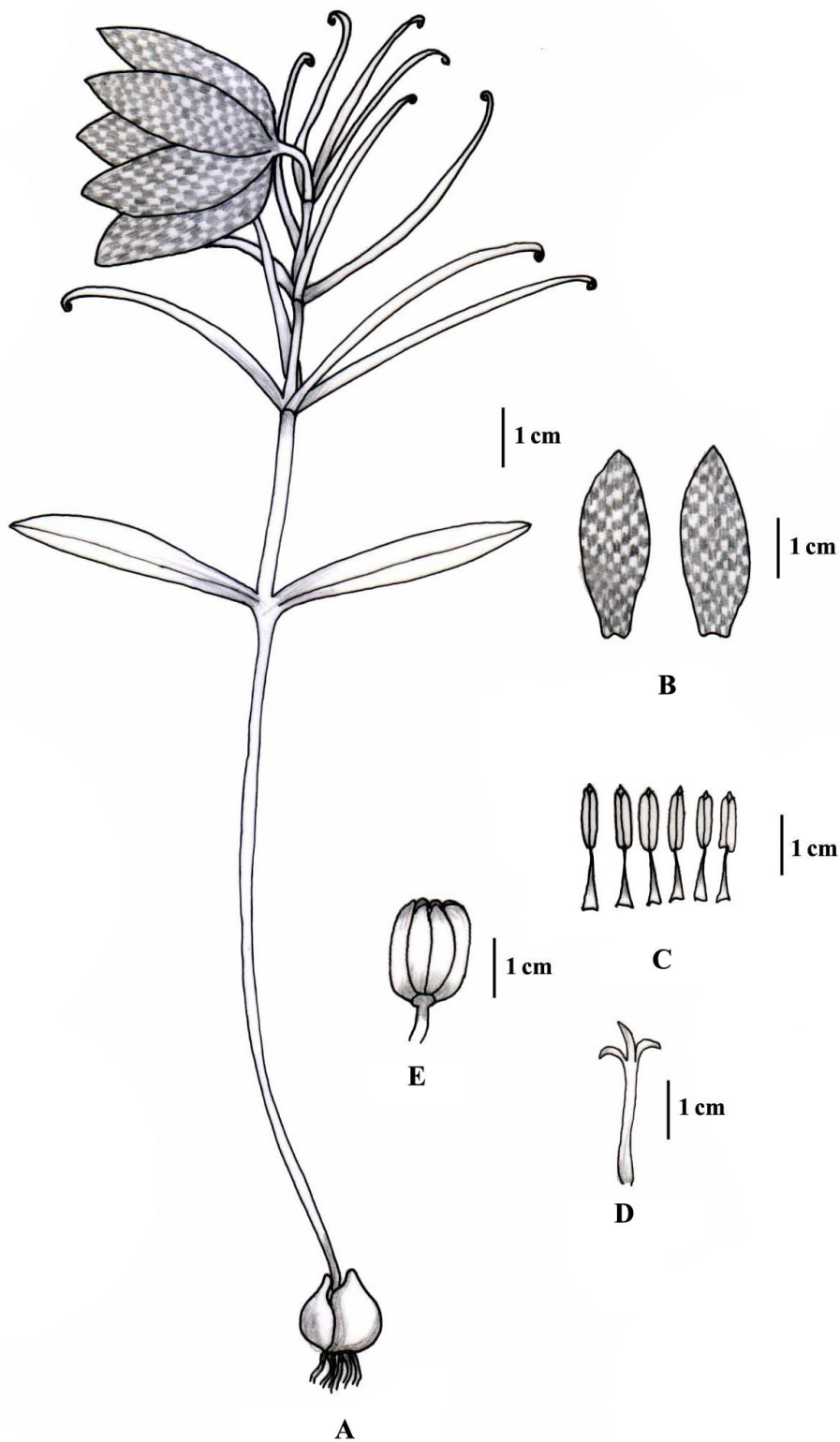


Fig. 9 *Fritillaria cirrhosa* D. Don; **A.** Habit sketch (based on T.B. Shrestha, 4137 KATH); **B.** Tepals: i) Outer and ii) Inner, **C.** Stamens and **D.** Carpel (based on T.B. Shrestha, 4054 KATH); **E.** Fruit (based on Olsen, 221 KATH).

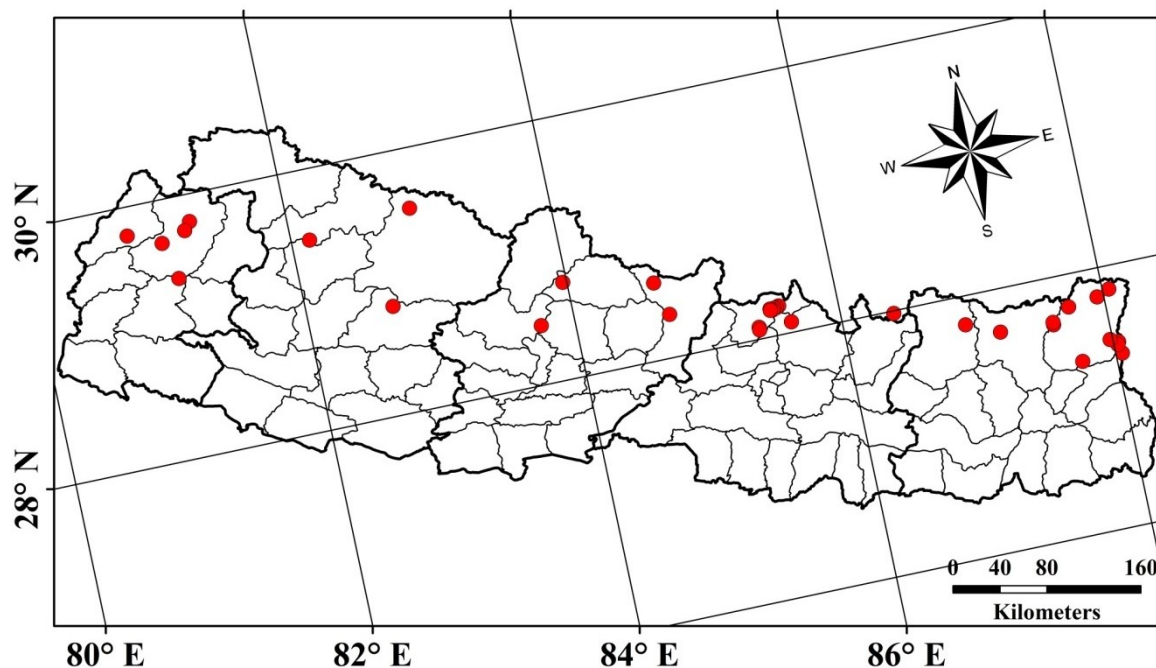


Fig.10 Distribution of *Fritillaria cirrhosa* in Nepal based on herbarium record.

3. *Gagea* Salisb., Ann. Bot. (König & Sims) 2: 555 (1806)

Herb perennial, bulbiferous. Bulb small ovoid or globose covered with tunics. Leaves basal, single, linear to linear-lanceolate. Inflorescence single flowered or many flowered umbel, subtended by a pair of unequal leaf-like bract. Flowers yellow or yellow green, complete, actinomorphic. Tepals 6, free. Stamens 6; filaments filiform; anthers basifixed. Ovary 3-loculed; style long; stigma capitate or 3 lobed. Fruit a capsule.

Worldwide about 90 species. Single species in Nepal.

Gagea elegans Wall. ex D. Don., in Royle, III. Bot. Himal. Mts. 2: t. 95, f. 2, (1833–1840); Hooker in Fl. Brit. Ind. 6: 355 (1896); Hara in Enum. Fl. Pl. Nep. 1: 72 (1978); Noltie in Fl. Bhutan 3 (1): 111 (1994); Press *et al.* in Ann. Check. Fl. Pl. Nep. 185 (2000); Rajbhandari in Cat. Nep. Fl. Pl. 1: 21 (2010) (Fig. 11).

G. lutea (L.) Ker Gawler; *Gagea coreana* Nakai; *G. coreanica* Koidzumi.

Bulb 0.5-1.2 × 0.6-1 cm, tunicate. Scape 5-15 cm, glabrous. Leaves basal, single, linear, 3-22 × 0.2-1 cm, entire, subacute apex. Inflorescence single flowered or 4 flowered umbel; bracts leaf-like, 2-5 × 0.2-1 cm; pedicel slender, 1.5-4 cm long. Flower erect, yellow, or yellow-

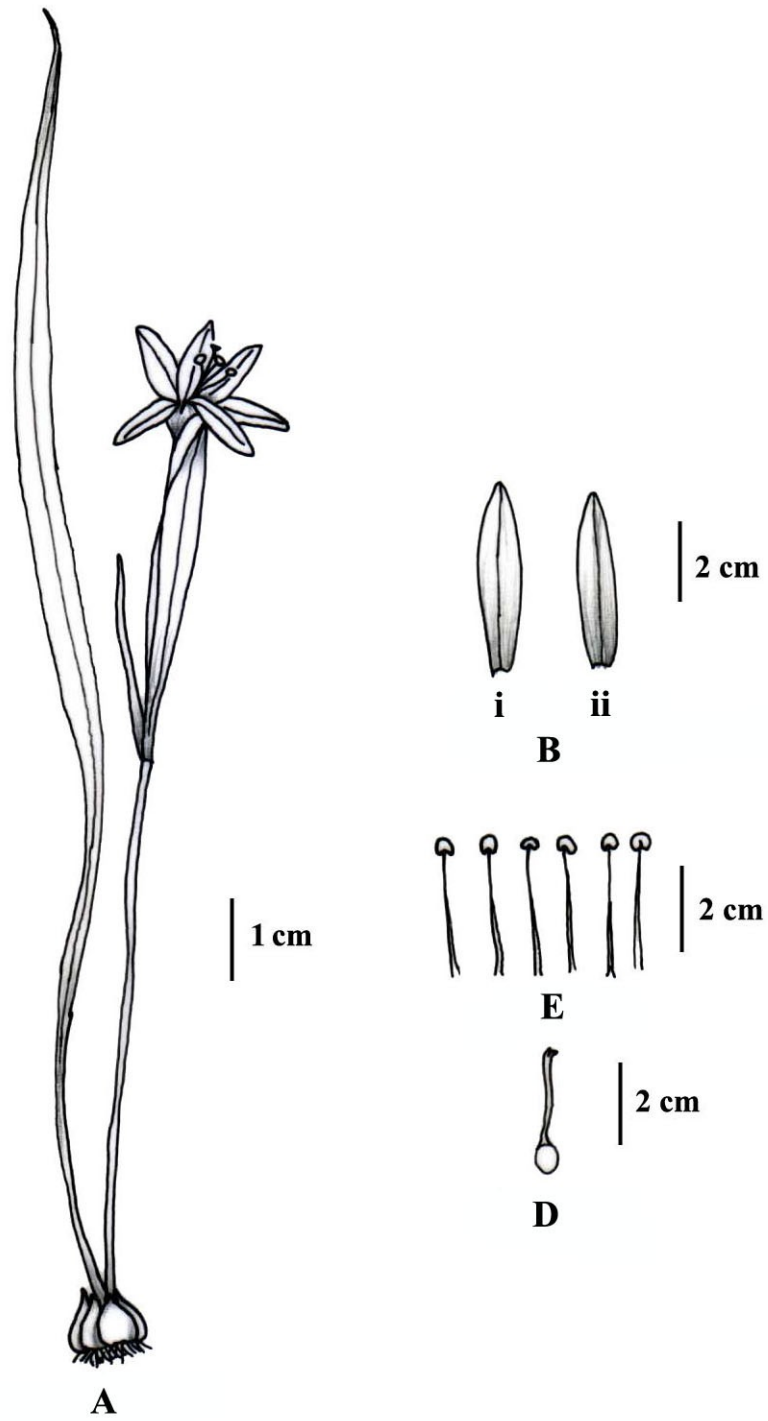


Fig.11 *Gagea elegans* (Wall.) ex D. Don; **A.** Habit sketch, **B.** Tepals, **C.** Stamens and **D.** Carpel (based on T.B. Shrestha, 4157 KATH).

green, star-shaped. Tepals oblong to obovate, 1-1.8 × 0.2-0.3 cm. Filaments 8 mm; anthers oblong, c. 1 mm, basifixed. Ovary obovoid, 3-loculed, c. 2 mm; style 5-6 mm; stigma 3-lobed. Capsule loculicidal, oblong. Seeds flat, wingless.

Distribution range: Nepal (Fig. 12), SW Asia, W Himalaya, E Himalaya, E Asia, N Asia.

Altitude: 2800–4300 m.

Ecology: Broadleaved forest, alpine thickets, pastures, rocky or grassy slopes.

Flowering: March–June.

Fruiting: May–July.

Specimens examined

Western Nepal: *Darchula*, Bramha Daha, Kawa Lekh, 3680 m, 18th May 1971, P.R. Shakya and D.P. Joshi, 550 (KATH). *Bajhang*, Near Dochand (N. of Dhuli), 11400 ft, 25th May 1965, T.B. Shrestha, 4157 (KATH). *Humla*, Dozam Khola, Near Simikot, 12000 ft, 31st May 1952, O. Polunin, W.R. Sykes and L.H.J. Williams, 4233 (E). *Jumla*, Between Padmara and Burma, Padmara Lagna, 11500 ft, 13th May 1952, O. Polunin, W.R. Sykes and L.H.J. Williams, 4065 (E). *Gorkha*, Between Samdo–Sama, 3650 m, 3rd June 1983, P.R. Sharma, M.K. Adhikari and M.N. Subedi, 7730 (KATH) (see Appendix 2 for more details).

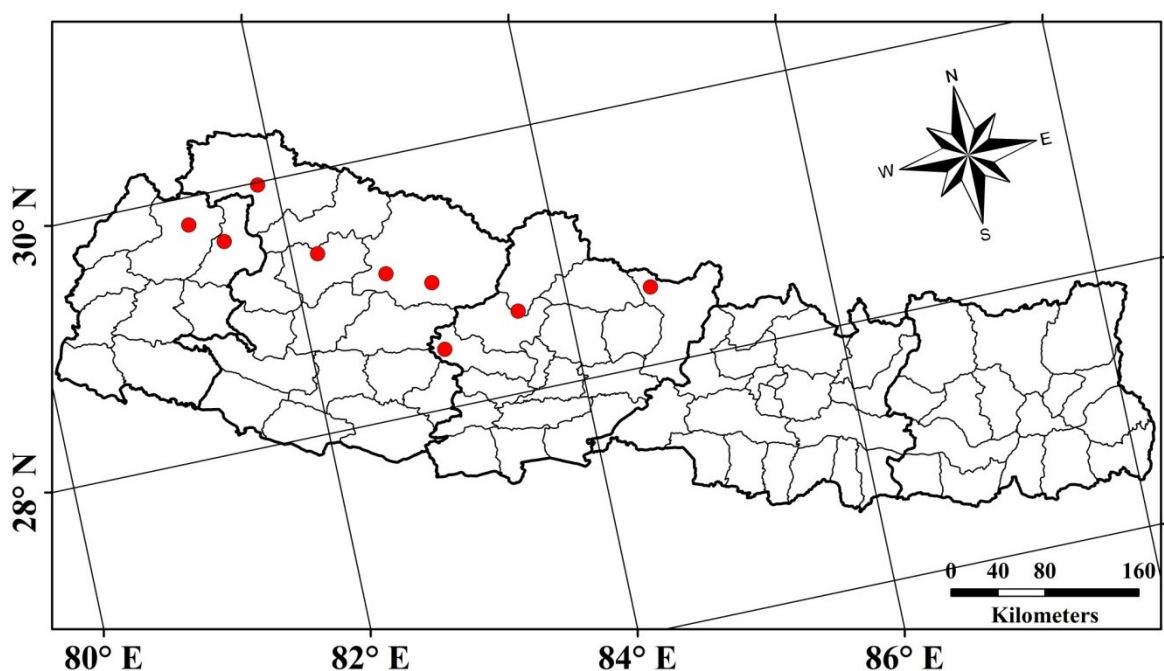


Fig. 12 Distribution of *Gagea elegans* in Nepal based on herbarium record.

4. *Lilium* L., Sp. Pl. 1: 302 (1753)

Herb perennial, bulbiferous. Bulb with many overlapping, fleshy scales. Stem erect, leafy. Leaves alternate, sometimes in whorl, sessile or shortly petiolated, usually linear to linear lanceolate. Inflorescence a terminal raceme, or a solitary flower, subtended by leaf-like bracts. Flowers funnel shaped or campanulate, white, yellow, greenish, purplish or reddish purple, complete, actinomorphic. Tepals 6, free, often reflexed, nectarines present near the base adaxially. Stamens 6; filaments subulate or filiform; anthers dorsifixed. Ovary 3-loculed; style elongate; stigma capitate, 3-lobed. Fruit a loculicidal capsule. Seeds many, flattened, densely stacked.

Worldwide about 115 species. Five species in Nepal.

Key to species

- 1.a. Flower small; tepals under 6 cm2
- b. Flower large; tepals over 6 cm3
- 2.a. Leaves linear; flowers bell shaped.....**L. nanum**
- b. Leaves elliptic lanceolate; flowers cup shaped.....**L. oxypetalum**
- 3.a. Leaves linear; flowers white with tubular base.....**L. wallichianum**
- b. Leaves oblong lanceolate; flowers yellowish- green, with funnel- shaped base.....
.....**L. nepalense**

Lilium nanum Klotzsch., in Klotzsch, Bot. Ergebn. ReiseWaldemar. 53 (1862); Hooker in Fl. Brit. Ind. 4: 352 (1896); Hara in Enum. Fl. Pl. Nep. 1: 73 (1978); Noltie in Fl. Bhutan 3 (1): 103-104 (1994); Press *et al.* in Ann. Check. Fl. Pl. Nep. 185 (2000); Chen *et al.* in Fl. China 24: 67 (2000); Rajbhandari and Maharjan in Cat. Nep. Fl. Pl. 1: 21-22 (2010) (Fig. 13).

Fritillaria gardneriana Wall. ex Baker; *Fritillaria stracheyi* Hook. f.; *Nomocharis nana* (Klotzsch) E.H. Wilson.

Basionym: *Nomocharis nana* (Klotzsch) E.H. Wilson

Type specimen: Chumbi, Dr. King's Collection 611, 29th July 1884. **Isosytype:** K.

Bulb 1.2-3 × 1-3 cm; scales oblong, c. 6 mm wide. Stem 10-30 cm. Leaves scattered, linear to linear lanceolate, 2.5-10 × 0.1-0.8 cm, apex blunt. Inflorescence a single flower; subtended with linear leaf-like bracts; pedicel 1-3 cm. Flowers drooping, reddish purple or mauve, white or

yellow, campanulate. Tepals elliptic, contracted at tip, inner slightly wider than outer, inner 1.2-3.2 × 0.6-1.5 cm, outer 1.2-3.2 × 0.4-1.2 cm; nectarines at base. Filaments 1-1.6 cm; anthers 3-4 mm, dorsifixed. Ovary cylindric, 9-12 × 3-5 mm; style 5-7 mm; stigma 3-lobed. Capsule pale yellow with purplish brown stripes on ribs, oblong, 0.8-1.6 × 0.8-1.4 cm. Seeds pear shaped, winged.

Distribution range: Nepal (Fig. 14), W Himalaya, E Himalaya, Assam-Burma, Tibetan Plateau, S Asia.

Altitude: 3400–4600 m.

Ecology: Forest margins, scrubs, grassy slopes, alpine grasslands.

Flowering: June–August.

Fruiting: August–September.

Key to forma

Flowers purple or mauve.....**L. nanum f. nanum**
Flowers whitish or yellowish.....**L. nanum f. flavidum**

Lilium nanum Klotzsch, in Klotzsch Bot. Ergebn. Reise Waldemar. 53 (1862) forma **nanum**; Hara in Enum. Fl. Pl. Nep. **1**: 73 (1978); Noltie in Fl. Bhutan **3** (1): 103 (1994); Press *et al.* in Ann. Check. Fl. Pl. Nep. 185 (2000); Chen *et al.* in Fl. China **24**: 67 (2000); Rajbhandari and Maharjan in Cat. Nep. Fl. Pl. **1**: 21-22 (2010).

Nomocharis nana (Klotzsch) E. H. Wilson.

Tepals reddish purple, pale yellow or mauve, with deep purple spots.

Distribution range: Nepal (Fig. 14), W Himalaya, E Himalaya, Assam-Burma, Tibetan Plateau.

Altitude: 3500–4500 m.

Ecology: Forest margins, thickets, grassy slopes.

Flowering: June–July.

Fruiting: July–August.

Specimens examined

Western Nepal: Dolpa, Jangla Bhanjyang, 3800 m, 19th June 1973, Einarsson, Skarby and Wetterhall, 599 (KATH). Kaski, Machapuchhre base camp, 3400 m, 28th June 2001, P.R. Shakya and S. Poudel,

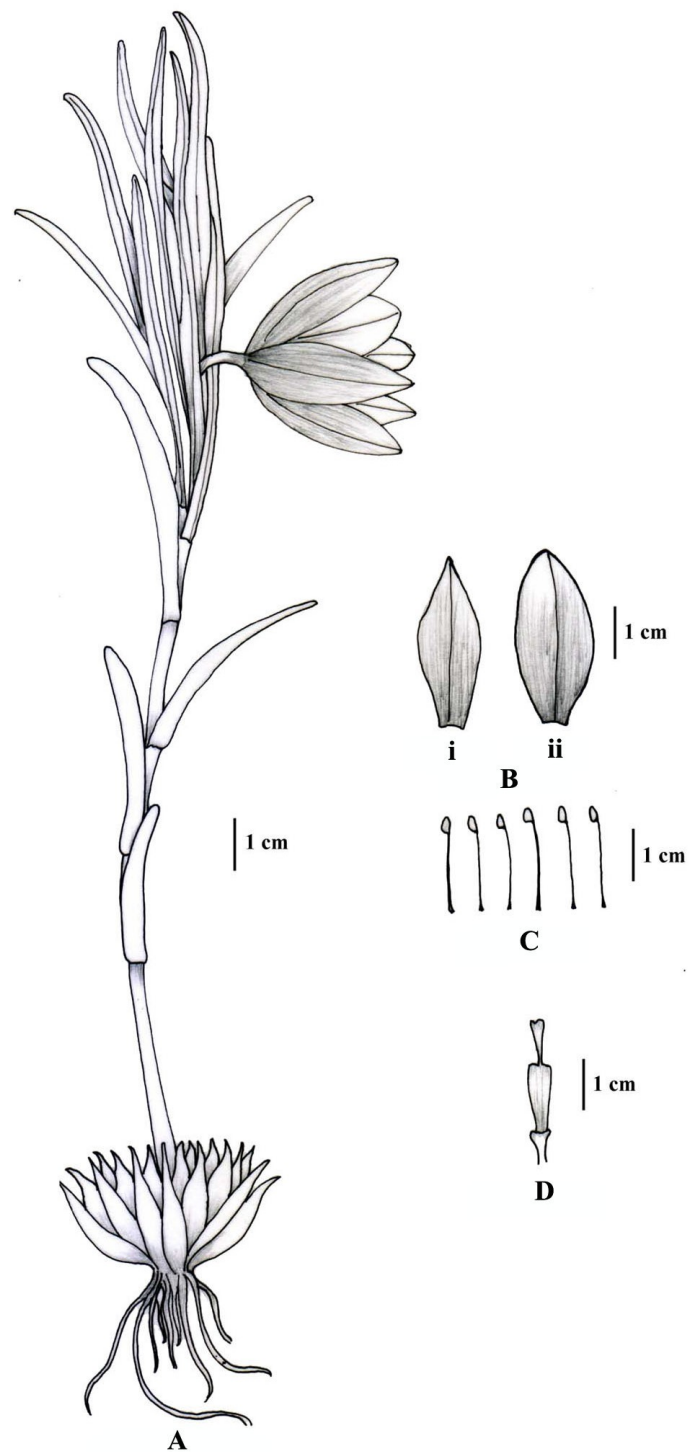


Fig. 13 *Lilium nanum* Klotzsch; **A.** Habit sketch, **B.** Tepals: i) Outer and ii) Inner, **C.** Stamens and **D.** Carpel (based on T.B. Shrestha, 15793 KATH).

10445 (KATH). *Gorkha*, Samdo: East of village on south side of Sanam Khola river valley, 4170 m, 9th August 2008, H. Ikeda, T. Kawahara, O. Yano, N. Yamamoto, M.F. Watson, Z.H. Li, M.N. Subedi and S.K. Acharya, 20817112 (E). **Central Nepal:** *Rasuwa*, Around Seto Kund, 3930 m, 9th August 1994, F. Miyamoto, K.R. Rajbhandari, S. Akiyama, M. Amano, H. Ikeda and Y. Tsukaya, 9420215 (KATH, E). **Eastern Nepal:** *Taplejung*, Mane Bhanjyang–Jaljala Pokhari, 3700 m, 8th August 1999, Y. Omori, N. Acharya, K. Fujikawa, M. Munemasa, M. Okada, R.H. Ree, M. Tateno and N. Thapa, 9920055 (KATH, E); Topke Gola–Jalang Ghyongo, 3600–4300 m, 20th August 1977, H. Obha, 772625 (TI); Lame khola, 13500 ft, 21st June 1969, T.B. Shrestha, 15793 (KATH) (see Appendix 2 for more details).

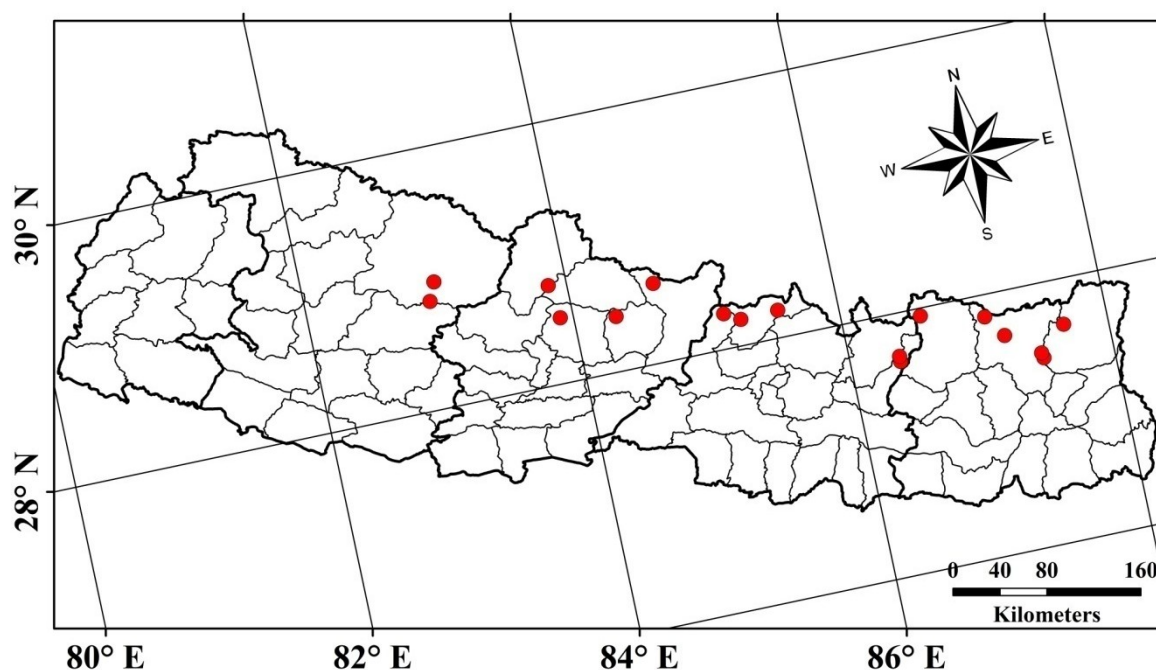


Fig. 14. Distribution of *Lilium nanum* in Nepal based on herbarium record.

Lilium nanum* forma *flavidum (Rendle) H. Hara., Fl. E. Himalaya. 132 (1975); Hara in Enum. Fl. Pl. Nep. **1**: 73 (1978); Noltie in Fl. Bhutan **3** (1): 104 (1994); Press *et al.* in Ann. Check. Fl. Pl. Nep. 185 (2000); Chen *et al.* in Fl. China **24**: 67 (2000); Rajbhandari and Maharjan in Cat. Nep. Fl. Pl. **1**: 22 (2010).

Fritillaria flavida Rendle; *Lilium euxanthum* (W.W. Smith & W.E. Evans) Sealy; *L. nanum* f. *flavidum* (Rendle) H. Hara; *Nomocharis euxantha* W.W. Smith & W.E. Evans.

Tepals creamy white with yellow, grey or brown streaks on the backside.

Distribution range: Nepal, E Himalaya, Assam-Burma.

Altitude: 3800–4300 m.

Ecology: Forest margins, alpine grasslands.

Flowering: June–August.

Fruiting: August–September.

Specimens examined

Western Nepal: Dolpa, Near Jangla Bhanjyang, 4268 m, 30th June 1952, O. Polunin, W.R. Sykes and H.J. Williams, 2344 (KATH). **Central Nepal:** Rasuwa, Kul kharka–Chilime, 3800–4100 m, 6th June 1970, Kanai and Shakya, 64235 (KATH). Ramechhap, Dubikharka–Gairi Kharka–Dhoben Kharka–Baula Pokhari, 3720–3850–4000–3960 m, 9th July 1985, H. Obha, T. Kikuchi, M. Wakabayashi, M. Suzuki, N. Kurosaki, K.R. Rajbhandari and S.K. Wu, 8530195 (KATH). **Eastern Nepal:** Solukhumbu, Chhule NE facing slope, 4681 m, 20th September 2005, M.F. Watson, K.R. Rajbhandari, K.K. Shrestha, D. Knott, C.A. Pendry, S.K. Acharya, U. Koirala, L.N. Manandhar, N. McCheyne, R.C. Poudel, S. Rajbhandari, and S. Vaidya, DNEP3 BY110 (KATH). Sankhuwasabha, Arun Valley, Kasuwa Khola, N of Num, 12500 ft, 5th June 1956, J.D.A. Stainton, 534 (KATH) (see Appendix 2 for more details).

Lilium nepalense D. Don., Mem. Wern. Nat. Hist. Soc. **3**: 412 (1821); Hook in Fl. Brit. Ind. **4**: 350-351 (1896); Hara in Fl. E. Himal. 408 (1966); Hara in Enum. Fl. Pl. Nep. **1**: 74 (1978); Noltie in Fl. Bhutan **3** (1): 102 (1994); Press *et al.* in Ann. Check. Fl. Pl. Nep. 185 (2000); Chen *et al.* in Fl. China **24**: 71 (2000); Rajbhandari and Maharjan in Cat. Nep. Fl. Pl. **1**: 22 (2010) (Fig. 15).

Lilium ochroleucum Wall. ex Baker

Type specimen: Kathmandu, Chandraghiry, Wallich, 5078A, Jun 1821. **Lectotype:** K-W; **Isotype:** BM.

Bulb 1.5-3.5 × 2-5 cm; scales oblong-ovate, 1-1.5 cm wide. Stem 30-120 cm. Leaves scattered, elliptic to oblong lanceolate, 4-14.5 × 0.7-3.5 cm, 5-7 veined, and apex sub acute, glabrous. Inflorescence a single terminal flower or few flowered raceme; 4-5 leaf-like bracts present; pedicels 2-10.5 cm. Flowers drooping, pale yellow to greenish, yellow above, tinged purplish or brownish at base, funnel shaped. Tepals lanceolate, reflexed at apex, narrowed towards base, inner broader than outer, inner 6-13.5 × 1.5-3 cm, outer 6-13.5 × 1.2-2.5 cm. Filaments 6-9.5 cm; anthers 1-1.5 cm, dorsifixed. Ovary cylindric, 1.2-1.5 cm × 2-3 mm; style 7-9 cm; stigma 3-lobed. Capsule loculicidal, oblong, 3-5.5 × 1.5-3.5 cm. Seeds flattened, winged.

Distribution range: Nepal (Fig. 16), W Himalaya, E Himalaya, Assam–Burma, Tibetan Plateau.

Altitude: 2000–3200 (–3800 m).

Ecology: Among bushes in mixed evergreen forest, in broadleaved and coniferous forests, hillsides, wet and shady places.

Flowering: June–August.

Fruiting: August–September.

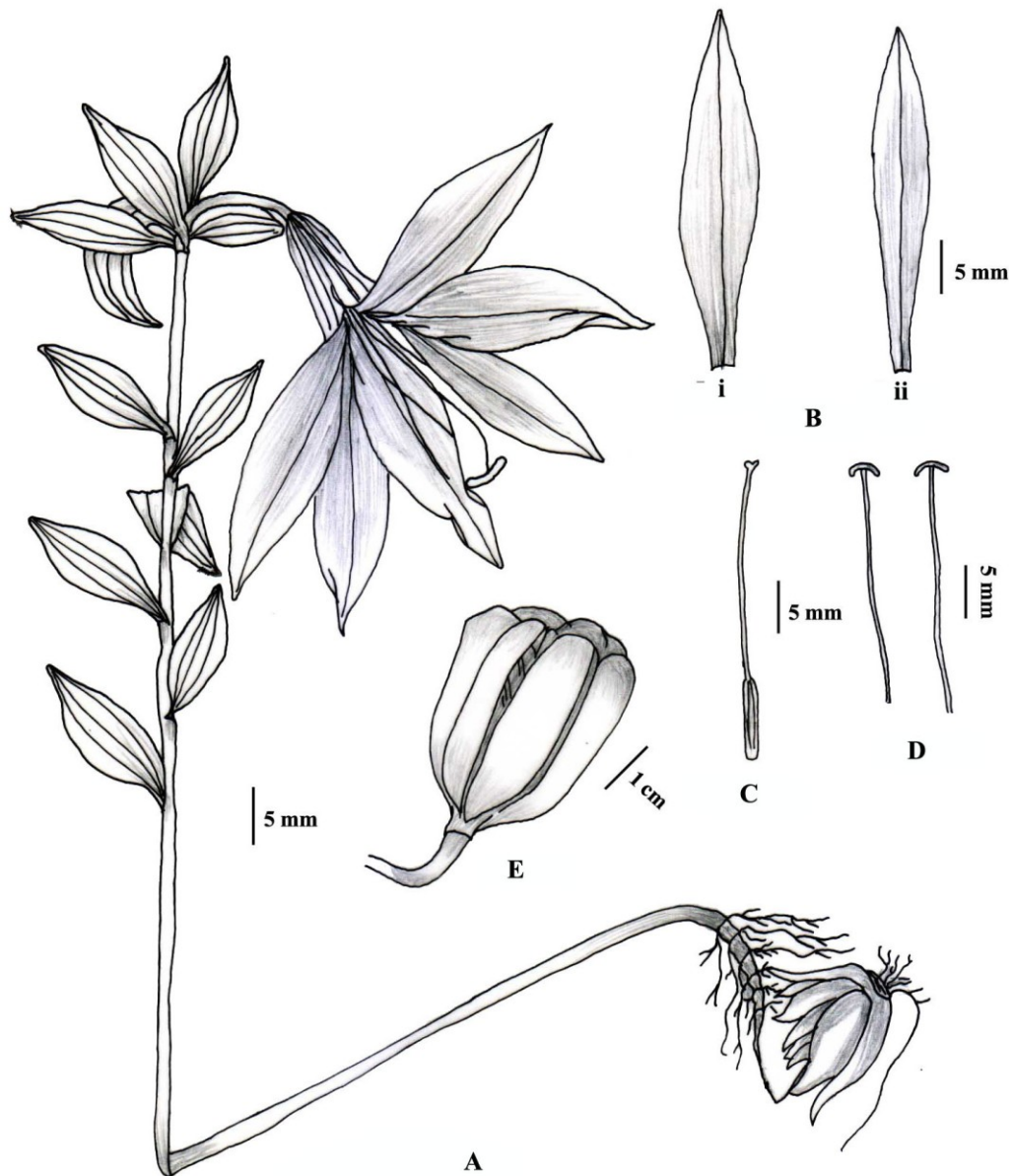


Fig.15 *Lilium nepalense* D. Don; **A.** Habit sketch, **B.** Tepals: i) Inner and ii) Outer, **C.** Stamens, **D.** Carpel (based on T.B. Shrestha, 31 KATH); **E.** Fruit (based on M.S. Bista 3660 KATH).

Specimens examined

Western Nepal: *Bajhang*, on trail from Pasela to Banjh, 2372 m, 16th July 2009, H. Ikeda, S. Noshiro, M. Amano, T. Tanaka, N. Yamamoto, C.A. Pendry, B. Dell, Y. Wang, G.D. Bhatta and A.P. Bhattarai, 20911134 (E). *Dolpa*, Suligad, 2592 m, 7th August 1966, T.B. Shrestha, 31 (KATH). *Mustang*, Ghasa–Lete, 2300 m, 22nd July 1979, P.R. Shakya, S.R. Adhikari and K.R. Amatya, 5076 (KATH). *Kaski*, Dhampus, 2450 m, 25th June 1975, D.P. Joshi and T.K. Bhattacharya, 75/3255 (KATH). **Central Nepal:** *Kathmandu*, Chandragiri, 2268 m, 28th September 1966, M.S. Bista, 3660 (KATH). *Lalitpur*, Phulchoki, 2300–2700 m, 16th September 1977, H. Ohashi, H. Obha and Y. Tateishi, 771457 (KATH, TI). *Makwanpur*, Simbhanjyang, 2240 m, 17th June 2014, H.K. Rana and S.K. Rana, MS11 (TUCH). *Dolakha*, Hum, 2200 m, 16th July 1977, K.R. Rajbhandari and B. Roy, 1442 (KATH). **Eastern Nepal:** *Solukhumbu*, Sete–Lamjura La–Taktor, 2620 m, 30th July 1997, M. Wakabayanshi, M. Amano, M. Mori, K.R. Rajbhandari, and K. Shinzoki, 9720033 (E). *Dhankuta*, Tute–Dor Pani–Tinjure Phedi, 2340–2650–2660 m, 14th July 1991, H. Obha, S. Akiyama, H. Ikeda, T. Kikuchi, S. Noshiro, Y. Omori, M.N. Subedi and M. Wakabayanshi, 9110056 (KATH). *Panchthar*, Prangbung–Namele Phedi–Namele–Goruwale Bhanjang (Banduke), c. 2300 m, 25th June 1992, S. Noshiro, S. Akiyama and N. Acharya, 9241073 (KATH) (see Appendix 2 for more details).

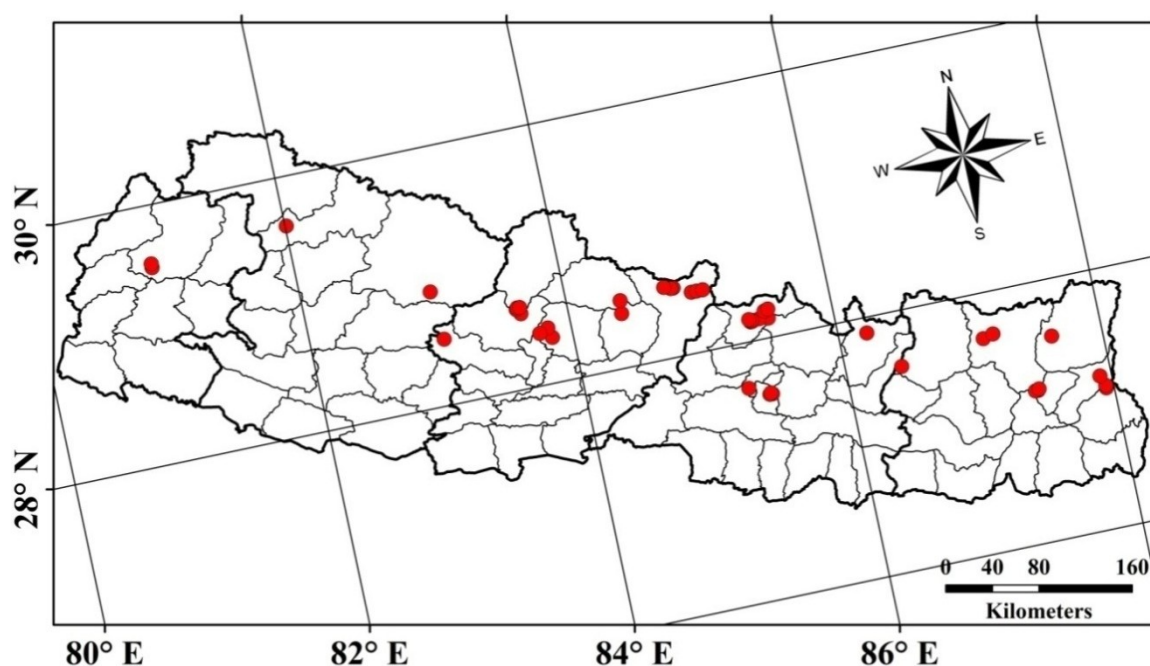


Fig. 16. Distribution of *Lilium nepalense* in Nepal based on herbarium record.

Lilium oxypetalum (D. Don) Baker, J. Linn. Soc., Bot. **14**: 234 (1874); Hooker in Fl. Brit. Ind. **4**: 352 (1896); Hara in Enum. Fl. Pl. Nep. **1**: 74 (1978); Polunin and Stainton in Fl. Himalaya 423 (1984); Press *et al.* in Ann. Check. Fl. Pl. Nep. 185 (2000); Rajbhandari and Maharjan in Cat. Nep. Fl. Pl. **1**: 22 (2010) (Fig. 17).

Nomocharis oxypetala (Royle) E. H. Wilson

Basionym: *Nomocharis oxypetala* (Royle) E. H. Wilson

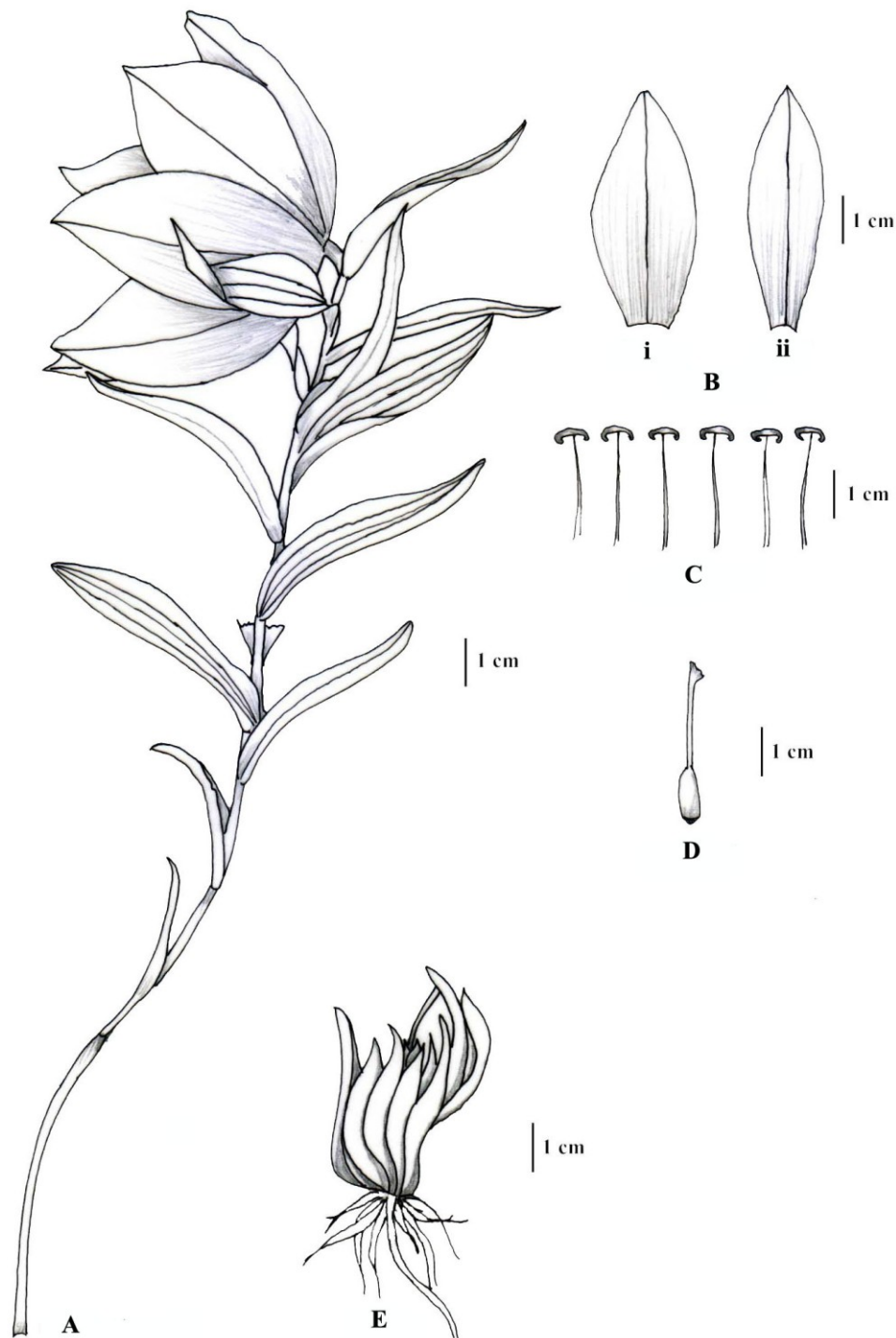


Fig. 17 *Lilium oxypetalum* (D. Don) Baker; **A.** Habit sketch (based on C.A. Pendry, S. Baral, S. Noshiro, S. Rajbhandary, P.P. Kurmi, B. Doli and B. Adhikari, JRS A231 KATH, E); **B.** Tepals: i) Inner and ii) Outer, **C.** Stamens and **D.** Carpel (based on P.R. Shakya and B. Roy, 5645 KATH).

Bulb *c.* 4.2 × 4 cm; scales *c.* 1 cm wide. Stem erect, 30-50 cm. Leaves alternate or scattered, elliptic lanceolate, 3.5-6 × 0.7-1.5 cm, acute apex, 3-5 veined. Inflorescence a single terminal flower; pedicel short, 0.5-1.2 cm, arising among the tufts of uppermost leaf-like bracts. Flower drooping, yellow to pale yellow, cup shaped, with tepals spreading outwards from the base not curved. Tepals oblanceolate narrowed apex, inner wider than outer, inner 4.2-5.5 × 1.2-2.2 cm, outer 4.2-5.5 × 1.5-2.5 cm, hairy at base adaxially; nectaries at base on adaxial surface. Filaments 1.5-2 cm; anthers 0.4-1 cm, dorsifixed. Ovary cylindric, 0.8-1.2 × 0.3-0.4 cm; style 1.5-2.2 cm long; stigma 3-lobed. Capsule loculicidal, oblong. Seeds flattened, winged.

Distribution range: Nepal (Fig. 18), W Himalaya, E Himalaya, Assam–Burma.

Altitude: 3100–3850 m.

Ecology: Coniferous forests, grassy slopes, crevices of bare stone rocks.

Flowering: June–July.

Fruiting: July–August.

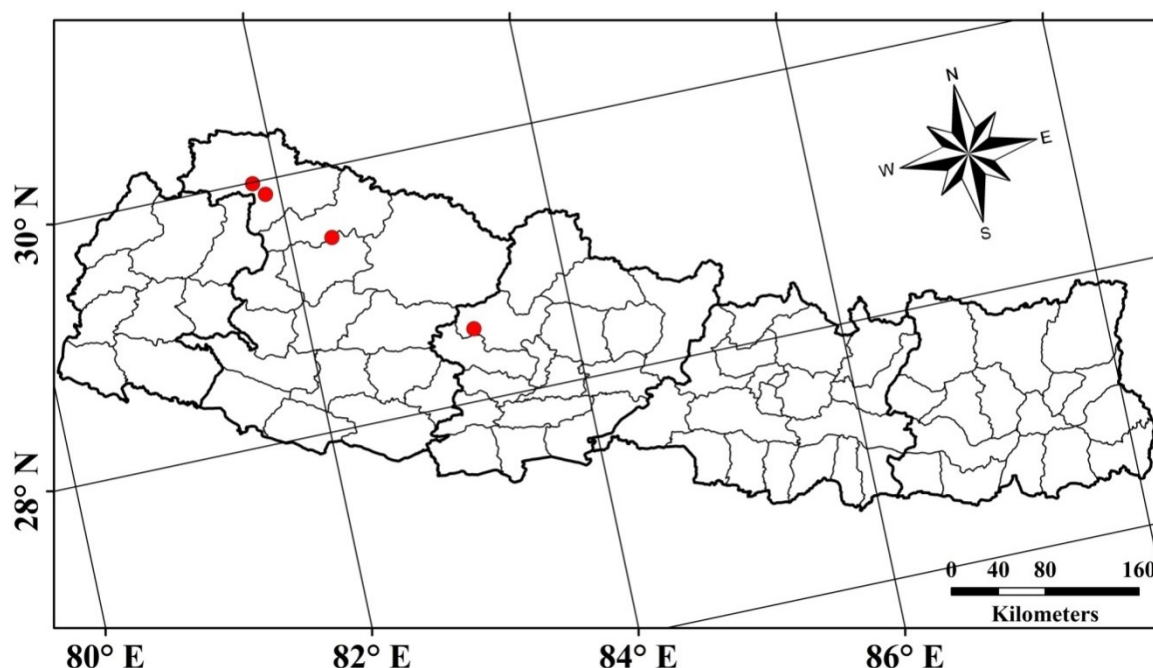


Fig. 18 Distribution of *Lilium oxypetalum* in Nepal based on herbarium record.

Specimens examined

Western Nepal: Darchula, Marmakhadi, Muna Lekh, 11000 ft, 17th June 1965, T.B.Shrestha, 4215 (KATH). Humla, Simikot lagna (above Simikot), 3850 m, 21st June 2008, C.A. Pendry, S. Baral, S. Noshiro, S. Rajbhandary, P.P. Kurmi, B. Doli and B. Adhikari, JRS A231 (KATH, E); Durpa, Humla

Karnali, 11000 ft, 15th June 1952, O. Polunin, W.R. Sykes and H.J. Williams, 4309 (E). *Mugu*, Mangri, 3100 m, 13th June 1980, P.R. Shakya and B. Roy, 5645 (KATH).

Lilium wallichianum J. A. & J. H. Schult., Syst. Veg. **7(2)**: 1689 (1830); Hooker in Fl. Brit. Ind. : 349-350 (1896); Hara in Enum. Fl. Pl. Nep. **1**: 74 (1978); Polunin and Stainton in Fl. Himalaya. 424 (1984); Noltie in Fl. Bhutan **3** (1): 100-102 (1994); Press *et al.* in Ann. Check. Fl. Pl. Nep. 185 (2000); Rajbhandari and Maharjan in Cat. Nep. Fl. Pl. **1**: 22 (2010) (Fig. 19).

Lilium batisua Buch.-Ham. ex D. Don; *Lilium longiflorum* Wall.

Type specimen: Sheopore, *Wallich s.n.*, ann. 1821. **Syntype:** K. Narekot, Napalia, *Wallich* 5076A, Aug 1821. **Syntype:** K-W.

Bulb 2.5-4.5 × 3.5 cm on a creeping rootstock; scales *c.* 1.2 cm. Stem 70-150 cm. Leaves scattered, sessile, linear, 8-20 × 0.3-0.7 cm, apex blunt, 1-3 veined. Inflorescence a single terminal flower, subtended with leaf-like bracts, 4.5-9 × 0.3-0.5 cm; pedicel 0.8-1.5 cm long. Flowers drooping, white or creamy white, narrowly tubular at base, reflexed apex. Tepals narrowly elliptic, contracted at apex into blunt tip, narrowed below into a claw for basal third, inner wider than outer, inner 14-20 × 2.5-4.5 cm, outer 14-20 × 2-3.5 cm. Filaments 10-13 cm; anthers 1.2-2 cm, dorsifixed. Ovary cylindric, 3-4.5 × 0.2-0.5 cm; style 8.5-15 cm; stigma 0.8-1 mm in diameter, 3-lobed. Capsule *c.* 5.5 × 3.5 cm. Seeds triangular, winged.

Distribution range: Nepal (Fig. 20), W Himalaya, E Himalaya, Assam–Burma.

Altitude: (870–)1100–2000 m.

Ecology: Coniferous forests, among grasses in grassy slopes.

Flowering: August–November.

Fruiting: October–November (–December).

Specimens examined

Western Nepal: *Rukum*, Chari Khola, 1500 m, 17th September 1982, K.R. Rajbhandari and K.J. Malla, 6517 (KATH). *Myagdi*, Near Lumsum, 6500 ft, 27th October 1954, Stainton, Skyes and Williams, 9155 (E), Near Lumsum, 6000 ft, 29th August 1954, Stainton, Skyes and Williams, 4060 (E); Shika–Khipang (Khibang)–Paudwar–Jibang–Gaunapani–Narchang (Nracheng), 2010-1740-1900-1760-1750-1300 m, 26th August 1988, M. Suzuki, T. Maeda, N. Naruhashi, R. Watanabe, M.N. Subedi, M. Minaki, S.

Noshiro, H. Ikeda, 8881443 (TI). *Central Nepal: Dhading*, Mathilo orbang Dhading, 870 m, 19th November 1989, N.P. Manandhar, 14178 (KATH). *Rasuwa*, Shyapru–Sherpagaon, 3500 ft, 13th September 1965, T.B. Shrestha and P.R. Shakya, 3852 (KATH); after Syabrubensi north side of Langtang river, 1500 m, 18th November 1966, D.H. Nicolson, 2545 (KATH).

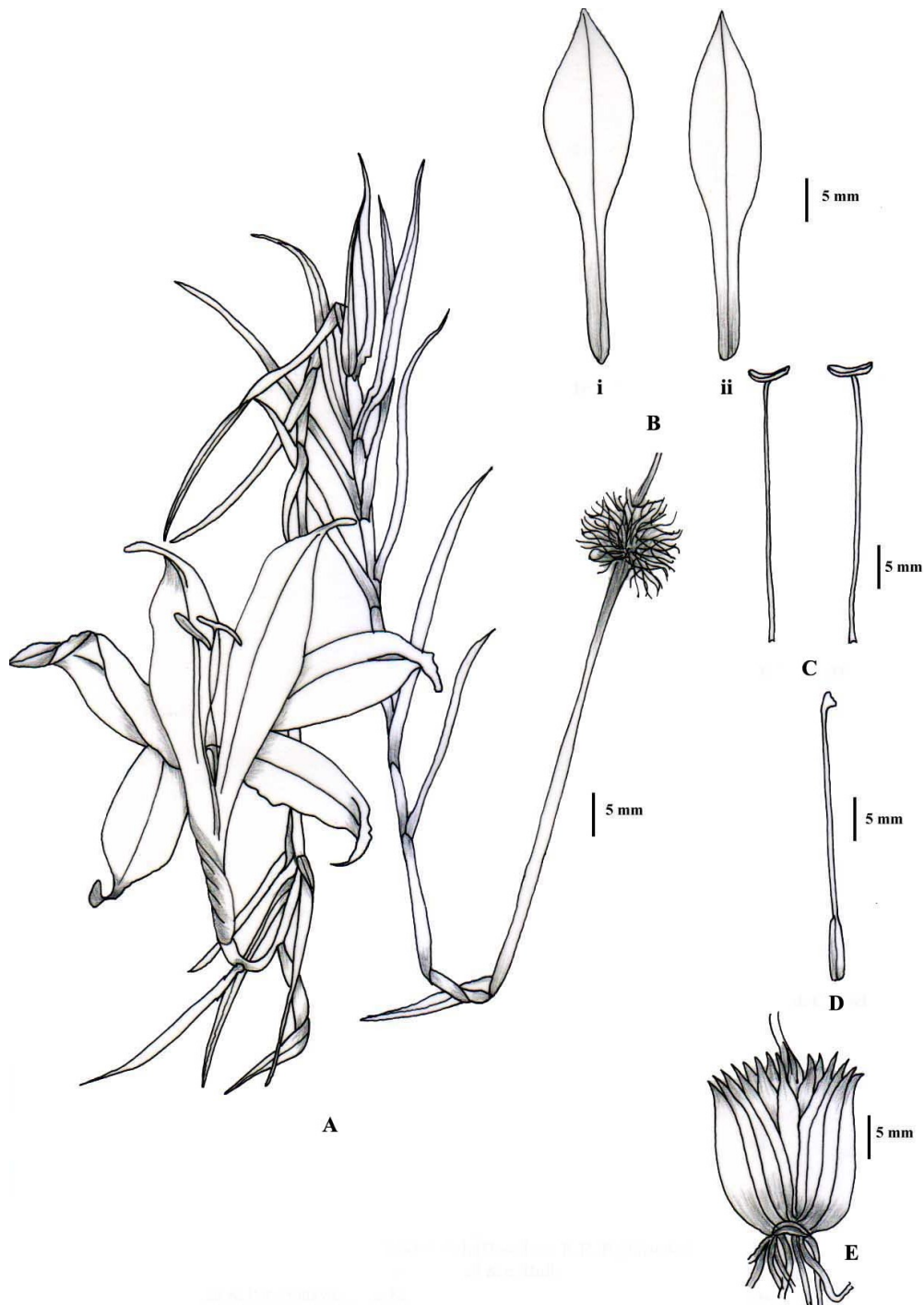


Fig. 19 *Lilium wallichianum* J. A. & J. H. Schult; **A.** Habit sketch (based on K.R. Rajbhandari and K.J. Malla, 6517 KATH, E); **B.** Tepals: i) Inner and ii) Outer, **C.** Stamens **D.** Carpel and **E.** Bulb (based on T.B. Shrestha and P.R. Shakya, 3852 KATH).

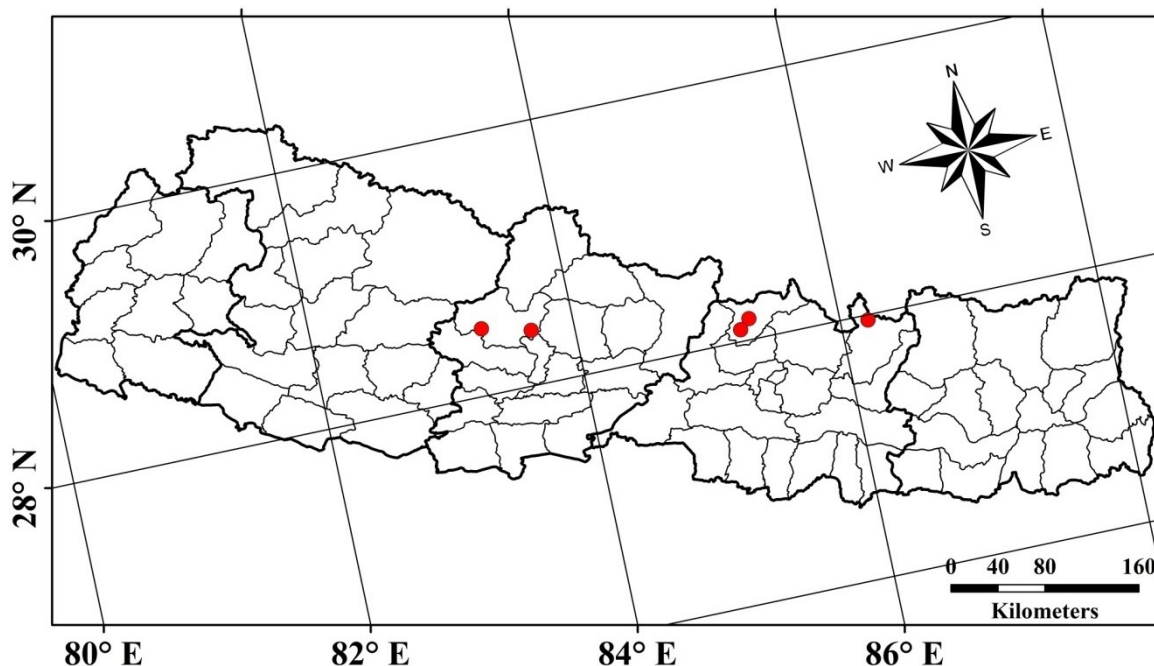


Fig. 20. Distribution of *Lilium wallichianum* in Nepal based on herbarium record.

5. *Lloydia* Salisb., Fl. Germ. Excurs. 102 (1830), nom. cons.

Herb perennial, bulbiferous. Bulb small, covered with tunics. Leaves basal 1 to several, filiform, linear, sessile. Inflorescence terminal single flowered or few flowered raceme, borne on scape subtended with leaf-like bracts. Flower erect or drooping, funnel-shaped or campanulate, white or yellow, complete, actinomorphic. Tepals 6, free, in two whorls, outer tepals wider than inner, hairy at base adaxially, usually with a basal nectary. Stamens-6, inserted at the base of tepals; filaments sometimes hairy; anthers basifixed. Ovary 3-loculed; style rather longer; stigma capitate or 3-lobed. Fruit a capsule.

Worldwide about 20 species. Six species in Nepal.

Key to species

- 1. a. Leaves 1 or 2; filaments glabrous.....2
- b. Leaves 3 or more; filaments hairy.....4
- 2. a. Stigma trifid; tepals over 1.6 cm.....**L. yunnanensis**
- b. Stigma obscurely 3-lobed; tepals under 1.6 cm.....3

- 3.a. Pedicel upto 2 mm; purplish midrib reaching apex in tepals.....**L. delicatula**
- b. Pedicel over 3 mm; purplish midrib not reaching apex in tepals.....**L. serotina**
- 4.a. Leaf shorter or almost equalling scape.....**5**
- b. Leaf longer than scape.....**L. tibetica**
- 5.a. Tepals white with basal spots and hairy base adaxially.....**L. longiscapa**
- b. Tepals yellow with basal spots and glabrous base adaxially.....**L. flavonutans**

Lloydia delicatula Noltie., Edinb. J. Bot. **50 (1)**: 55 (1993); Noltie in Fl. Bhutan **3 (1)**: 109 (1994); Press *et al.* in Ann. Check. Fl. Pl. Nep. 185 (2000); Rajbhandari and Maharjan in Cat. Nep. Fl. Pl. **1**: 22 (2010) (Fig. 21).

Plant 1-3 cm tall. Bulb clumped, 3-5 × 3 mm, covered with tunics. Scape 0.5-2.5 cm. Leaf basal, single, linear, filiform, exceeding stem, 1.5-3 × 0.05 cm, apex blunt. Inflorescence a single terminal flower. Leaf like bracts 2-3 in number, 3-8 × 0.5-1 mm; pedicel 1-2 mm. Flower drooping, white with purplish midrib reaching apex in tepals. Tepals oblong to narrowly elliptic, 3.5-5 × 1-1.5 mm, outer slightly wider than inner; nectary at base of tepals round or transversely elongate. Filaments 2.5-3 mm, glabrous; anther rounded or circular, c.1 mm, basifixed. Ovary oblong-ovoid, 1.5-2 × 8-1.2 mm; style 1.2-2 mm; stigma capitate or obscurely 3-lobed. Capsule loculicidal. Seeds winged.

Distribution range: Nepal (Fig. 22), E Himalaya.

Altitude: 3600–4600 m.

Ecology: Forest floor among herbs and rock crevices.

Flowering: June–July.

Fruiting: July–August.

Specimens examined

Eastern Nepal: Sankhuwasabha, Giddhe to Jaljale, 12000 ft, 22nd July 1971, T.B. Shrestha and D.P. Joshi, 239 (KATH); Naulekh, 14000 ft, 19th June 1981, J.D.A. Stainton, 8358 (E).

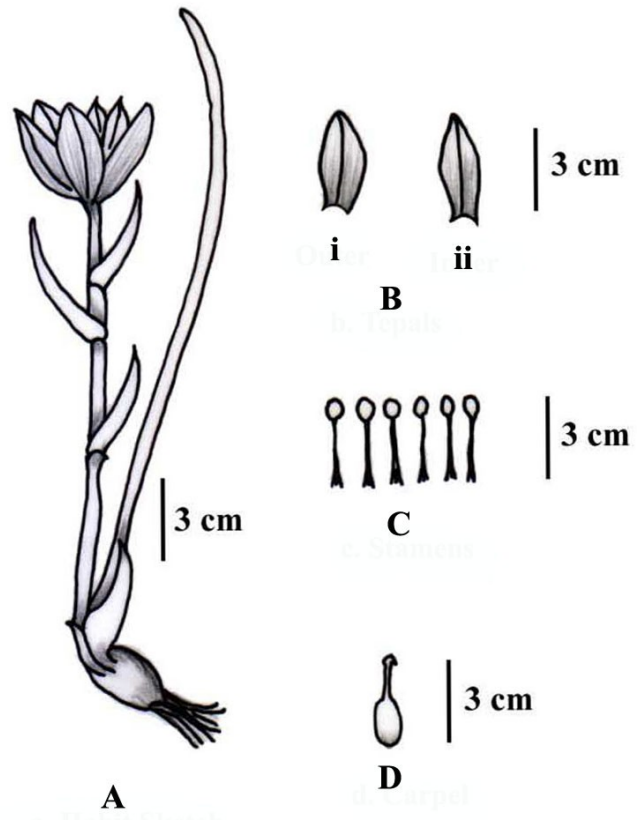


Fig. 21 *Lloydia delicatula* Noltie; **A.** Habit sketch, **B.** Tepals: i) Outer and ii) Inner, **C.** Stamens and **D.** Carpel (based on T.B. Shrestha and D.P. Joshi, 239 KATH).

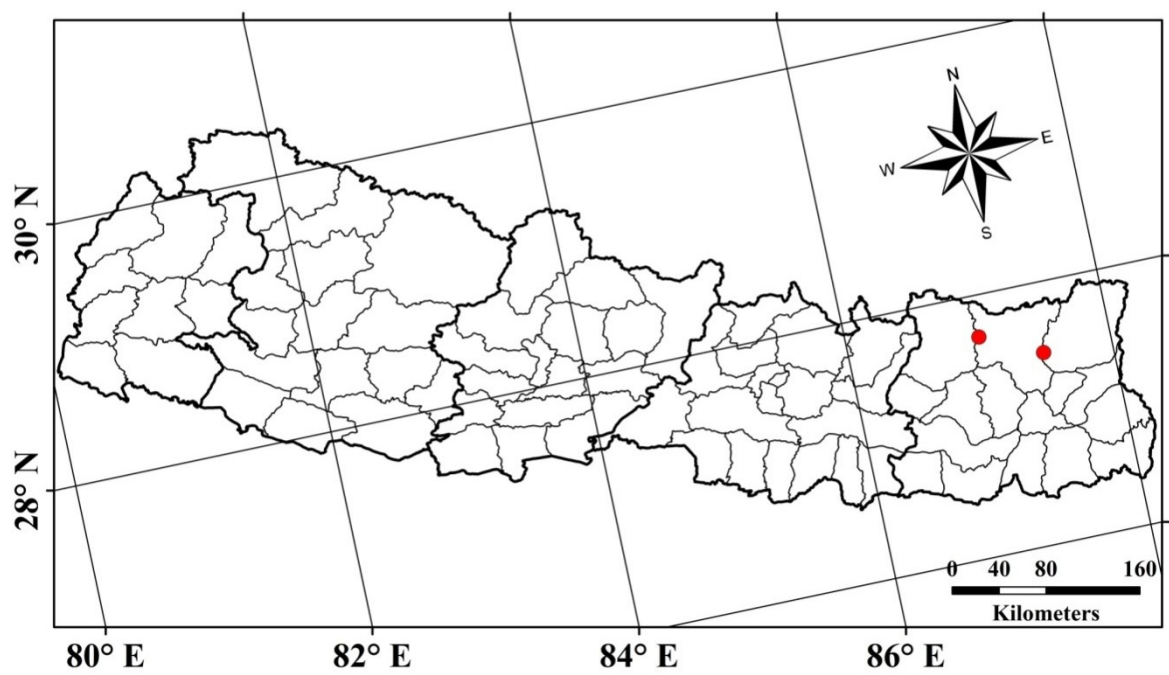


Fig. 22. Distribution of *Lloydia delicatula* in Nepal based on herbarium record.

Lloydia flavonutans H. Hara., J. Jap. Bot. **49**: 202 (1974); Hara in Enum. Fl. Pl. Nep. **1**: 74 (1978); Polunin and Stainton in Fl. Himalaya. 425 (1984); Noltie in Fl. Bhutan **3** (1): 110-111 (1994); Press *et al.* in Ann. Check. Fl. Pl. Nep. 185 (2000); Chen *et al.* in Fl. China **24**: 51 (2000); Rajbhandari and Maharjan in Cat. Nep. Fl. Pl. **1**: 22 (2010) (Fig. 23).

Plants 6-15 cm tall. Bulb with whitish tunics. Scape 5-13 cm. Leaves basal, 5 or upto 9, linear, filiform, shorter or equal to scape, $4-13 \times 0.05-0.2$ cm, sessile, apex blunt. Inflorescence single flowered or upto 3 flowered terminal raceme; leaf like bracts many in number, $1.5-3 \times 0.1-0.2$ mm; pedicel 1-1.4 cm. Flower drooping, yellow with orange or brownish spots at the base. Outer tepals oblong $1.2-1.6 \times 0.5-0.8$ cm, inner tepals ovovate to elliptic, $1.2-1.6 \times 0.3-0.4$ cm, outer broader than inner, basal nectaries present adaxially. Filaments 3-6 mm, hairy; anthers 1.5-2 mm, basifixed. Ovary oblong-ovoid, $3-4 \times 1-1.5$ mm; style 3-4 mm; stigma capitate or 3-lobed, scarcely developed. Capsule loculicidal, $7-8 \times 3-4$ mm, seeds oblong, winged.

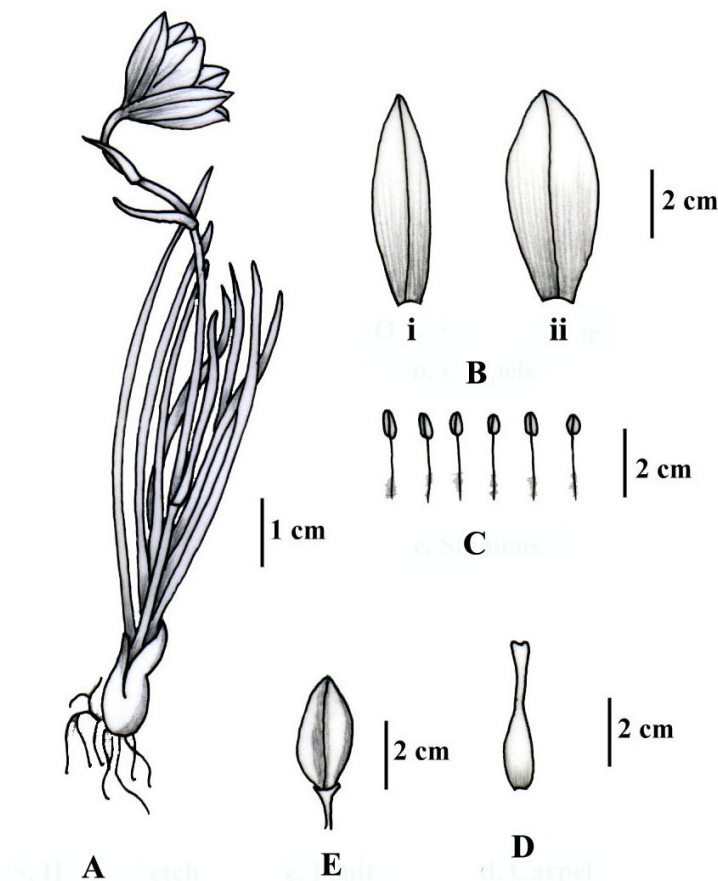


Fig. 23 *Lloydia flavonutans* H. Hara; **A.** Habit sketch (based on P.R. Shakya and K.K. Dangol, 10132 KATH); **B.** Tepals: i) Outer and ii) Inner, **C.** Stamens and **D.** Carpel (based on T.B. Shrestha and D.P. Joshi, 275 KATH); **E.** Fruit (based on F. Miyamoto, M. Amano, H. Ikeda, C.M. Joshi, K. Arai, and T. Komatsu, 9584193 KATH).

Distribution range: Nepal (Fig. 24), E Himalaya, Tibetan Plateau.

Altitude: (3800–) 4000–5200 m.

Ecology: Alpine grassy and rocky meadows, thickets.

Flowering: May–July (–August). **Fruiting:** August.

Specimens examined

Central Nepal: *Rasuwa*, Ganesh kund, 17–18000 ft, 1928, Capt. Lall Dhowj, 232 (E); Down from Gosaikunda, 12500 ft, 15th June 1969, Dr. Saman and Mr. Bista, 13169 (KATH); Above Thonglu Kharka, 3720 m, 16th May 1973, 2345 (KATH); Gosaikunda, 13600 ft, 16th July 1977, N.P. Manandhar, 168 (KATH). **Eastern Nepal:** *Solukhumbu*, Gorita chhedhi, 4000 m, 15th June 1994, P.R. Shakya and K.K. Dangol, 10132 (KATH); Around Khola Kharka, 4170 m, 7th August 1997, M. Wakabayashi, M. Amano, M. Mori, K.R. Rajbhandari and K. Shinozaki, 9715091 (E). *Taplejung*, Jaljale to Bhalukhop, 13500 ft, 23rd July 1971, T.B. Shrestha and D.P. Joshi, 275 (KATH); Iwanagi Kharka–Langur Danda–Thulo Bhanjyang–Tembe Pokhari–Danphe Bhir–Khola Tar–Thulo Bhanjyang, c.4200 m, 17th June 1992, S. Noshiro, S. Akiyama and N. Acharya, 9240870 (KATH) (see Appendix 2 for more details).

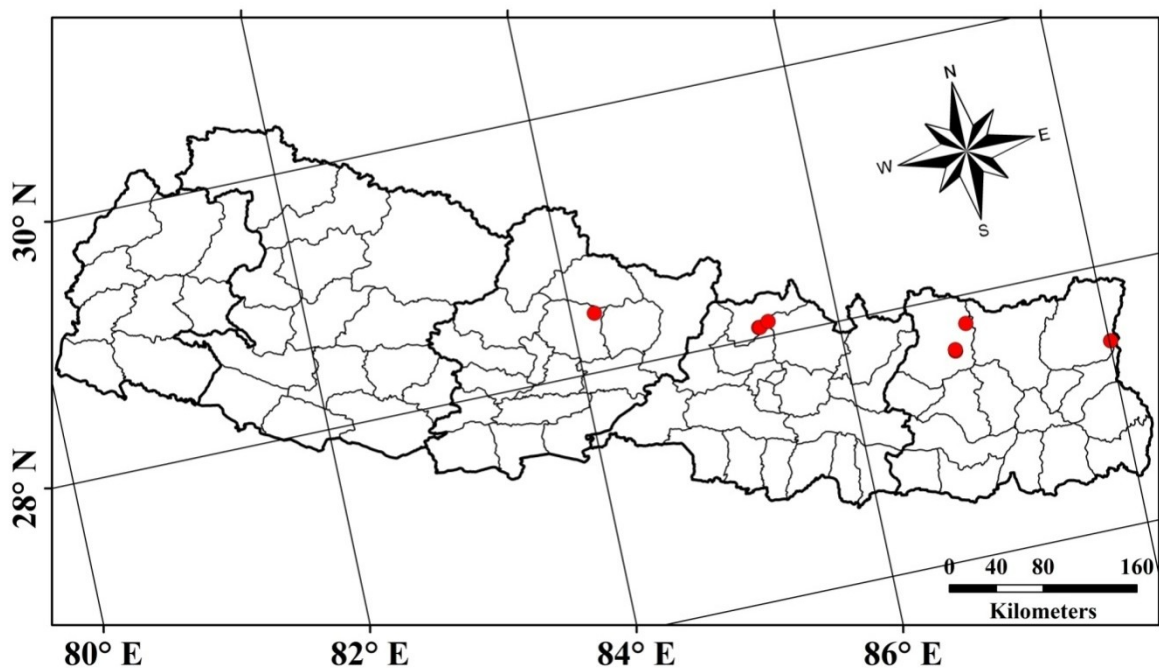


Fig. 24 Distribution of *Lloydia flavonutans* in Nepal based on herbarium record.

Lloydia longiscapa Hook., Icon. Pl. **9**: t. 834 (1852); Hara in Enum. Fl. Pl. Nep. **1**: 74 (1978); Polunin and Stainton in Fl. Himalaya. 425 (1984); Noltie in Fl. Bhutan **3** (1): 110 (1994); Press *et al.* in Ann. Check. Fl. Pl. Nep. 186 (2000); Rajbhandari and Maharjan in Cat. Nep. Fl. Pl. **1**: 22-23 (2010) (Fig. 25).

Plant 12-30 cm tall. Bulb clumped tunicate. Scape 10-26 cm. Leaves basal upto 6, apex blunt, almost equalling scape, 7-24 × 0.1-0.15 cm. Inflorescence terminal single flowered or 2-3 flowered raceme; leaf like bracts upto 5, 1.5-6 × 0.1-0.15 cm; pedicel 5-10 mm. Flower drooping, white with orange or brownish or reddish basal shade on lower half of tepals. Tepals lanceolate to elliptic, inner 1.2-2 × 0.4-0.7 cm, outer 1.2-2 × 0.4-0.6 cm; hairy at base adaxially, surrounded by short hairs. Filaments 3-6 mm, hairy; anther 1.2 mm. Ovary ovoid, 3-5 × 1.5-2 mm; style 3-5 mm; stigma capitate. Seeds oblong, winged.

Distribution: Nepal (Fig. 26), W Himalaya, E Himalya, Tibetan Plateau.

Altitude: 2500–5000 m.

Ecology: Alpine scrubland and grassland, shady or open and slopes.

Flowering: May–June (–August).

Fruiting: August.

Specimens examined

Western Nepal: *Jumla*, Bhurchula lekh, Near Jumla, 14000 ft, 13th July 1952 O. Polunin, W.R. Sykes and L.H.J. Williams, 4632 (E). *Mustang*, Lete, S. of Tukucha, Kali Gandaki, 12500 ft, 7th June 1954, Stainton, Sykes and Williams, 1015 (KATH). *Gorkha*, Samdo: E of village, on south side of Sanam Khola river Valley, 4190 m, 8th August 2008, H. Ikeda, T. Kawahara, O. Yano, N. Yamamoto, M.F. Watson, J.H. Li, M.N. Subedi and S.K. Acharya, 20815170 (KATH). **Central Nepal:** *Rasuwa*, Down from Gosaikunda, 12500 ft, 15th June 1969, Dr. Saman and Mr. Bista, 13167 (KATH); Mailung Khola, 13000 ft, 26th June 1975, J.D.A. Stainton, 7390 (E); Gosainkunda, 4350 m, 9th July 2006, T.N. Belbase, 60 (TUCH). **Eastern Nepal:** *Solukhumbu*, Around Khola Kharka, 4100 m, 7th August 1997, M. Wakabayashi, M. Amano, M. Mori, K.R. Rajbhandari and K. Shinozaki, 9715091 (KATH). *Sankhuwasabha*, Kalo Pokhari–Wane Danda, 3900 m, 15th June 1994, P.R. Shakya and K.K. Dangol, 10139 (KATH); Giddhe to Jaljale, 13500 ft, 22nd July 1971, T.B. Shrestha and D.P. Joshi, 243 (KATH). *Taplejung*, Kangrang La, 13000 ft, 18th June 1969, T.B. Shrestha, 15760 (KATH) (see Appendix 2 for more details).

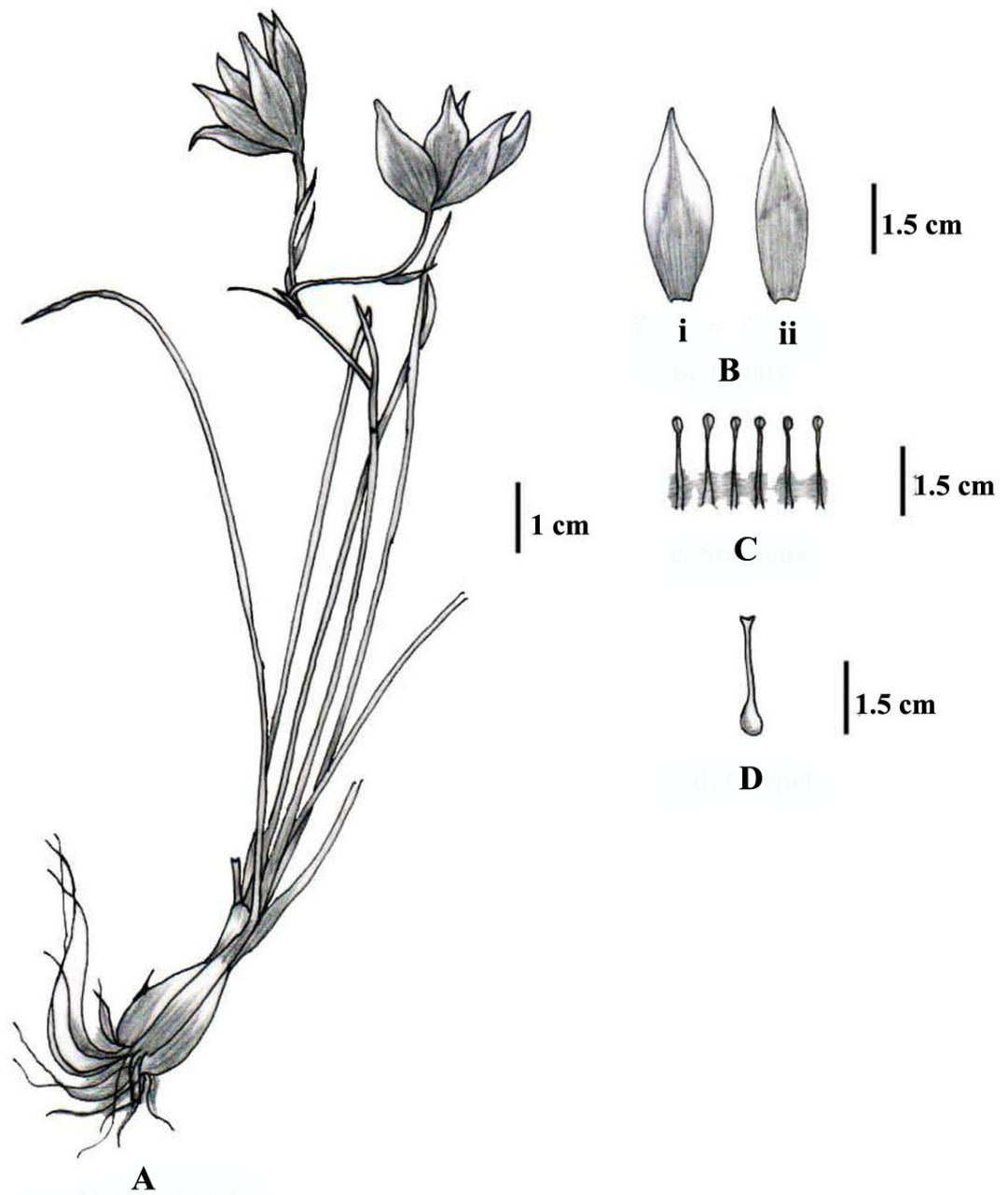


Fig. 25 *Lloydia longiscapa* Hook.; **A.** Habit sketch (based on P.R. Shakya and K.K. Dangol, 10139 KATH); **B.** Tepals: i) Inner and ii) Outer, **C.** Stamens and **D.** Carpel (based on T.B. Shrestha and D.P. Joshi, 243 KATH).

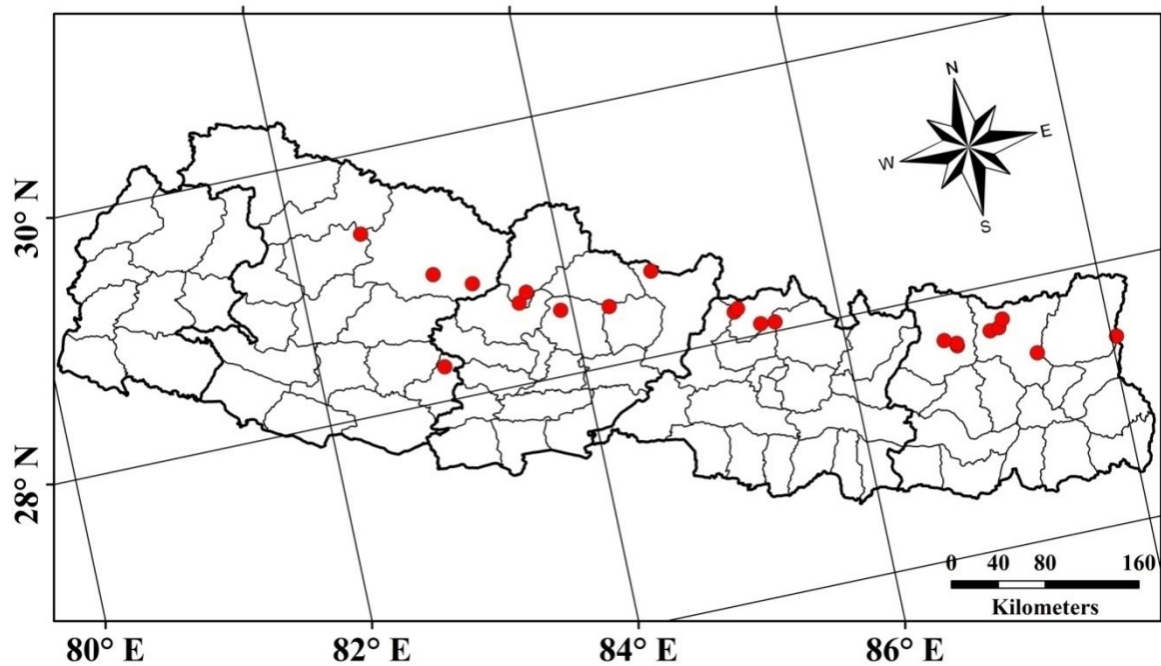


Fig. 26 Distribution of *Lloydia longiscapa* in Nepal based on herbarium record.

Lloydia serotina (L.) Rchb., Fl. Germ. Excurs. 102 (1830); Hooker in Fl. Brit. Ind. **6**: 354 (1896); Hara in Fl. E. Himal. 408–409 (1966); Hara in Enum. Fl. Pl. Nep. **1**: 74 (1978); Noltie in Fl. Bhutan **3** (1): 108–109 (1994); Press *et al.* in Ann. Check. Fl. Pl. Nep. 186 (2000); Chen *et al.* in Fl. China **24**: 50 (2000); Rajbhandari and Maharjan in Cat. Nep. Fl. Pl. **1**: 23 (2010).

Lloydia himalensis Royle.

Plant 2.5-25 cm tall. Bulb covered with tunics. Scape 2-22 cm. Leaves basal 1 or 2, linear, filiform, 2.5-30 × 0.05-0.15 cm, apex blunt. Inflorescence 1 or rarely 2-flowered; leaf like bracts 3-5 in number, 0.4-3.5 × 0.5-2.5 cm; pedicel 0.3-1.5 cm. Flowers drooping, white with purple midrib not reaching apex, campanulate. Outer tepals wider than inner, outer 0.4-1.6 × 0.2-0.65 cm, inner 0.4-1.6 × 0.1-0.6 cm, nectary 1.5-2.5 cm from base. Filaments 1.5-7 mm, glabrous; anthers 0.5-2 mm, basifixed. Ovary obovoid, 1-5 × 1-15 mm; style 1-4 mm; stigma capitate or indistinctly 3-lobed. Capsule loculicidal. Seeds oblong ovoid and winged.

Distribution range: Nepal (Fig. 29), E Himalaya, S Asia, C Asia, E Asia, N Asia, Europe, North America.

Altitude: 3300–4900 m.

Ecology: Alpine meadows, among grasses and rocks, sometimes in rock ledges and cliffs, thickets.

Flowering: (May–) June–Aug.

Fruiting: Aug–Oct.

Key to variety

- Plants taller; scape 16-22 cm.....**L. serotina** var. **serotina**
Plants smaller; scape 2-5 cm.....**L. serotina** var. **parva**

Lloydia serotina var. **parva** (C. Marquand & G. Shaw) H. Hara in Fl. E. Himalaya **2**: 166 (1971); Hara in Fl. E. Himal. 408–409 (1966); Hara in Enum. Fl. Pl. Nep. **1**: 74 (1978); Noltie in Fl. Bhutan **3** (1): 109 (1994); Press *et al.* in Ann. Check. Fl. Pl. Nep. 186 (2000); Chen *et al.* in Fl. China **24**: 50 (2000); Rajbhandari and Maharjan in Cat. Nep. Fl. Pl. **1**: 23 (2010) (Fig. 27).

Lloydia serotina f. *parva* C. Marquand & Airy Shaw, *Lloydia serotina* forma *parva* Marquand & Shaw.

Plant 2.5-6 cm tall. Scape 2-5 cm. Basal leaves 2.5-8 × 0.05-0.1 cm. Leaf like bracts 4-10 × 0.5-1 mm. Outer tepals 4-8 × 2-4 mm, inner tepals 4-8 × 1-2.5 mm. Filaments 1.5-4 mm; anthers 0.5-1 mm. Ovary 1-2.5 × 1-2 mm; style 1-3 mm.

Distribution range: Nepal, E Himalaya, Tibetan Plateau.

Altitude: 3500-4700 m.

Ecology: Alpine grasslands.

Flowering: June-August.

Fruiting: August-October.

Specimens examined

Western Nepal: Mustang, Namdo, North of Mustang, 15500 ft, 7th August 1954, Stainton, Sykes and Williams, 2263 (E); Lamangthang–Spakkharka–Lamangthang, 4250 m, 21st August 2002, M.N. Subedi, 162/2002 (KATH). **Central Nepal:** Rasuwa, Gosaikunda, 13600 ft, 16th July 1977, N.P. Manandhar, 178 (KATH). **Eastern Nepal:** Sankhuwasabha, Around Merek (Mera), 4450 m, 22nd July 1988, M. Suzuki, H. Narushashi, S. Kurosaki, S. Noshiro, Y. Hedota, M. Minaki, and H. Ikeda, 8880680 (E); Around Khongma (Kauma), 3900 m, 16th July 1988, M. Suzuki, H. Narushashi, S. Kurosaki, S. Noshiro, Y. Hedota, M. Minaki, and H. Ikeda, 8810429, 8850410 (TI). Taplejung, North of Kangrang La, 13000 ft, 20th June 1969, T.B. Shrestha, 15786 (KATH) (see Appendix 2 for more details).

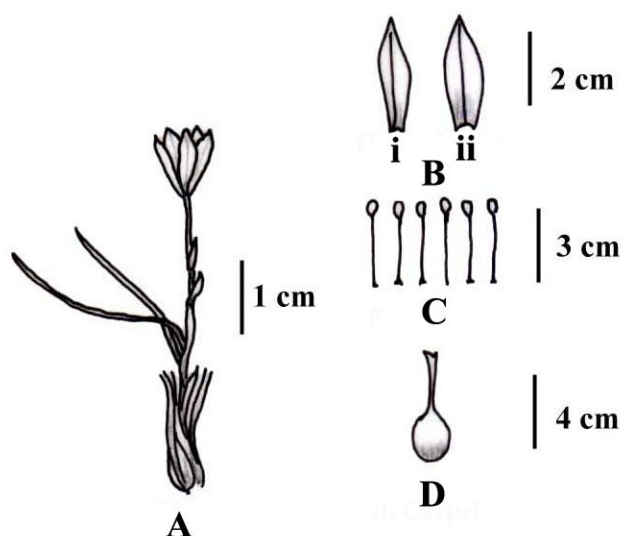


Fig. 27 *Lloydia serotina* var. *parva* (C. Marquand & G. Shaw) H. Hara; **A.** Habit sketch (based on M.N. Subedi, 162/2002 KATH); **B.** Tepals: i) Outer and ii) Inner, **C.** Stamens, and **D.** Carpel (based on T.B. Shrestha, 15786 KATH).

Lloydia serotina (L.) Rchb., Fl. Germ. Excurs. 102 (1830) var. ***serotina***; Hara in Fl. E. Himal. 408–409 (1966); Hara in Enum. Fl. Pl. Nep. **1**: 74 (1978); Noltie in Fl. Bhutan **3** (1): 108–109 (1994); Press *et al.* in Ann. Check. Fl. Pl. Nep. 186 (2000); Chen *et al.* in Fl. China **24**: 50 (2000); Rajbhandari and Maharjan in Cat. Nep. Fl. Pl. **1**: 23 (2010) (Fig. 28).

Bulbocodium serotinum Linnaeus; *Anthericum serotinum* (Linnaeus) Linnaeus; *Lloydia alpina* Salisbury; *L. himalensis* Royle; *L. serotina* var. *unifolia* Franchet.

Plant 10-25 cm tall. Scape 16-22 cm. Basal leaves 7-30 × 0.1-0.15 cm. Leaf-like bracts 0.8-3.5 × 0.1-0.25 mm. Outer tepals 1-1.8 × 0.4-0.65 cm, inner tepals 1-1.8 × 0.3-0.6 cm. Filamnets 3-7 mm; anthers 1.5-2 mm. Ovary 2.5-5 × 5-15 mm; style 3-4 mm.

Distribution range: Nepal, E Himalaya, S Asia, C Asia, E Asia, N Asia, Europe, North America.

Altitude: 3300–4900 m.

Ecology: Thickets, grassy slopes.

Flowering: May–August.

Fruiting: August–October.

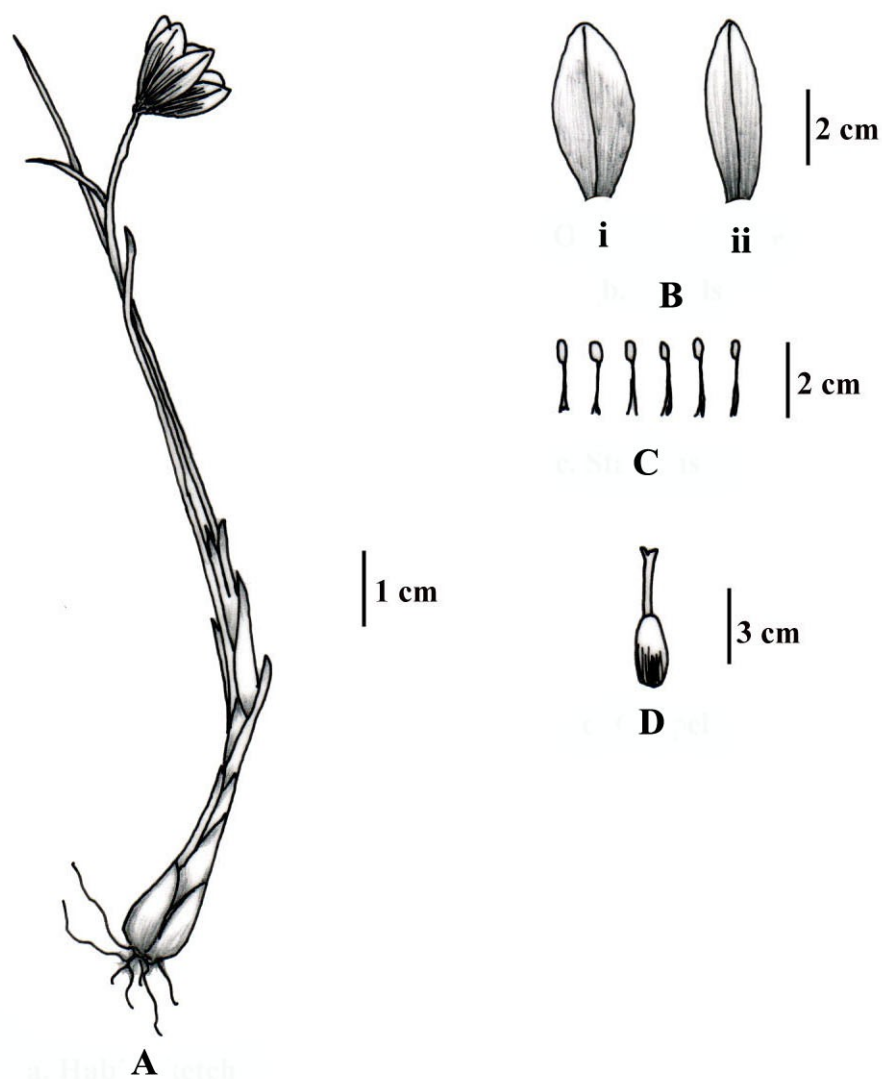


Fig. 28 *Lloydia serotina* (L.) Rchb. var. *serotina*; **A.** Habit sketch (based on T.B. Shrestha, 4156 KATH); **B.** Tepals: i) Inner and ii) Outer, **C.** Stamens and **D.** Carpel (based on Schilling, Sayers and Bista, 409 KATH).

Specimens examined

Western Nepal: *Bajhang*, Dachaud Saipal, 11400 ft, 25th May 1965, T.B. Shrestha, 4156 (KATH). *Humla*, Simikot Lagna, Above Simikot, 4230 m, 20th June 2008, C.A. Pendry, S. Baral, S. Noshiro, P.P. Kurmi, B. Dell and B. Adhikari, JRS A200 (E). **Mustang**, N. of Tukucha, 16000 ft, 16th August 1954, Stainton, Sykes and Williams, 7253 (KATH). **Central Nepal:** *Rasuwa*, Langtang valley, 13000 ft, 25th June 1965, Schilling, Sayers and Bista, 409 (KATH). *Ramechhap*, Baula Pokhari–Chhu

Ningma, 3960-4040 m, 11th July 1985, H. Obha, T. Kikuchi, M. Wakabayashi, M. Suzuki, N. Kurosaki, K.R. Rajbhandari and S.K. Wu, 8580257 (KATH). **Eastern Nepal: Solukhumbu**, Khumbu, Phorche, 12000 ft, 25th June 1974, J.D.A. Stainton, 7149 (KATH) (see Appendix 2 for more details).

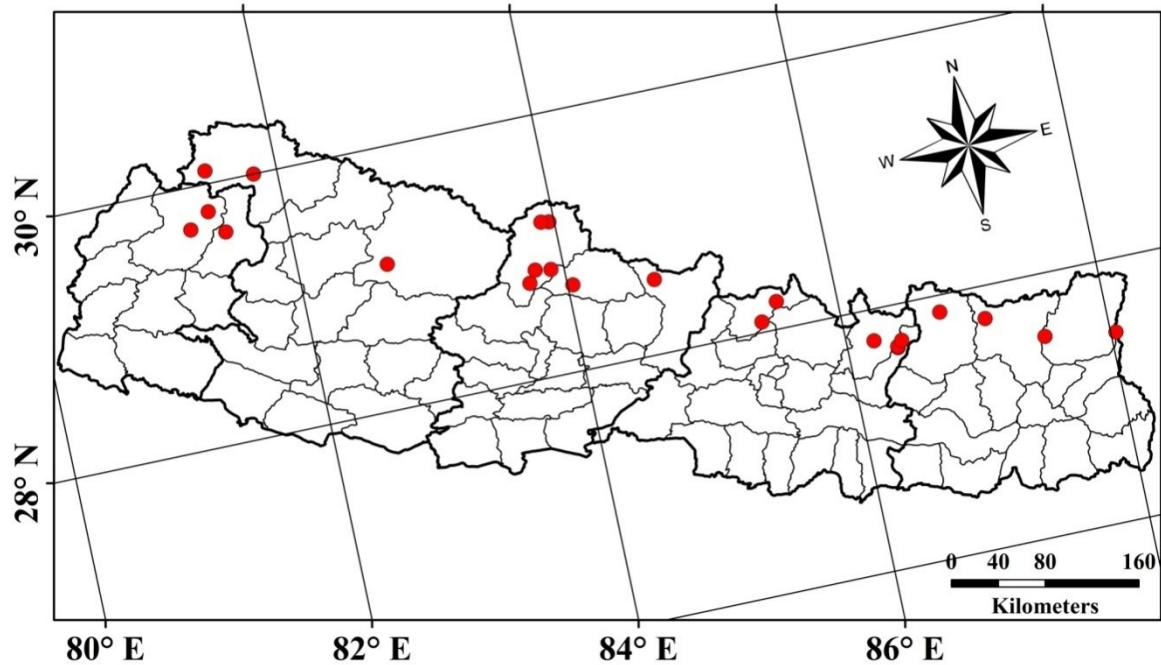


Fig. 29 Distribution of *Lloydia serotina* in Nepal based on herbarium record.

Lloydia tibetica Baker ex Oliv. in *Icon. Pl.* **23**: t. 2216 (1892); Hara in *Enum. Fl. Pl. Nep.* **1**: 75 (1978); Press *et al.* in *Ann. Check. Fl. Pl. Nep.* 186 (2000); Chen *et al.* in *Fl. China* **24**: 51 (2000) (Fig. 30).

Giraldiella montana Dammer; *Lloydia montana* (Dammer); P.C. Kuo; *L. tibetica* var. *lutescens* Franchet.

Plant 12-26 cm. Bulb small, covered with tunics. Scape 10-22 cm. Leaves basal, 3-10 in number, filiform, 11-25 × 0.1-0.25 cm, apex blunt. Inflorescence 1-5 flowered raceme; leaf like bracts 2 or 3, linear, filiform, 1.2-2.5 × 0.05-0.1 cm; pedicel 1-1.5 cm. Flowers drooping, yellow with purplish green veins, campanulate. Outer tepals broader than the inner, outer 1.2-2 × 0.6-0.9 cm, inner 1.2-2 × 0.3-0.6 cm, hairy at base adaxially; nectaries at the base of tepals. Filaments yellow, hairy; anther yellow, 1-2 mm. Ovary ovoid, 3-4 mm; stigma capitate or obscurely 3-lobed. Capsule loculicidal. Seed ovoid, winged.

Distribution range: Nepal (Fig. 31), E Himalaya, Tibetan Plateau.

Altitude: 2300–4100 m.

Ecology: Shady slopes, mossy rock edges, grasslands.

Flowering: May–July.

Fruiting: July–August.

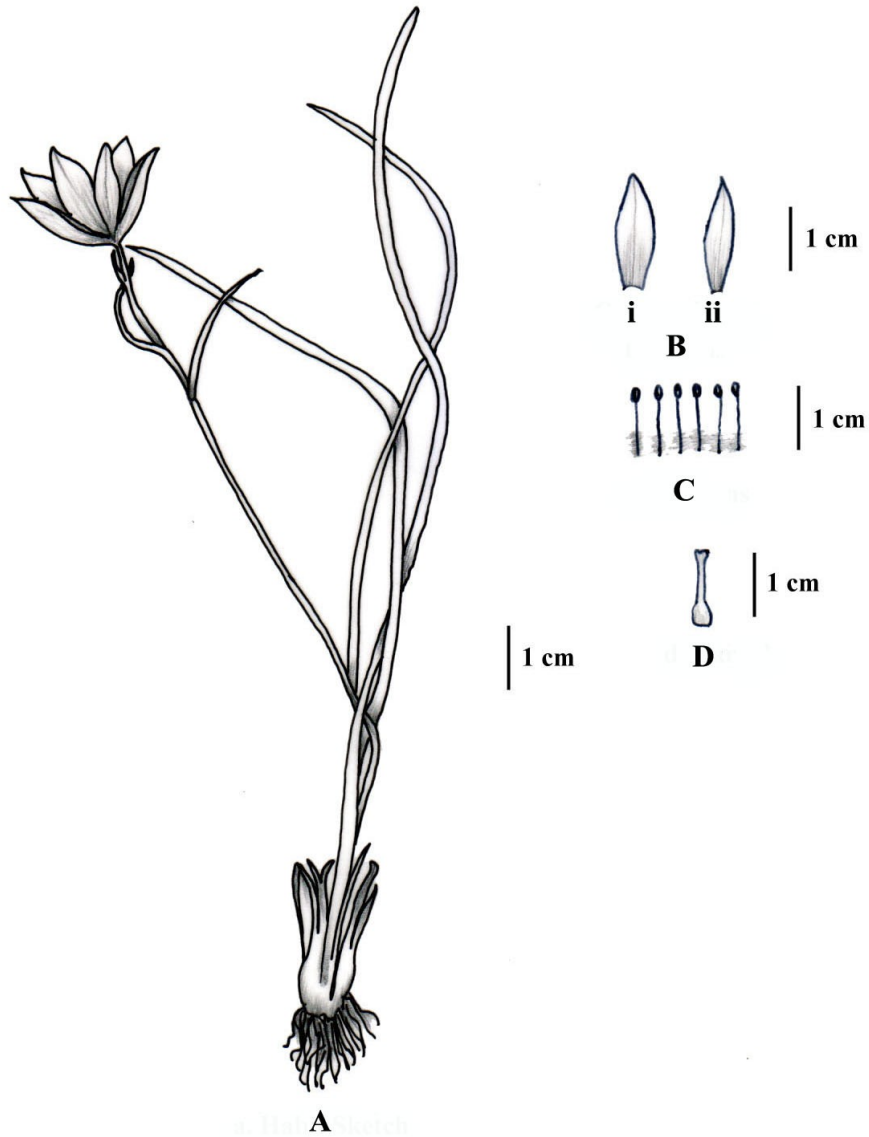


Fig. 30 *Lloydia tibetica* Baker ex Oliv.; **A.** Habit sketch (based on Stainton, Sykes and Williams 1018 E); **B.** Tepals: i) Inner and ii) Outer, **C.** Stamens and **D.** Carpel (based on Description from Flora of China).

Specimens examined

Western Nepal: Mustang, Lete, S. of Tukucha, Kali Gandaki, 12000 ft, 7th June 1954, Stainton, Sykes and Williams, 1018 (E).

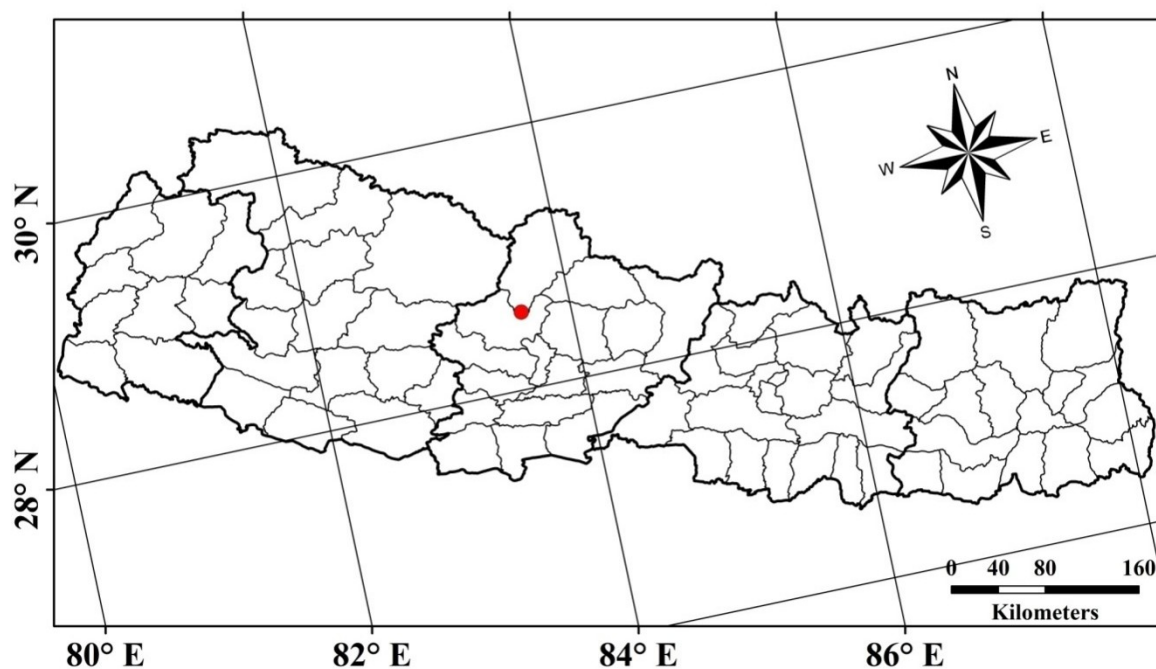


Fig. 31 Distribution of *Lloydia tibetica* in Nepal based on herbarium record.

Lloydia yunnanensis Franch., J. De Bot. **12 (12)**: 192 (1898); Noltie in Fl. Bhutan **3 (1)**: 110 (1994); Press *et al.* in Ann. Check. Fl. Pl. Nep. 186 (2000); Chen *et al.* in Fl. China **24**: 51 (2000); Rajbhandari and Maharjan in Cat. Nep. Fl. Pl. **1**: 23 (2010) (Fig. 32).

Plant 10-14 cm tall. Bulb clumped tunicate. Scape 10-30 cm. Leaves basal, 1 or 2 in number, often exceeding scape, linear, filiform, 0.5-1 mm wide, blunt tipped. Inflorescence single terminal flower; pedicel *c.* 5 mm. Flowers drooping, white with reddish brown veins, campanulate; leaf like bracts upto 5 in number, 0.8-1.5 × 0.5-0.8 cm; pedicel 5 mm. Tepals unequal, outer wider than inner; outer tepal oblong, 1.7-2 × 0.4-0.6 cm, inner one oblanceolate, 1.7-2 × 0.3-0.4 cm. Filaments 4-6 mm, glabrous; anthers oblong, 2-2.5 mm. Ovary ovoid, 3-4 × 1.5 mm; style 0.7-1 cm; stigma 3-lobed. Capsule loculicidal. Seeds winged oblong.

Distribution range: Nepal (Fig. 33), E Himalaya, Assam–Burma, Tibetan Plateau.

Altitude: 2300–4300 m.

Ecology: Forest margins, scrub, shady places on slopes, grasslands, damp mossy rocks along valleys.

Flowering: June–July.

Fruiting: July–August.

Specimens examined

Central Nepal: Sindhupalchok, Helambu, 4267 m, 10th June 1972, John and Naomi Bishop, WF 71 (KATH).

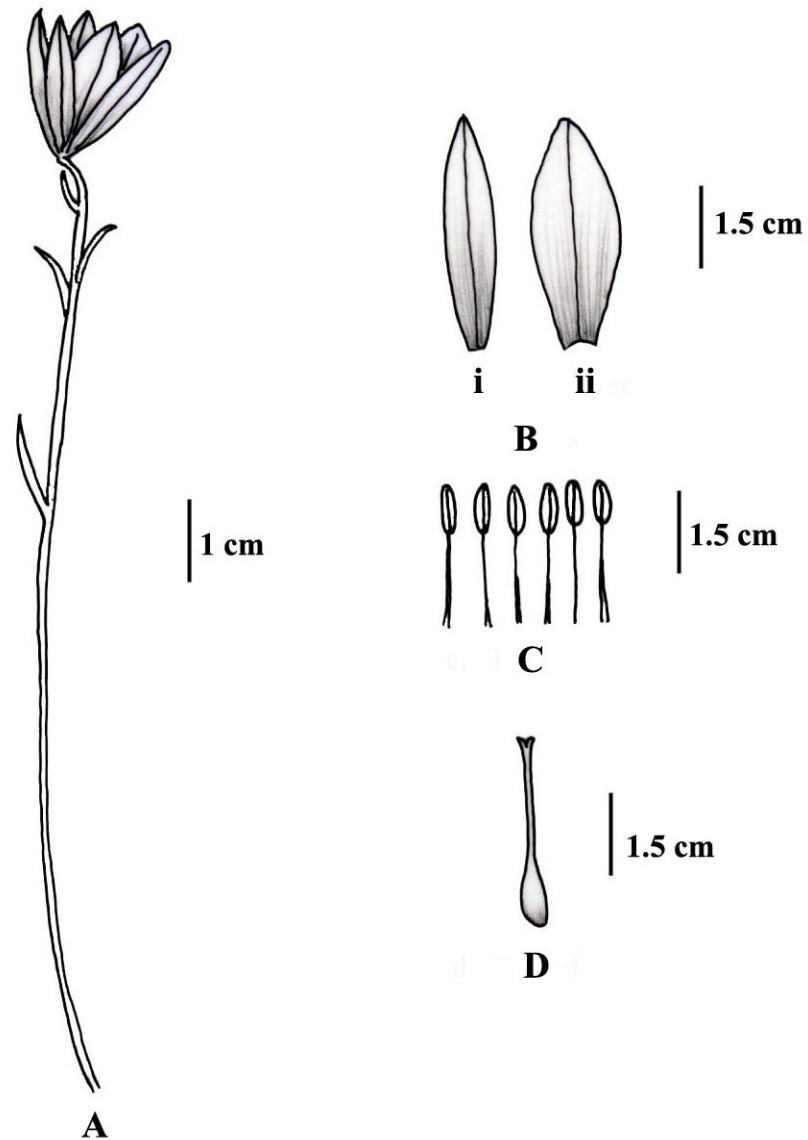


Fig. 32 *Lloydia yunnanensis* Franch.; **A**. Habit sketch, **B**. Tepals: i)Outer and ii) Inner, **C**. Stamens and **D**. Carpel (based on John and Naomi Bishop, WF 71 KATH).

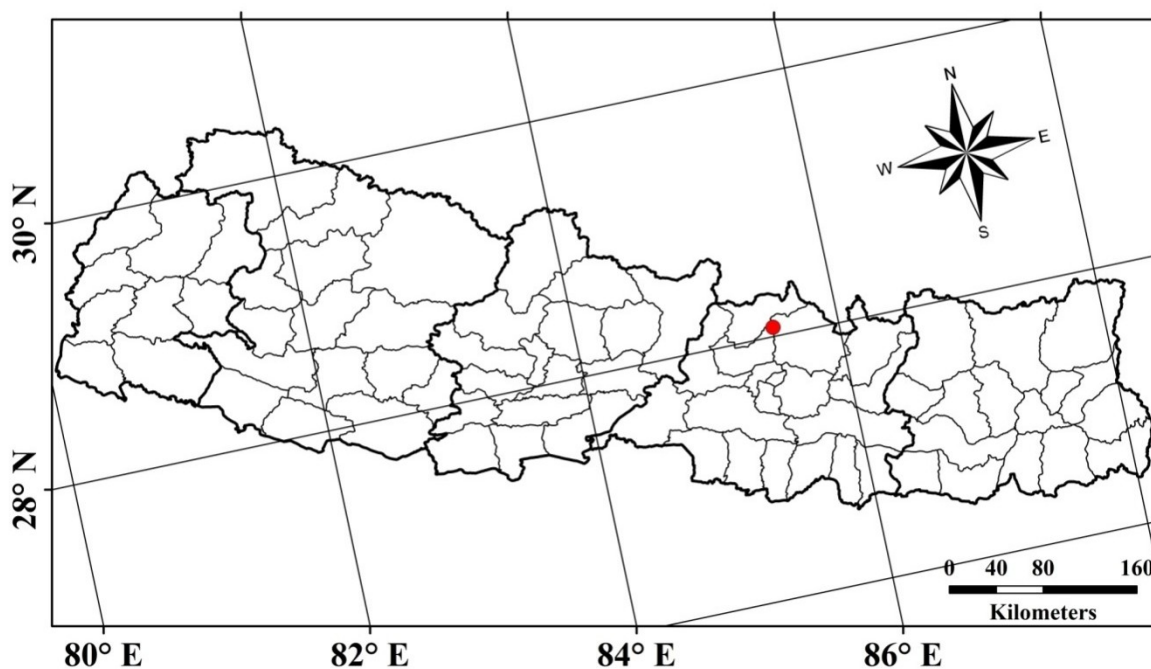


Fig. 33 Distribution of *Lloydia yunnanensis* in Nepal based on herbarium record.

6. *Notholirion* Wall. ex Boiss., Fl. Orient. 5: 190 (1882)

Herb perennial, bulbiferous. Bulb cylindrical, covered with tunics. Stem erect, stout. Leaves alternate, sessile, linear to linear lanceolate. Inflorescence a terminal raceme, few to many flowered, bracteate; pedicel short. Flowers campanulate to funnel shaped, usually blue or purple. Tepals 6, free. Stamens 6, inserted at base of tepals; filaments filiform; anthers dorsifixed. Ovary 3-loculed, ovules many per locule; style slender; stigma 3-lobed. Fruit many seeded capsule.

Worldwide five species. Three species in Nepal.

Key to the species

- Plant under 35 cm; inflorescence 2-7-flowered raceme.....**N. macrophyllum**
- Plant over 60 cm; inflorescence more than 10-flowered raceme.....**N. bulbuliferum**

Notholirion bulbuliferum (Lingelsh.) Stearn, Kew Bull. **1950**: 421 (1950); Hara in Enum. Fl. Pl. Nep. **1**: 75 (1978); Noltie in Fl. Bhutan **3** (1): 106 (1994); Press *et al.* in Ann. Check.

Fl. Pl. Nep. 186 (2000); Chen *et al.* in Fl. China **24**: 62 (2000); Rajbhandari in Cat. Nep. Fl. Pl. **1**: 24 (2010) (Fig. 34).

Liliastrum bulbuliferum (Lingelsh.) Rothm.; *Lilium hyacinthinum* E. H. Wilson; *Notholirion hyacinthinum* (E. H. Wilson) Stapf.

Basionym: *Paradisea bulbuliferum* Lingelsh. ex H. Limpr.

Bulb tunicate, replaced by mass of tiny bulbils. Stem more than 60 cm tall. Leaves simple, linear lanceolate, 8-20 × 0.5-2.5 cm, entire, many veined, subacute apex. Inflorescence racemose, with more than 10 flowers; pedicel short, 1-3 mm, recurved. Bracteole linear lanceolate, 2.5-7 × 0.2-0.4 cm. Flower horizontal, purple, darker near base inside, campanulate, zygomorphic. Tepals oblanceolate, inner wider than outer, outer 3.5 × 1-1.2 cm, inner 3.5 × 1.2-1.5 cm, apex blunt. Filaments *c.* 3 cm; anthers *c.* 5 mm. Ovary cylindrical, *c.* 1 cm; style *c.* 3.2 cm; stigma short, 3-lobed. Capsule oblong. Seeds oblong.

Distribution range: Nepal (Fig. 35), E Himalaya, Tibetan Plateau.

Altitude: (1830–) 3000–4500 m.

Ecology: Forest among sedges and ferns, thickets, alpine grassy slopes.

Flowering: July–August.

Fruiting: August.

Specimens examined

Western Nepal: Manang, Lamjung Himal, 13500 ft, 15th July 1954, Stainton, Skyes and Williams, 6358 (E); Dharapani to Tal, near Khotro, 1830 m, 15th August 2008, H. Ikeda, T. Kawahara, O. Yano, N. Yamamoto, M.F. Watson, Z.H. Li, M.N. Subedi and S.K. Acharya, 20817133 (E). **Central Nepal:** Sankhuwasabha, Jaljale Himal, around Banduke, 4100 m, 25th July – 3rd August 1991, H. Obha, S. Akiyama, H. Ikeda, S. Noshiro, Y. Omori, M.N. Subedi, T. Kikuchi and M. Wakabayanshi, 9120199 (KATH, TI). Taplejung, Tamur valley, Mewa Khola, Topke Gola, 10500 ft, 13th July 1956, J.D.A. Stainton, 983 (E).

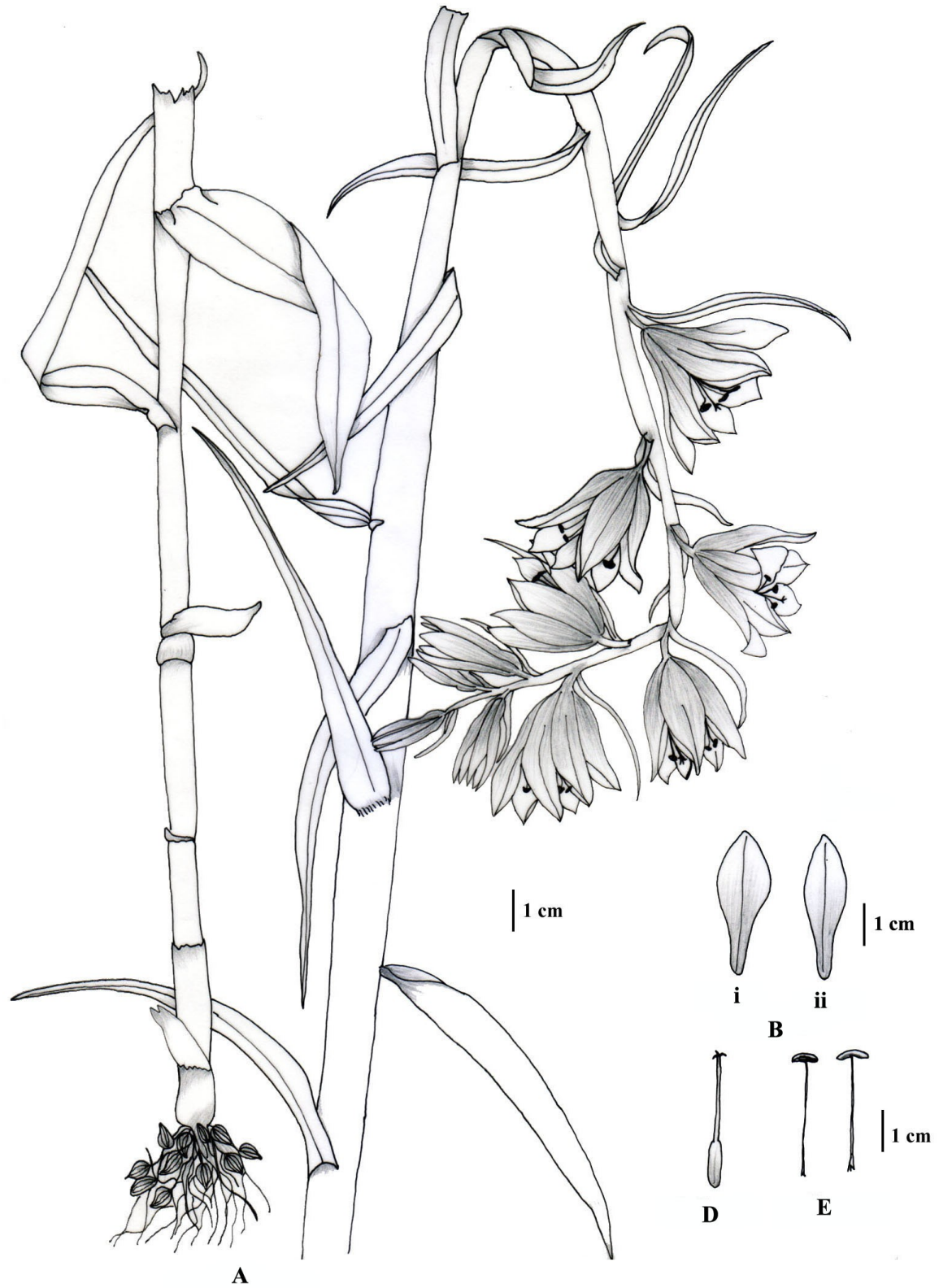


Fig. 34 *Notholirion bulbuliferum* (Lingelsh.) Stearn; **A.** Habit sketch, **B.** Tepals: i) Inner and ii) Outer, **C.** Stamens and **D.** Carpel (based on H. Obha, S. Akiyama, H. Ikeda, S. Noshiro, Y. Omori, M.N. Subedi, T. Kikuchi, and M. Wakabayanshi, 9120199 KATH, TI).



Fig. 35. Distribution of *Notholirion bulbuliferum* in Nepal based on herbarium record.

Notholirion macrophyllum (D. Don) Boiss., Fl. Orient. **5**: 190 (1882); Hooker in Fl. Brit. Ind. **6**: 352 (1896); Hara in Fl. E. Himal. 409 (1966); Hara in Enum. Fl. Pl. Nep. **1**: 75 (1978); Bull. Dept. Med. Pl. Nep. **6**: 219 (1976); Noltie in Fl. Bhutan **3** (1): 105 (1994); Press *et al.* in Ann. Check. Fl. Pl. Nep. 186 (2000); Chen *et al.* in Fl. China **24**: 62 (2000); Rajbhandari in Cat. Nep. Fl. Pl. **1**: 24 (2010) (Fig. 36).

Fritillaria macrophylla D. Don.; *Lilium hookeri* Baker; *Lilium macrophyllum* (D. Don) Voss.

Basionym: *Fritillaria macrophylla* D. Don.

Type specimen: Rasuwa, Gossain Than, Gardner, (*in Herb Wallich*) s.n., Aug 1819.

Holotype: BM.

Bulb 1.5-5 × 1.2-2.5 cm, with whitish scale of 2.5-4.5 × 1-2 cm, covered with tunics. Stem leafy, erect, 15-35 cm. Basal leaves 14-35 × 1.5-2 cm, cauline leaves linear-lanceolate, 8.5-20 × 0.2-1.5 cm. Inflorescence 2-5(-7)-flowered raceme; flower subtended with leaf-like bracts; pedicel 1-2.2 cm. Flowers horizontal, purple, campanulate, weakly zygomorphic. Tepals oblanceolate, inner wider than outer, outer 2.5-5 × 0.6-1 cm, inner 2.5-5 × 0.9-1.7 cm, apex blunt. Filaments 1.7-2.2 cm; anthers 0.4-1.5 cm. Ovary cylindrical, 0.6-1.2 cm; style 2.5-3.5 cm; stigma 3-lobed. Capsule oblong, 1.4 × 1 cm. Seeds irregular triangular.

Distribution range: Nepal (Fig. 37), E Himalaya, Tibetan Plateau.

Altitude: 2500–4400 m.

Ecology: Coniferous, mixed or broadleaved forests, moist or shady grassy slopes, rocky place, alpine meadows.

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

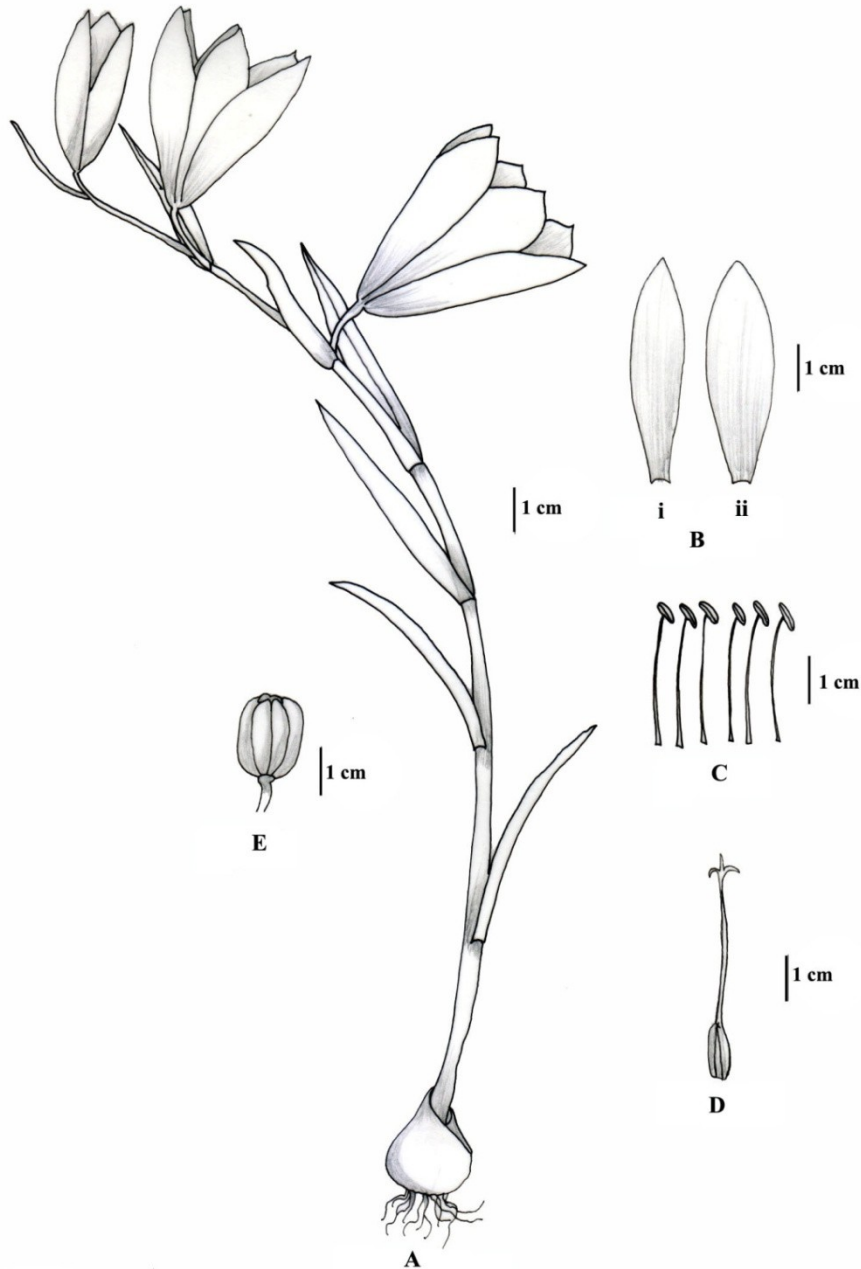


Fig. 36 *Notholirion macrophyllum* (D. Don) Boiss.; **A.** Habit sketch (based on H.K. Saiju and S.R. Tuladhar, 35/79ST KATH); **B.** Tepals: i) Outer and ii) Inner, **C.** Stamens and **D.** Carpel (based on P.R. Shakya, K.R. Rajbhandari and H.K. Saiju 2946 KATH); **E.** Fruit (based on P.R. Sharma, H.N. Subedi and R.K. Uprety, 8782 KATH).

Specimens examined

Western Nepal: Mustang, Lete, south of Tukucha, 9000 ft, 18th September 1954, Stainton, Skyes and Williams, 7921 (E); Pina–Ghurchi, 2670 m, 23rd August 1985, P.R. Sharma, H.N. Subedi and R.K. Uprety, 8782 (KATH). *Baglung*, Dhorpatan, 3300 m, 23rd June 1979, H.K. Saiju and S.R. Tuladhar, 35/79ST (KATH). *Lamjung*, Chamche, 1300 m, 20th April 2000, K. Gurung, 4 (TUCH). **Central Nepal:** *Rasuwa*, Langtang–Thangshab–Ghora–Chumna Lodge–Lama Lodge, 3500-3200-3000-2800-2470 m, 23rd July 1992, H. Takayama, K. Arai, H. Hatta, T. Noshiro, F. Miyamoto, M.N. Subedi and S. Takatsuki, 9233127 (KATH, E); above Langtang, 3400 m, 21st September 2011, H.K. Rana and S.K. Rana, LSA 32 (TUCH). *Ramechhap*, Serdingma–Dubikharka, 3400–3720 m, 07th July 1985, H. Obha, T. Kikuchi, M. Wakabayashi, M. Suzuki, N. Kurosaki, K.R. Rajbhandari and S.K. Wu, 8570269 (KATH, TI). **Eastern Nepal:** *Solukhumbu*, Namche bazaar, 3200 m, 6th July 1970, J.F. Dobremez, DBR NEP N331 (KATH). *Taplejung*, Tamur Valley, Walangchung gola, 11000 ft, 18th July 1956, J.D.A. Stainton, 1039 (E) (see Appendix 2 for more details).

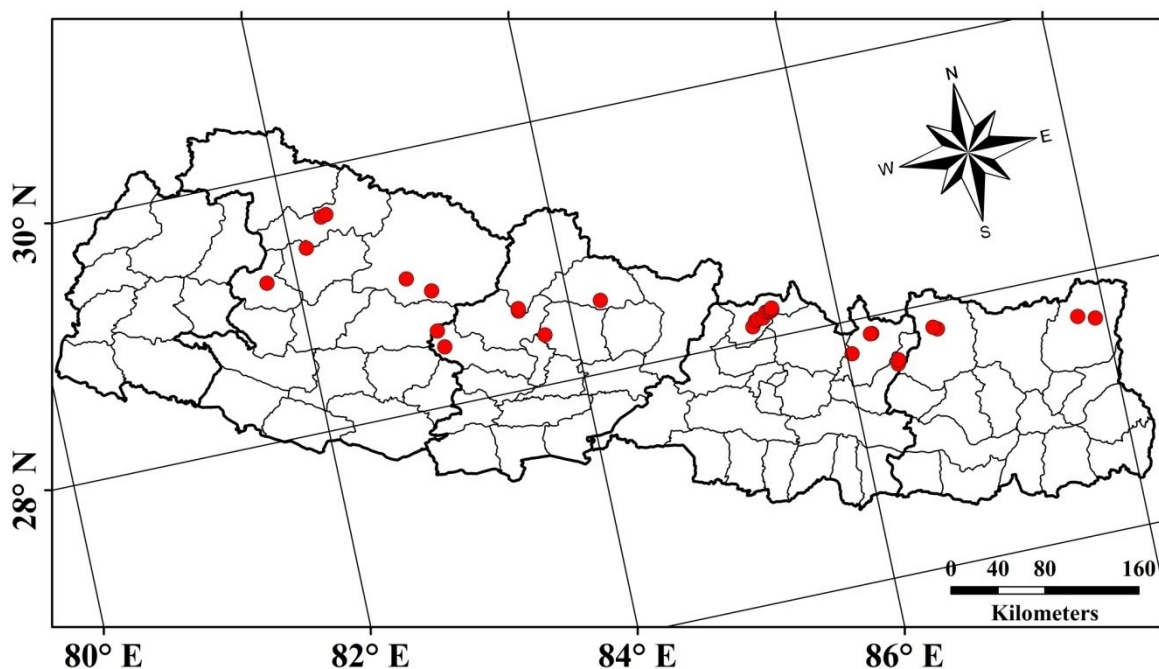


Fig. 37 Distribution of *Notholirion macrophyllum* in Nepal based on herbarium record.

B. MEDEOLEAE Bentham

Synonymy: *Medeolaceae* Takhtajan

Herb perennial, rhizomatous. Stem unbranched. Leaves simple, arranged in single or two whorls, obovate to oblanceolate, parallel venation, sessile to subsessile. Inflorescence short racemes or umbel-like. Flowers many, solitary. Tepals 6, with nectaries at base. Stamens 6, inserted at the base of tepals; anthers oblong-ovate-linear. Ovary rounded or cylindrical. Fruit a berry. Seeds rounded.

Worldwide two genera. Single genus in Nepal.

Clintonia Raf., *Amer. Monthly Mag. & Crit. Rev.* **2**: 266 (1818)

Herb perennial; rhizome short. Leaves in basal rosette, simple, entire. Inflorescence a terminal raceme or umbel; rachis and pedicels usually elongate in fruit. Flowers small campanulate, whitish or bluish, complete, actinomorphic. Tepals 6, free. Stamens 6, inserted at base of tepals, filaments filiform. Ovary 3-loculed; stigma 3-lobed. Fruit a berry.

Worldwide five species. One species in Nepal.

Clintonia udensis Trautv. & C.A. Mey., *Reise Sibir.* **1** (Theil 2, Bot. Lief. 3): 92 (1856); Hooker in *Fl. Brit. Ind.* **6**: 361 (1896); Hara in *Fl. E. Himal.* 407 (1966); Hara in *Enum. Fl. Pl. Nep.* **1**: 71 (1978); Noltie in *Fl. Bhutan* **3** (1): 94–95 (1994); Press *et al.* in *Ann. Check. Fl. Pl. Nep.* : 184 (2000); Chen *et al.* in *Fl. China* **24**: 79 (2000); Rajbhandari in *Cat. Nep. Fl. Pl.* **1**: 20 (2010) (Fig. 38).

Clintonia alpina Kunth ex Baker; *C. udensis* var. *alpina* (Kunth ex Baker) H. Hara.

Basionym: *Clintonia alpina* Kunth ex Baker

Rhizome stiff. Scape 10-35cm, usually upto 90 cm in fruiting, densely pubescent. Leaves 3-5, elliptic-ovovate or oblanceolate, 8-35 × 3-10 cm, margins usually pubescent; petiolate. Inflorescence racemose or umbellate, 2-12-flowered; bracts 3.5-5 × 1.2-2.5 mm; pedicel shorter when flowering, 0.4-1 cm, longer, curving upward when fruiting 4-5 cm. Flowers

white or bluish, streaked mauve, campanulate. Tepals oblanceolate, 0.8-1.2 × 2-4 mm.

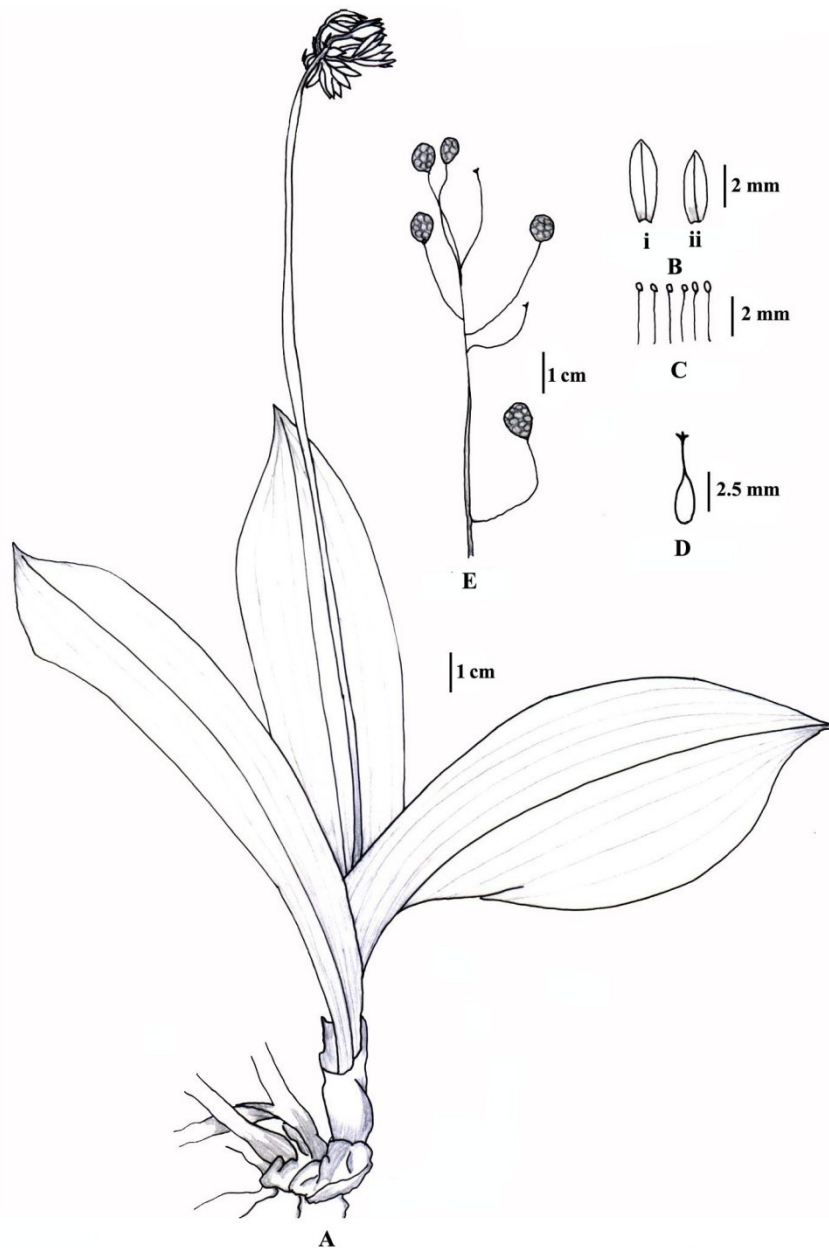


Fig. 38 *Clintonia udensis* Trautv. & C.A. Mey; **A.** Habit sketch (based on T.B. Shrestha, 15735 KATH); **B.** Tepals, **C.** Stamens and **D.** Carpel (based on T.B. Shrestha, 5106 KATH); **E.** Fruits (based on F. Miyamoto, M. Amano, H. Ikeda, C.M. Joshi, K. Arai and T. Komatsu, 9588106 KATH).

Filaments 3-6 mm; anthers oblong, *c.* 1 mm. Ovary ellipsoid, 3-4 mm; style 2-4 mm. Berries globose or ellipsoid, 6-8 × 6-8 mm. Seeds many, globose.

Distribution range: Nepal (Fig. 39), E Himalaya, Assam–Burma, Tibetan Plateau, E Asia, N Asia.

Altitude: 1600–4000 m.

Ecology: Sparse coniferous or mixed forests or subalpine forests, under tree shades.

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

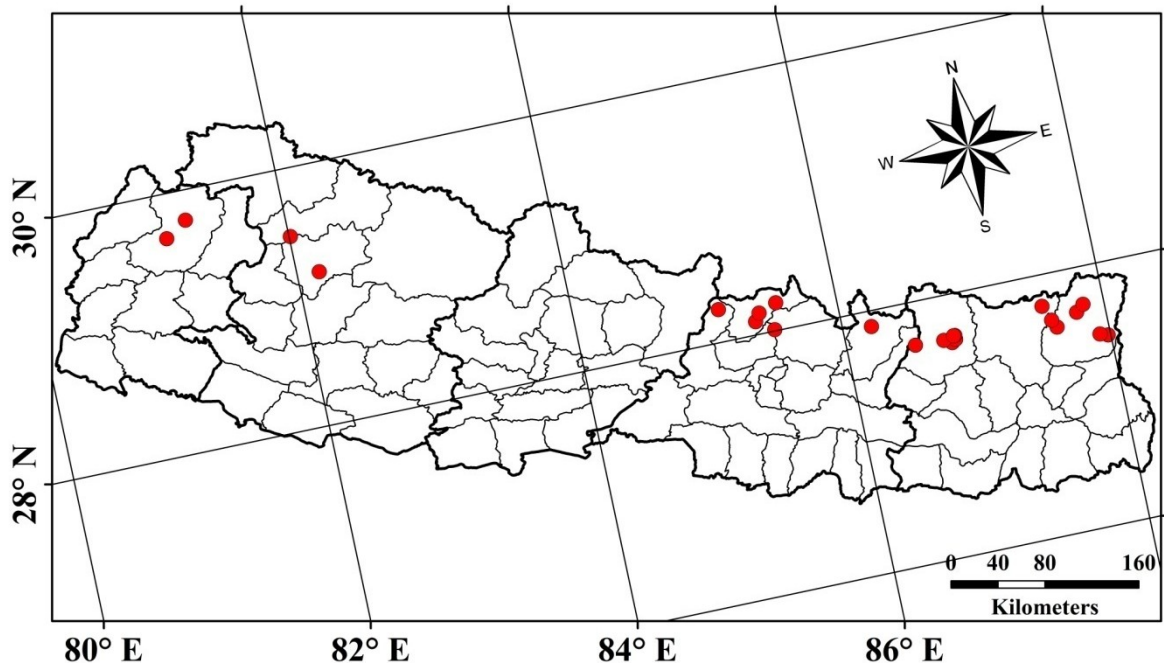


Fig. 39 Distribution of *Clintonia udensis* in Nepal based on herbarium record.

Specimens examined

Western Nepal: *Bajhang*, Thegundanda–Surma sarowar, 11000 ft, 6th June 1965, T.B. Shrestha, 4175 (KATH). *Jumla*, Rara–Chaudhabise dhara, 11000 ft, 15th June 1966, T.B. Shrestha, 5106 (KATH); Camp site–Quadrat#5 (*Abies*)–Gothichaur, 3800–3340–2760 m, 16th November 1991, M. Minaki, K.K. Joshi, Y. Kadota, H. Sugita, A. Takahashi, S. Tsuda, H. Yagi and C. Yonebayashi, 9104261 (KATH). *Manang*, Banglep, 3150 m, 25th May 1973, Shakya and Bhattacharya, 2323 (KATH). **Central Nepal:** *Rasuwa*, Langtang, 12500 ft, 28th July 1965, Schilling, Sayers and Bista, 471 (KATH); Chilime and Langtang valley (Oo Kharka–Kul Kharka), 3400–3800 m, 1st July 1970, 6236 (KATH). *Dolakha*, Beding, 3300 m, 20th may 1979, N.P. Manandhar and M.K. Adhikari, 1647 (KATH). **Eastern Nepal:** *Solukhumbu*, Rangdu Kharka–Mosom Kharka–Horsola Kharka, 3300–3800 m, 10th August 1997, M. Wakabayashi, M. Amano, M. Mori, K.R. Rajbhandari and K. Shinozaki, 9715123 (KATH). *Sankhuwasabha*, Thasing Dingma–Sanu Khola–Saure Kharka, 3320–3515–3735 m, 4th April 1995, F. Miyamoto, M. Amano, H. Ikeda, C.M. Joshi, K. Arai and T. Komatsu, 9588106 (KATH). *Taplejung*, Kangrang La, 12000 ft, 17th June 1969, T.B. Shrestha, 15735 (KATH) (see Appendix 2 for more details).

II. STREPTOPOIDEAE

Synonymy: *Scoliopaceae* Takhtajan

Herb perennial, rhizomatous. Stem usually branched or sometimes unbranched. Leaves simple, sessile, lanceolate to elliptic. Flower borne singly, axillary or terminal, pendulous. Tepals 6. Stamens 3, inserted at base of tepals; filaments flattened; anthers basifixed. Ovary 3-angled; style divided at least at the apex. Fruit a berry. Seeds rounded, striate.

Worldwide three species. Single genus in Nepal.

Streptopus Michx., Fl. Bor.-Amer. 1: 200 (1803)

Herb perennial, with a creeping rhizome. Stem leafy, erect, simple or branched distally. Leaves alternate, simple, sessile with amplexicaul base, ovate to lanceolate, many veined. Flower borne singly or two on leaf axils. Flowers white, campanulate, complete, actinomorphic. Tepals 6, free. Stamens 6, inserted at base of tepals; filaments flattened; anthers basifixed. Ovary 3-loculed; style columnar or very short. Fruit a berry, globose, many seeded.

Worldwide about ten species. Two species in Nepal.

Key to the species

Stem branched distally; filaments shorter than anthers.....**S. simplex**
Stem unbranched; filaments equalling anthers.....**S. parasimplex**

Streptopus parasimplex H. Hara & H. Ohashi, J. Jap. Bot. **48**: 101, f. 2B (1973); Hara in Enum. Fl. Pl. Nep. **1**: 80 (1978); Noltie in Fl. Bhutan **3** (1): 98 (1994); Press *et al.* in Ann. Check. Fl. Pl. Nep. 188 (2000); Rajbhandari in Cat. Nep. Fl. Pl. **1**: 29 (2010) (Fig. 40).

Type specimen: Sankhuwasabha, Thudam, 3400 m, *Kanai, Ohashi, Obha, Iwatsuki, Shakya*, 723120, 22nd Jun 1972. **Holotype:** TI; **Isotype:** TI.

Rhizome short, stolons cream coloured. Stem simple, usually unbranched, 10-35 cm, glabrous. Leaves alternate, simple, sessile, lanceolate to ovate-lanceolate, 3-8 × 1.2-2 cm, 3-7-veined, base rounded, margin entire, apex acuminate. Flowers axillary, solitary; ebracteate;

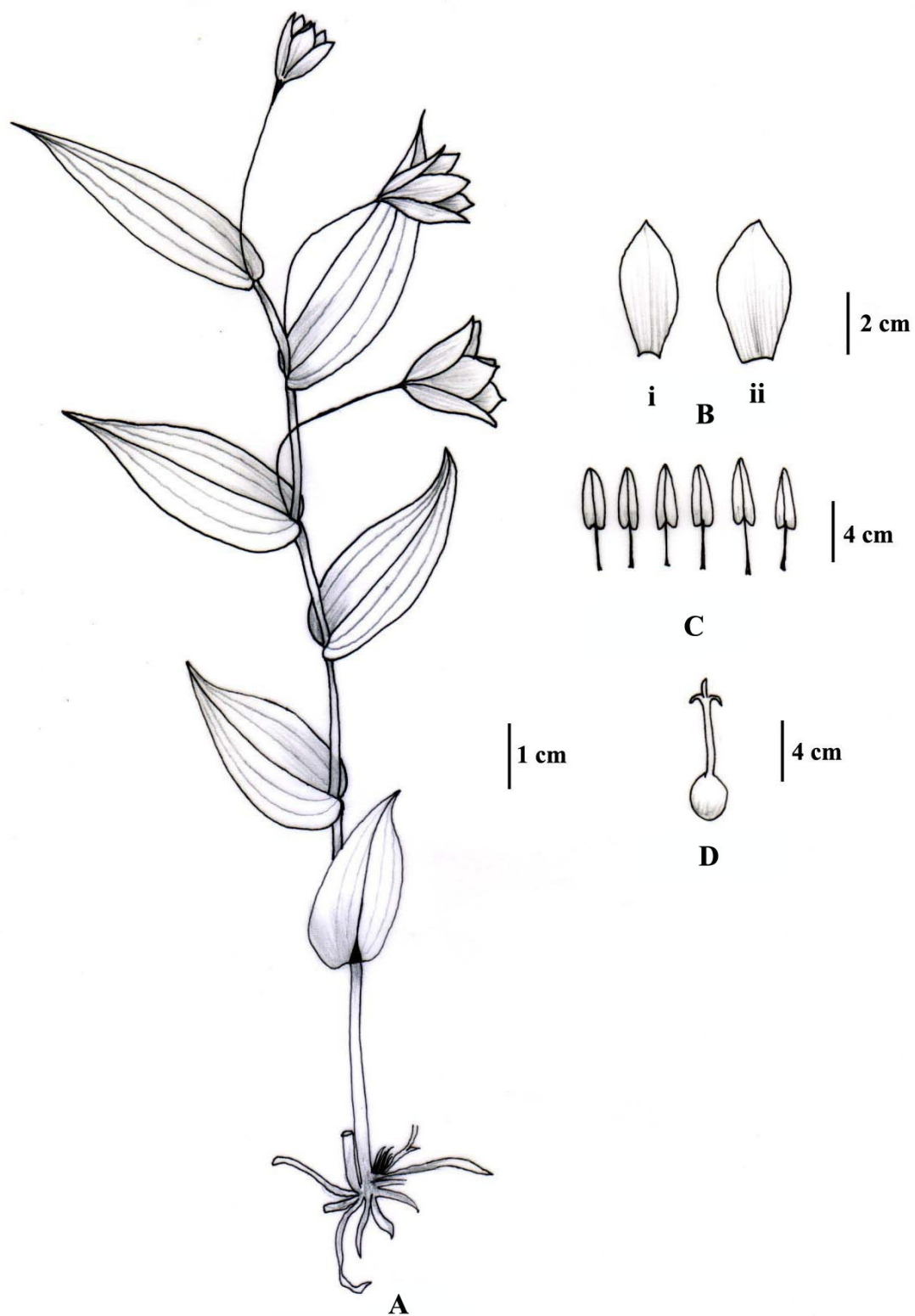


Fig. 40 *Streptopus parasimplex* H. Hara & H. Ohashi; **A.** Habit sketch (based on P.R. Shakya and K.K. Dangol, 10094 KATH); **B.** Tepals: i) Outer and ii) Inner, **C.** Stamens and **D.** Carpel (based on P.R. Shakya, 1468 KATH).

pedicel 1.5-4 cm. Flower drooping, white, spotted purplish, campanulate. Tepals ovate-oblong, inner wider than outer, outer 1-1.5 × 0.3-0.6 cm, inner 1-1.5 × 0.5-0.1 cm. Filaments *c.* 2 mm equalling the anthers; anthers *c.* 2 mm. Ovary ovoid, 2 mm; style slender, 3-4 mm; stigma 3-lobed, short. Berries globose. Seeds oblong.

Distribution range: Nepal (Fig. 41), E Himalaya.

Altitude: 3100–4200 m.

Ecology: Coniferous, mixed or broadleaved forests, shady or exposed slopes, among shrubs, hillsides along streams, alpine grasslands.

Flowering: May–August.

Fruiting: August–October.

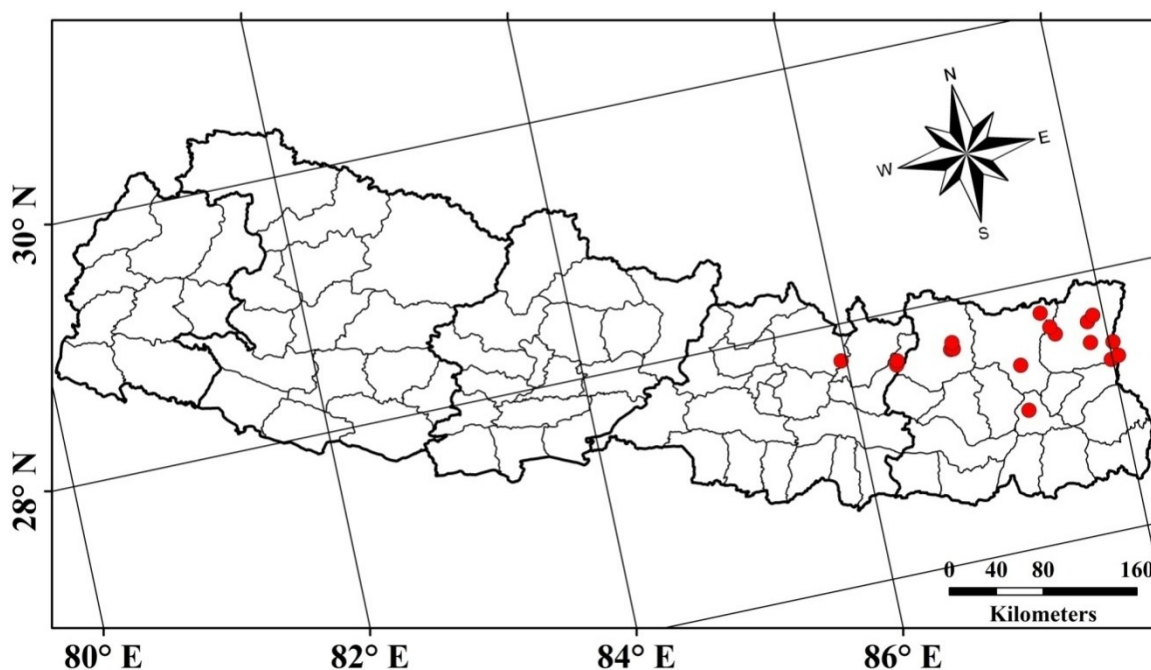


Fig. 41 Distribution of *Streptopus parasimplex* in Nepal based on herbarium record.

Specimens examined

Central Nepal: *Dolakha*, Dobate, 11500 ft, 21st June 1971, T.B. Shrestha and D.P. Joshi, 187 (KATH). *Ramechhap*, Serdingma–Dubikharka, 3400–3720 m, 7th July 1985, H. Obha, T. Kikuchi, M. Wakabayashi, M. Suzuki, N. Kurosaki, K.R. Rajbhandari and S.K. Wu, 8580194 (E). *Dhankuta*, above Hile, 3420 m, 12th June 1972, P.R. Shakya, 1468 (KATH). **Eastern Nepal:** *Sankhuwasabha*, Thudam, 3400 m, 22nd June 1972, H. Kanai, H. Ohashi, K. Iwatsuki, H. Obha, Z. Iwatsuki and P.R.

Shakya, 723/20 (TI); Dhap Kharka, 3200 m, 13th June 1994, P.R. Shakya and K.K. Dangol, 10094 (KATH). *Taplejung*, Kang rang La, 12000 ft, 17th June 1969, T.B. Shrestha, 15742 (KATH). *Panchthar*, Gairi Kharka–Phaleke–Lasune Kharka–Deurali–Rabi Kholabridge–Beteni, 3270–3350–3110–2530–1910–1980 m, 21st June 1992, S. Noshiro, S. Akiyama and N. Acharya, 9240963 (E) (see Appendix 2 for more details).

Streptopus simplex D. Don., Prodr. Fl. Nepal. 48 (1825); Hooker in Fl. Brit. Ind. 6: 322 (1896); Hara in Enum. Fl. Pl. Nep. 1: 80 (1978); Noltie in Fl. Bhutan 3 (1): 97 (1994); Press *et al.* in Ann. Check. Fl. Pl. Nep. 188 (2000); Chen *et al.* in Fl. China 24: 82-83 (2000); Rajbhandari in Cat. Nep. Fl. Pl. 1: 29-30 (2010) (Fig. 42).

Hektorima candida Kunth.

Basionym: *Hektorima candida* (D. Don) Kunth.

Type specimen: Nepal, 1819, **Syntype:** BM. Rasuwa, Gossain Than, Napalia, *Wallich* 5112A, Aug 1821. **Lectotype:** K-W; **Isotype:** BM.

Rhizome short, thick. Stem simple or branched distally, 20–80 cm, glabrous. Leaves simple, sessile, entire, lanceolate to ovate lanceolate, 5-12 × 1.2–5 cm, 5-7-veined, base cordate or rounded, apex acuminate. Flowers arise singly from leaf axils; ebracteate; pedicel 2.5-7 cm. Flower drooping, pink or white, spotted purplish at base, campanulate. Tepals ovate-oblong, inner wider than outer, outer 1-1.8 × 0.4-0.5 cm, inner 1-1.8 × 4.5-8 cm. Filaments flattened *c.* 2 mm, shorter than anthers; anthers *c.* 4 mm. Ovary ovoid, 2-4 mm; style *c.* 3 mm; stigma 3-lobed. Berry 5-7 cm in diameter. Seeds oblong.

Distribution range: Nepal (Fig. 43), E Himalaya, Assam–Burma, Tibetan Plateau.

Altitude: 1800–4000 m.

Ecology: Coniferous or broadleaved forests, bamboo thickets, hillsides along streams, alpine grasslands.

Flowering: May–August.

Fruiting: August–September.

Specimens examined

Western Nepal: *Bajhang*, Ghodilekh, 4000 m, 17th August 1972, M.S. Bista and D.P. Joshi, 496 (KATH). *Myagdi*, South of Gurjakhani, 9800 ft, 6th July 1954, Stainton, Sykes and Williams, 3040 (E). *Parbat*, Banthanti–Gorepani Deorali, 2650-3170 m, 12th July 1983, H. Obha, H. Kanai, M.

Wakabayashi, M. Suzuki and S. Akiyama, 8310332 (E), 8330391 (KATH). **Central Nepal:** Rasuwa, Mul Kharka–Oo Kharka–Yatumbal–Chilime Khola, 3800–2700 m, 7th July 1970, H. Kanai and P.R. Sharma, 166 (KATH). *Dolakha*, Kalinchok danda, 1800 m, 2nd July 1975, P.R. Shaky, K.R.

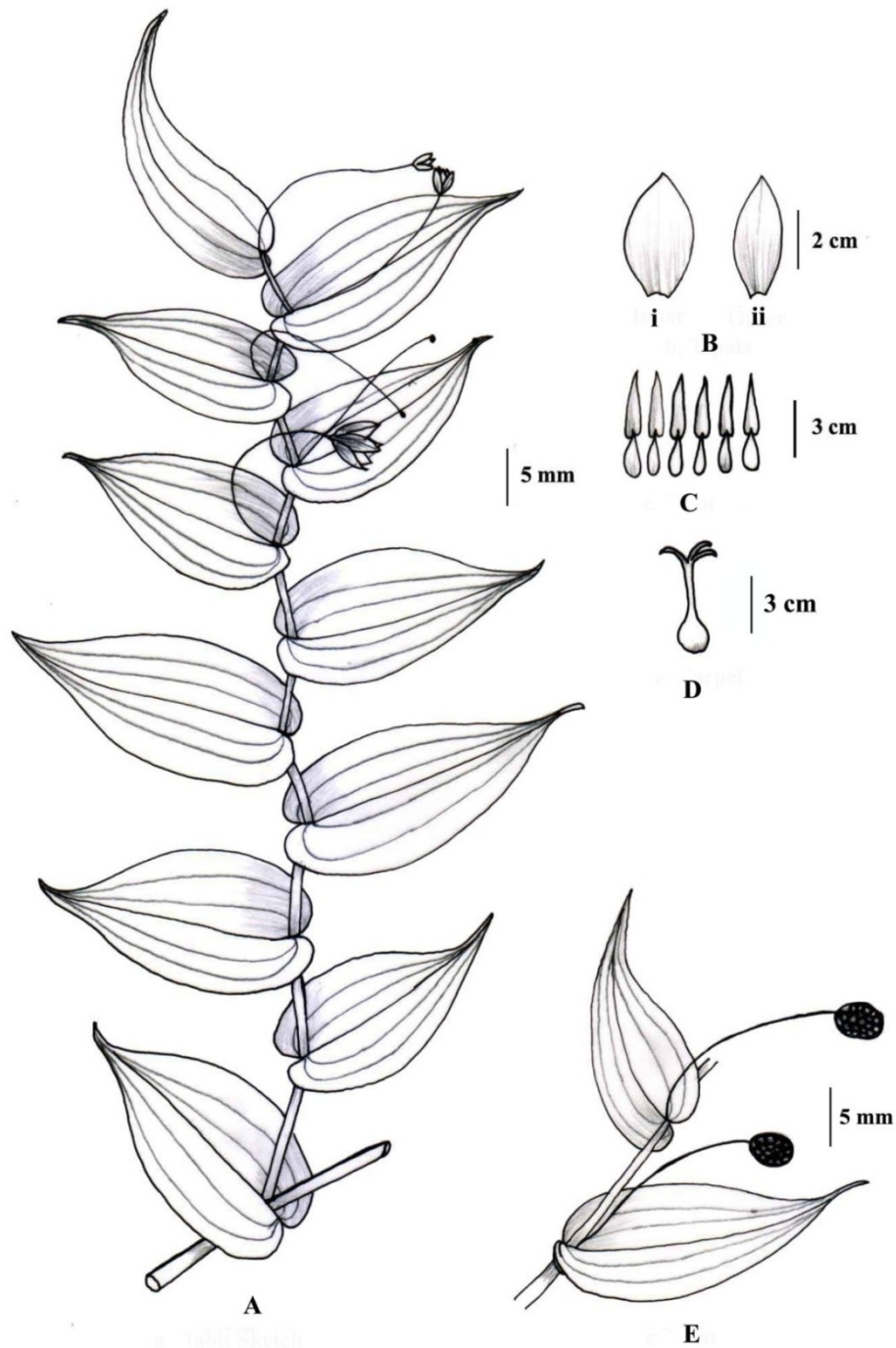


Fig. 42 *Streptopus simplex* D. Don; **A.** Habit sketch (based on H. Kanai and P.R. Sharma, 166 KATH); **B.** Tepals: i) Inner and ii) Outer, **C.** Stamens and **D.** Carpel (based on Dr. Banerjii and P.R. Shaky, 5603 KATH); **E.** Fruit (based on P.R. Shaky, 7168 KATH).

Rajbhandaari, H.K. Saju, 2764 (KATH). *Ramechhap*, Around Neju, 3651 m, 31st July–1st August 1985, H. Obha, T. Kikuchi, M. Wakabayashi, M. Suzuki, N. Kurosaki, K.R. Rajbhandari and S.K. Wu, 8541174 (TI). **Eastern Nepal: Sankhuwasabha**, Bhainsi Kharka–Danda Kharka–Unshisa Kharka–Khongma, 2560–2875–3150–3510 m, 15th July 1988, M. Suzuki, N. Naruhashi, N. Kurosaki, Y. Kadota, M.N. Subedi, M. Minaki, S. Noshiro and H. Ikeda, 8820462 (E). *Dhankuta*, Tute–Dor Pani–Tinjure Phedi, 2340–2660 m, 14th July 1991, H. Obha, S. Akiyama, H. Ikeda, S. Noshiro, Y. Omori, M. N. Subedi, T. Kikuchi, and M. Wakabayashi, 9110057 (KATH). *Taplejung*, Topkegola to Mauwakhola, 11000 ft, 3rd August 1971, T.B. Shrestha and D.P. Joshi, 478 (KATH) (see Appendix 2 for more details).

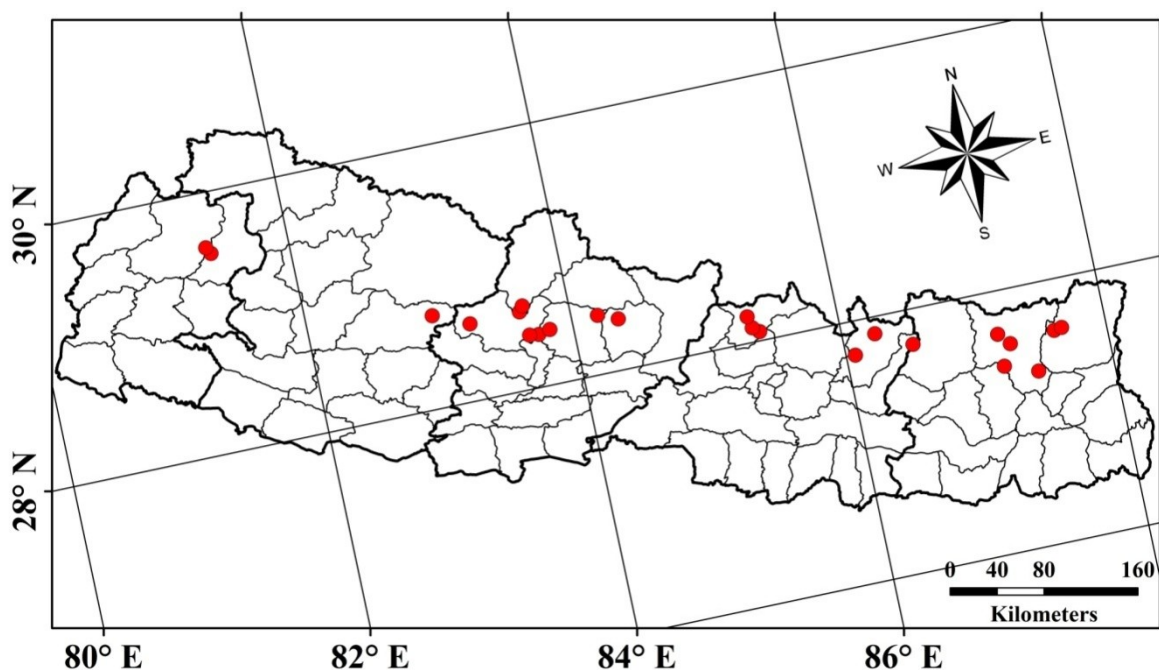


Fig. 43 Distribution of *Streptopus simplex* in Nepal based on herbarium record.

III. CALOCHORTOIDEAE Dumortier

Synonymy: *Calochortaceae* Dumortier, *Compsoaceae* Horaninow, *nom. illeg.*, *Tricyrtidaceae* Takhtajan, *nom. cons.*

Herb perennial, rhizomatous or bulbous. Stem usually branched, sometimes unbranched. Leaves simple, arranged alternate, linear to lanceolate, sessile or sub-sessile. Inflorescence thyrose or racemose. Flowers 2-many, showy, solitary, campanulate, bracteate or ebracteate. Tepals 6; nectaries saccate, present at the base of tepals. Stamens 6, inserted at the base of

tepals; filaments flattened; anthers dorsifixed. Ovary 3-loculed; style divided at least at the apex. Fruit a septicial capsule. Seeds flattened.

Worldwide two species. Single genus in Nepal.

Tricyrtis Wall., Tent. Fl. Nepal. 61 (1826), nom. cons.

Herb perennial, with creeping rhizome. Stem erect, simple or branched. Leaves cauline, alternate, simple, sessile, amplexicaul. Inflorescence terminal raceme. Flowers greenish white with purple spots, campanulate, complete, actinomorphic. Tepals 6, in two whorls, free. Stamens 6, inserted at base of tepals. Filaments flattened; anthers dorsifixed. Ovary 3-loculed; style columnar; stigma 3-lobed. Fruit a capsule.

Worldwide about 18 species. One species in Nepal.

Tricyrtis maculata (D. Don) J. F. Macbr., Contr. Gray Herb., n.s. **3**: 5 (1918); Hooker in Fl. Brit. Ind. **6**: 359 (1896); Hara in Enum. Fl. Pl. Nep. **1**: 80 (1978); Noltie in Fl. Bhutan **3** (1): 98 (1994); Press *et al.* in Ann. Check. Fl. Pl. Nep. 188 (2000); Chen *et al.* in Fl. China **24**: 80 (2000); Rajbhandari in Cat. Nep. Fl. Pl. **1**: 30 (2010) (Fig. 44):.

Compsanthus maculatus (D. Don) Spreng.; *Tricyrtis pilosa* Wallich.

Basionym: *Composita maculata* D. Don

Type specimen: Nepalia (Sheopore et Chandraghury), Wallich s.n., Sep 1821. **Syntype:** K-W.

Rhizome thick, creeping. Stem simple or branched, 35-90(-130) cm. Leaves simple, sessile, lanceolate to oblanceolate, 6-17 × 2.5-7.5 cm, deeply cordate, apex acuminate, glabrous, margin ciliate. Inflorescence terminal, two to many flowered; bracts small; pedicel 2.5-5 cm. Flower greenish or creamy white with purple spots, erect. Tepals spreading horizontally, outer oblong, with two lobed pouches near base, inner narrowly lanceolate, 1.2-1.6 × 4-5 cm. Filaments recurved near tips, hairy, 1.2-1.6 cm; anthers elliptic, 1-2 mm. Ovary narrow, 2-5 mm; style 0.6-1.5 cm; stigma lobes spreading with bifid apices. Capsule triquetrous, septicial, 3-3.5 × 4-6 cm. Seeds flattened.

Distribution range: Nepal (Fig. 45), E Himalaya, Assam–Burma, Tibetan Plateau.

Altitude: 1300–2500(–3900 m).

Ecology: Mixed or broadleaved forests, forest edges, dense, shady or moist slopes, meadows.

Flowering: July–August.

Fruiting: July–September.

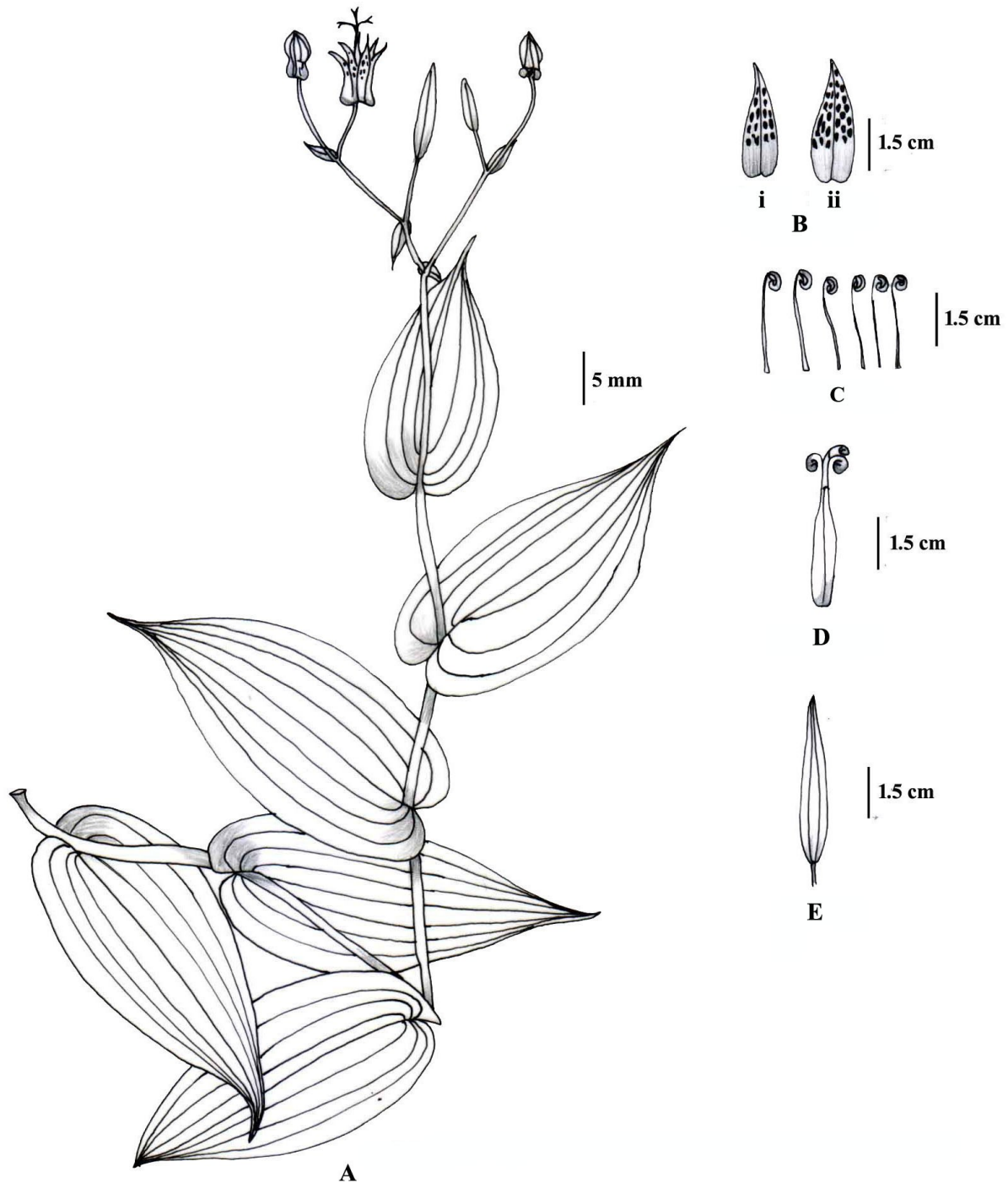


Fig. 44 *Tricyrtis maculata* (D. Don) J.F. Macbr.; H. Hara & H. Ohashi; **A.** Habit sketch (based on T.B. Shrestha and D.P. Joshi, 506 KATH); **B.** Tepals: i) Inner and ii) Outer, **C.** Stamens, **D.** Carpel and **E.** Fruit (based on H. Ohashi, H. Obha, H. Kanai and Y. Tareishi, 770193 KATH).

Specimens examined

Central Nepal: *Rasuwa*, Bhorlang–Latsu–Ingyur, 2300–2240 m, 21st August 1969, Kanai and Malla, 693593 (KATH); Kutungehang–Patibhanjyang, 6–7000 ft, 30th July 1967, Dr. Malla, 9569 (KATH). *Dolakha*, Lhapchu, 3910 m, 21st August 1969, Dr. Malla, 16056 (KATH). **Eastern Nepal:** *Sankhuwasabha*, Furura–Mur–Num, 2050–1600 m, 29th July 1977, H. Ohashi, H. Obha, H. Kanai and Y. Tareishi, 770193 (KATH); Bhotebas–Gogane–Chichila (chichira), 1800–1870 m, 8th July 1988, M. Suzuki, H. Narushashi, S. Kurosaki, S. Noshiro, Y. Hedota, M. N. Subedi, M. Minaki, and H. Ikeda, 8850203 (KATH). *Taplejung*, Mewakhola, 7500 ft, 4th Aug 1971, T.B. Shrestha and D.P. Joshi, 506 (KATH); Shewaden–Papung, 2600–2000 m, 22nd August 1977, H. Ohashi, H. Obha, H. Kanai and Y. Tareishi, 772705 (KATH) (see Appendix 2 for more details).

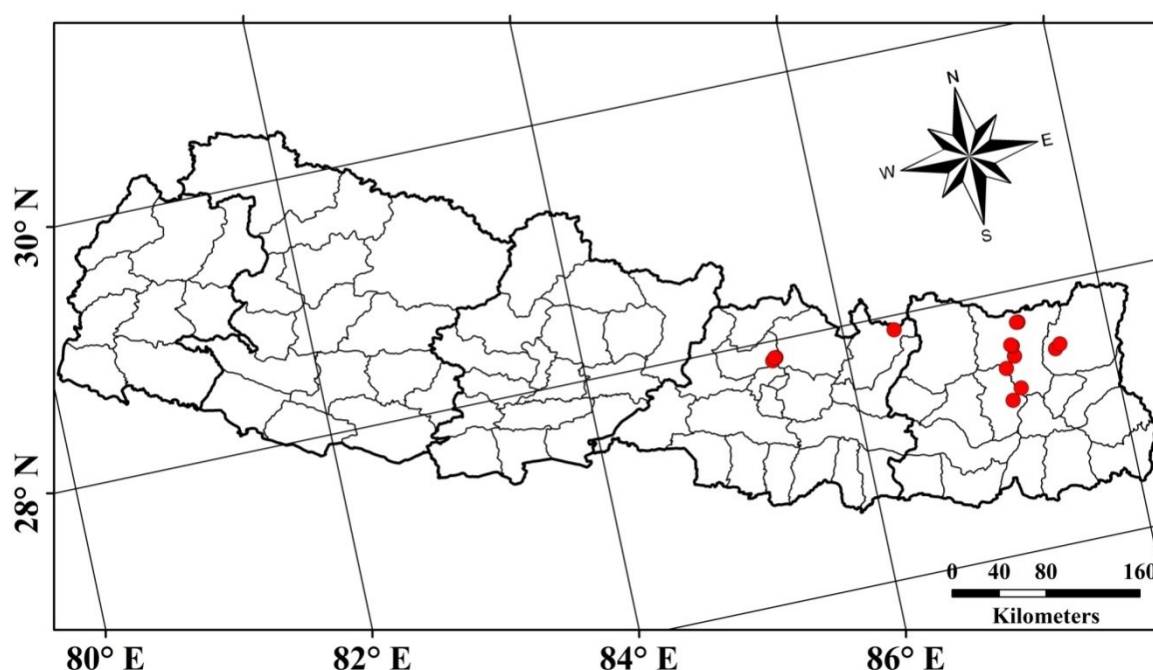


Fig. 45 Distribution of *Tricyrtis maculata* in Nepal based on herbarium record.

4.3 Excluded Species

The following species reported from Nepal were excluded in the present work mainly due to the lack of specimens.

Lilium bakerianum Collette and Hemsl., J. Linn. Soc., Bot. **28**: 138, t.22 (1890).

This species has been mentioned by Press *et al.* (2000) from Eastern region of Nepal only. No herbarium specimen could be traced out while examining the specimens in the herbaria of Nepal, Japan and U.K.

Distribution: Nepal, Assam–Burma, Tibetan Plateau.

Altitudinal range: 1500–3800 m.

Lilium sherriffiae Stearn., J. Roy. Hort. Soc., London. **75**: 192 (1950).

Herbarium specimen for this species was only available from Bhutan. There is no specimen available from Nepal. But, it was mentioned by Press *et al.* (2000) and described by Polunin and Stainton (1984) in Flowers of the Himalaya from eastern region of Nepal.

Distribution: Nepal, E Himalaya.

Altitudinal range: 2700–4000 m.

Notholirion thomsonianum (Royle) Stapf., Kew Bull. 1934: 95 (1934).

This species was mentioned in Press *et al.* (2000) from eastern region of Nepal. It was also described in Flowers of the Himalaya by Polunin and Stainton (1984). But, no herbarium specimen could be traced out from the herbaria under study. So, it is also not included in the present study.

Distribution: Nepal, W Himalaya, SW Asia.

Altitudinal range: 800–1800 m.

4.4 Hierarchical Cluster Analysis

Cluster analysis for the phenotypic similarity was done by identifying the discrete character and character state variation among species. Characters and character states and data matrix containing coded characters taken to analyze the relationship between species are shown in Table 3 and Appendix 3.

Table 3. Character and character states coding.

S.N.	Character	character state
1	Secondary root	Bulb=0, Rhizome=1
2	Scale	Absent=0, Present=1
3	Tunic	Absent=0, Present=1
4	Leaf phyllotaxy	Basal=0, Cauline=1, Both=2
5	Stem branching	Unbranched=0, Branched=1
6	Leaf shape	Ovate=1, Linear/linear lanceolate=1, Elliptic/lanceolate-ob lanceolate=2
7	Leaf venation	Reticulate=0, Parallel=1
8	Leaf petiole	Sessile=0, Petiolated=1
9	Leaf apex	Blunt=0, Subacute/acute=1, Acuminate=2
10	Leaf base	Round or cordate=0, Neither round nor cordate=1
11	Flower stem	Without leaves=0, Leafy=1
12	Flower position	Erect=0, Horizontal/Drooping=1
13	Flower shape	Stellate=0, Campanulate=1, Tubular or funnel shaped=2, Cup shaped=3
14	Attachment of filament	Basifixed=0, Dorsifixed=1
15	Filament surface	Smooth=0, Glabrous=1
16	Ovary shape	Ovoid/globose=0, Oblong ovoid/obovoid=1, Cylindric=2
17	Stigma shape	Capitate/Scarcely 3-lobed=0, Distinctly 3-lobed=1
18	Fruit type	Berry=0, Loculicidal capsule=1, Septicidal capsule=2
19	Seed	Without wings=0, With wings=1

The coded characters (Appendix 3) were used to generate dendrogram (Fig. 46). At the first hierarchy, the dendrogram yielded two main clusters. The first cluster included all the taxa with bulb; whereas the second cluster represented all taxa which bear rhizome. Both the clusters were further divided into two subclusters and many sub-subclusters.

Dendrogram using Average Linkage (Between Groups)

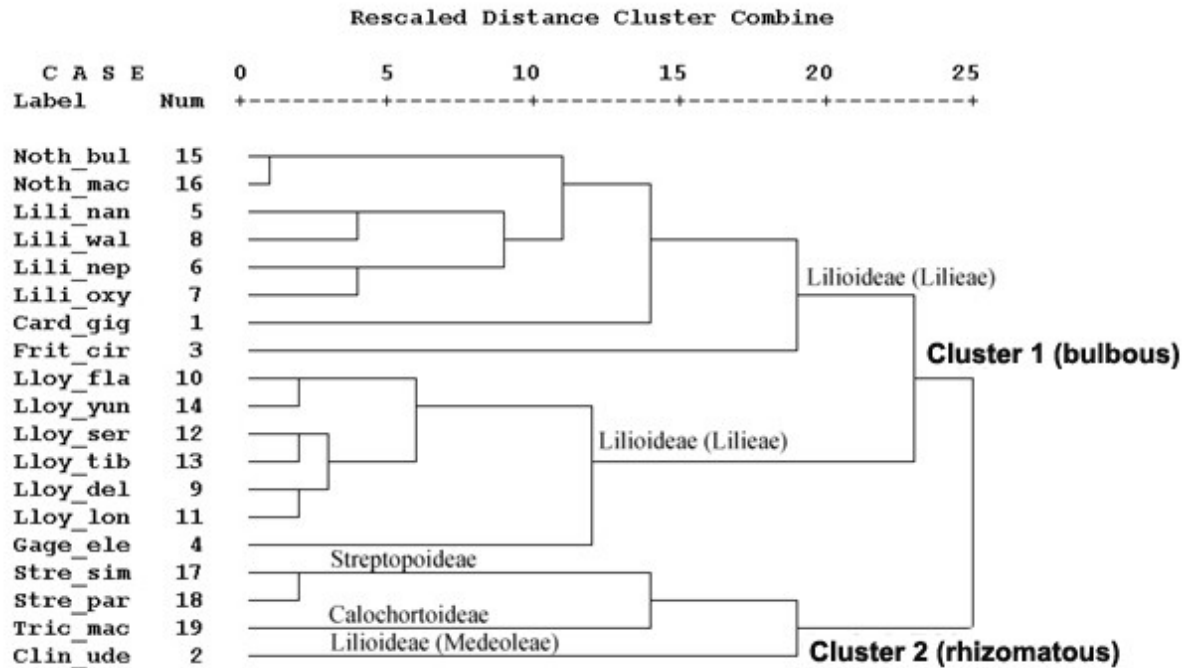


Fig. 46 Dendrogram generated through cluster analysis of morphological characters. (Full forms of species abbreviations in Appendix 4)

Species belonging to the subfamily Lilioideae and the tribe Lilieae (species of genera *Notholirion*, *Lilium*, *Cardiocrinum*, *Fritillaria*) form a subgroup within the cluster 1, indicating that these taxa shares maximum similar characters and have close relationships with each other. Similarly, within the same cluster, species belonging to the subfamily Lilioideae and the tribe Lilieae (*Lloydia flavonutans*, *L. yunnanensis*, *L. serotina*, *L. tibetica*, *L. delicatula*, *L. longiscapa* and *Gagea elegans*) showed close relationship forming another subgroup. In cluster 2, two subgroups were defined, the first was represented by the subfamily Streptopoideae and Calochortoideae; and the second was represented by a single genus of the tribe Medeoleae of the subfamily Lilioideae. The results of cluster analysis revealed that species belonging to the subfamilies Streptopoideae and Calochortoideae are closer to each other, than with the species of the subfamily Lilioideae. Within subfamily Lilioideae, *Clintonia udensis* of the tribe Medeoleae was placed far apart from other species of the same subfamily.

4.5 Flowering and Fruiting Phenology

Flowering in Nepalese Liliaceae starts in March and culminates in November, with peak flowering in June and July during which period almost all of the species are in flower (Fig. 47, Table 4). Earliest flowering (in March) occurs in *Gagea elegans* and late flowering (early August to early November) in *Lilium wallichianum*. Fruiting starts in late May and culminates in late October, but in some species (such as *Lilium wallichianum*) it goes upto early December.

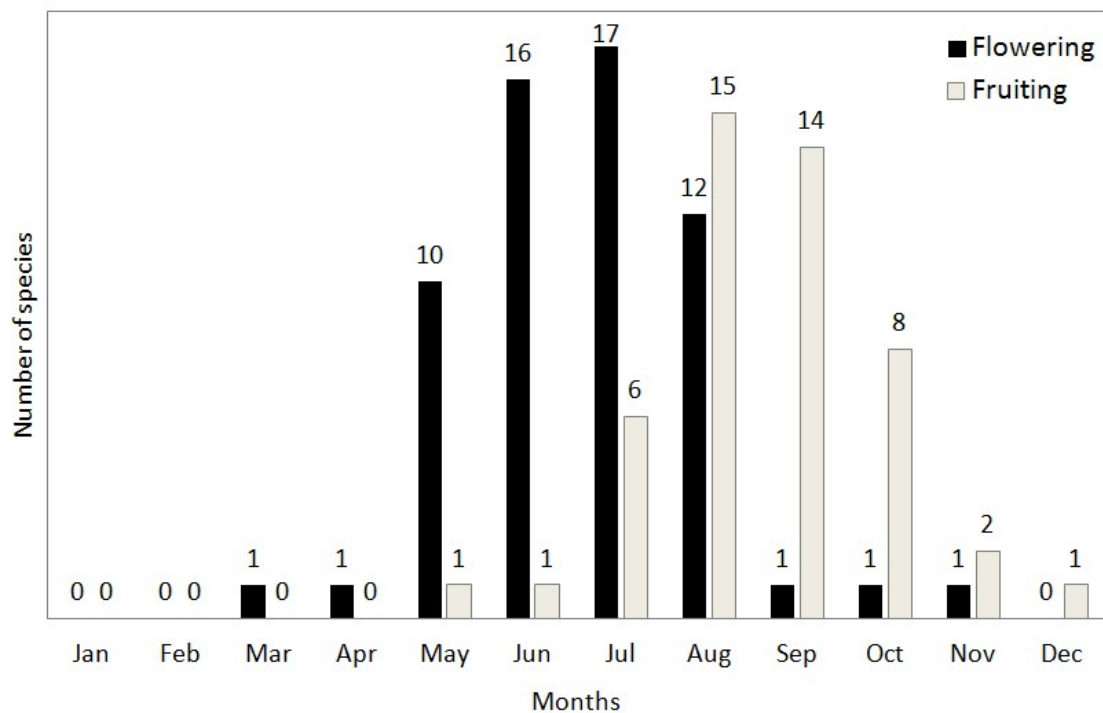


Fig. 47 Flowering and fruiting phenology: number of species in flower or fruit at different months.

Table 4. Phenology (flowering and fruiting months) of 19 species of family Liliaceae in Nepal.

Taxa	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
<i>Cardiocrinum giganteum</i>						→	→	→	→	→		
<i>Clintonia udensis</i>						→	→	→	→	→		
<i>Fritillaria cirrhosa</i>					→	→	→	→	→	→		
<i>Gagea elegans</i>			→	→	→	→	→	→	→	→		
<i>Lilium nanum</i>						→	→	→	→	→		
<i>Lilium nepalense</i>						→	→	→	→	→		
<i>Lilium oxypetalum</i>						→	→	→	→	→		
<i>Lilium wallichianum</i>								→	→	→	→	→
<i>Lloydia delicatula</i>						→	→	→	→	→		
<i>Lloydia flavonutans</i>					→	→	→	→	→	→		
<i>Lloydia longiscapa</i>					→	→	→	→	→	→		
<i>Lloydia serotina</i>					→	→	→	→	→	→		
<i>Lloydia tibetica</i>					→	→	→	→	→	→		
<i>Lloydia yunnanensis</i>						→	→	→	→	→		
<i>Notholirion bulbuliferum</i>							→	→	→	→		
<i>Notholirion macrophyllum</i>						→	→	→	→	→		
<i>Streptopus parasimplex</i>					→	→	→	→	→	→		
<i>Streptopus simplex</i>					→	→	→	→	→	→		
<i>Tricyrtis maculata</i>							→	→	→	→		

Note: upper arrows for flowering and lower arrows for fruiting time.

4.6 Species Distribution in Himalayan Region

All the 19 members of the family Liliaceae under study are also found in Bhutan Himalaya other than the Nepal Himalaya. The number of species occurrence varies in other Himalayas; for example, 12 species are reported from north-west Himalaya, 16 species from Sikkim Himalaya and 15 species from north-east Himalaya (out of total 19 species) (Fig. 48).

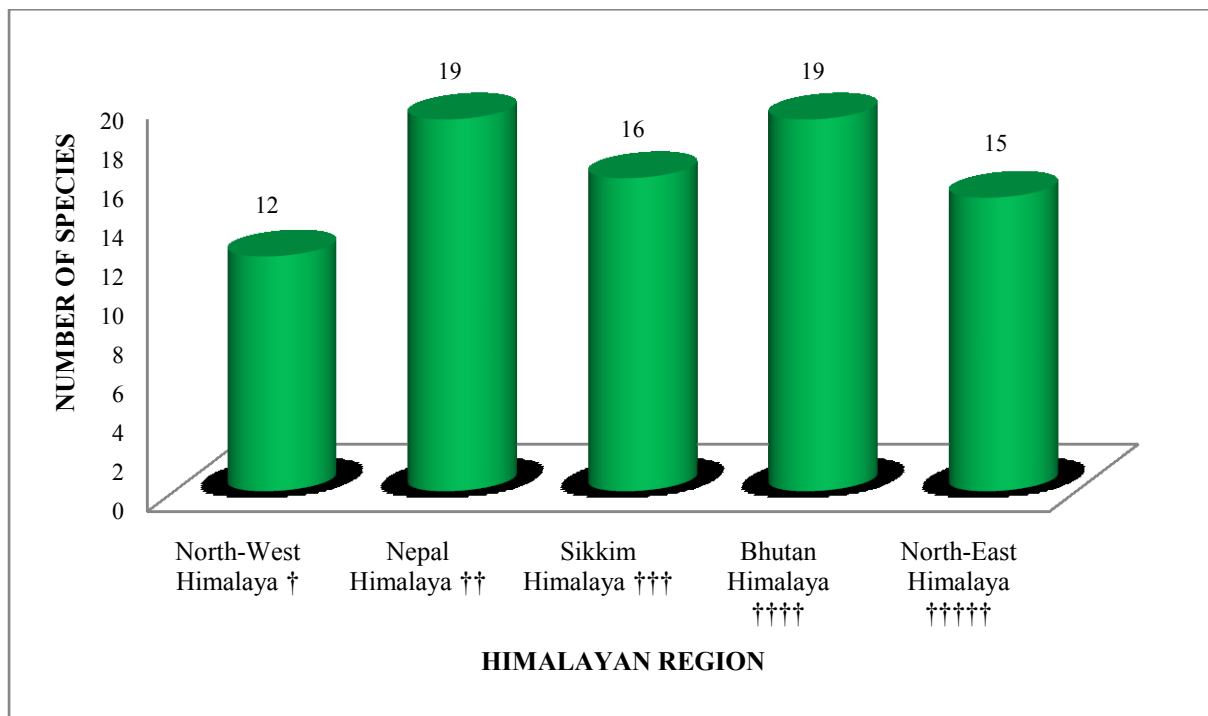


Fig. 48 Distribution of number of species in Himalayan region. **Note:** † Between Afganistan to Garhwal–Kumaon, †† Western border from Mahhakli to eastern border Mechi, ††† Eastern border of nepal and West Bengal to western border between Sikkim and Himalaya, †††† Western border of Sikkim Himalaya and eastern border of north–eastern Himalaya, ††††† Eastern part of India including Meghalaya, Arunachal Pradesh and upto the border of Burma

4.7 Species Distribution Modeling

Among the members of the family Liliaceae, taxa belonging to the subfamily Lilioideae are distributed throughout the northern part of Nepal (Fig. 49). But the model predicted greater concentration of the subfamily Lilioideae in north-central and north-western region than in north-eastern region of Nepal (Fig. 50). The best region for Lilioideae is explained by 20-30 percentile value for north-central Nepal. For the members of the subfamily Streptopoideae north-western region seems to be less favourable than the north-eastern region (Fig. 51).

North-eastern region is with maximum parts of excellent distribution (20-30 percentiles). In the case of the subfamily Calochortoideae, mostly the north-eastern region and very less parts of the north-central region seems to be favourable for species occurrence (Fig. 52). Present distribution of *Tricyrtis maculata* (the only member of the subfamily Calochortoideae) is restricted only to these regions.

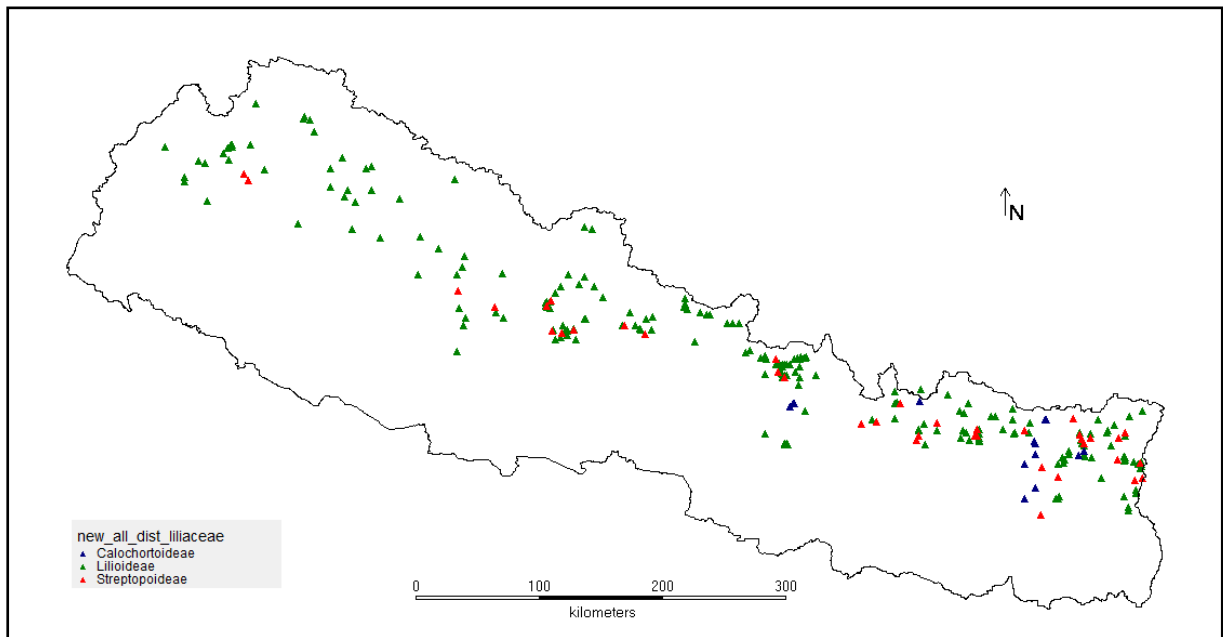


Fig. 49 Overall distribution of Liliaceae in Nepal based on herbarium records of species occurrence points.

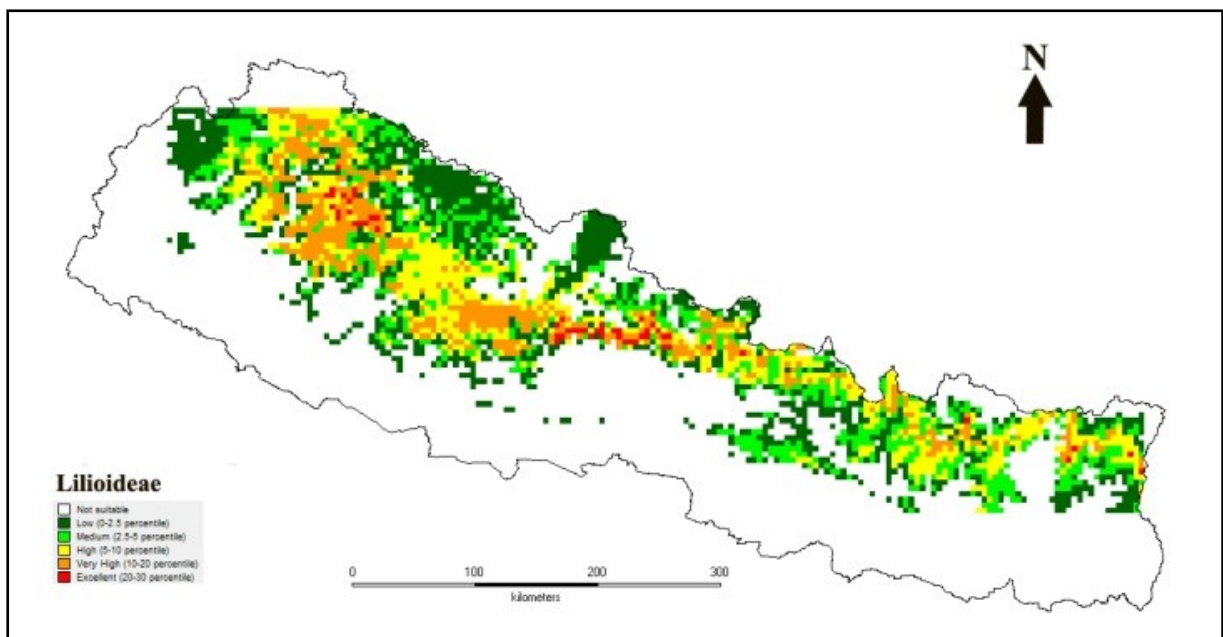


Fig. 50 Current potential distribution of subfamily Lilioideae in Nepal.

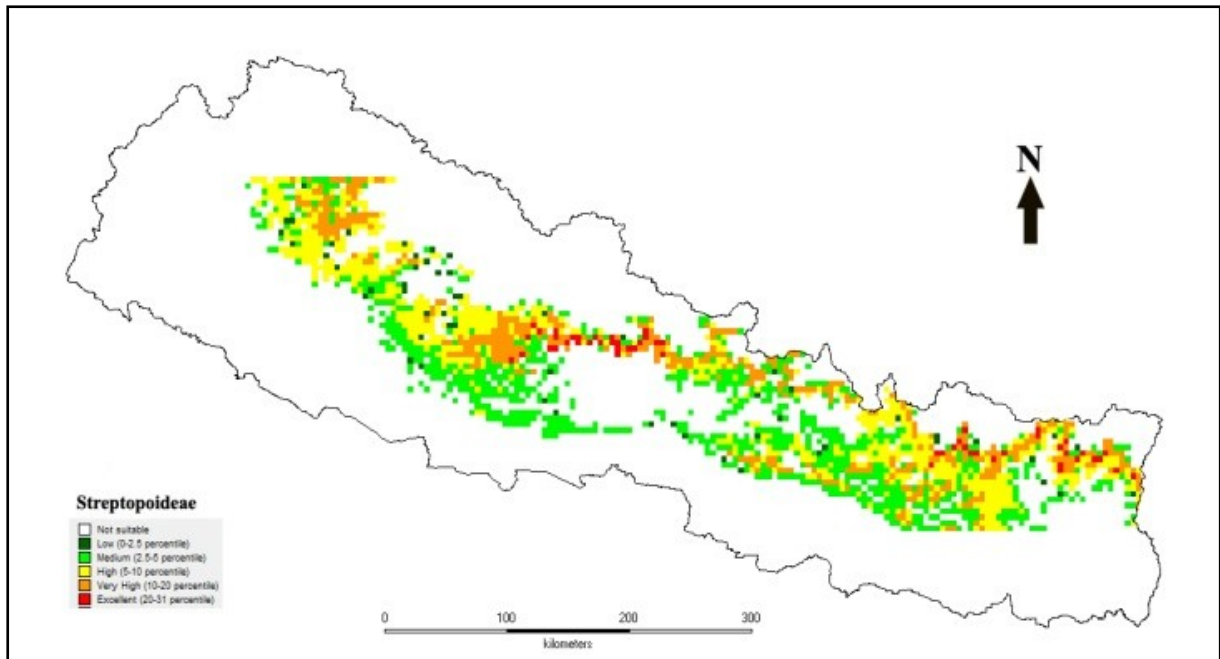


Fig. 51 Current potential distribution of subfamily Streptoipoideae in Nepal.

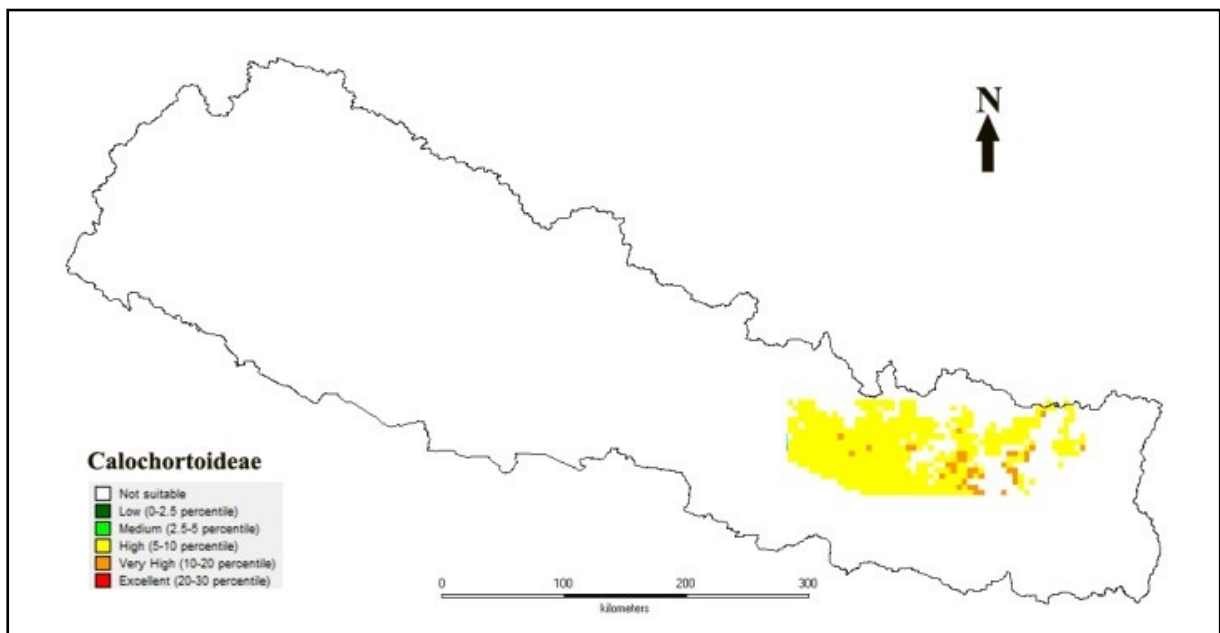


Fig. 52 Current potential distribution of subfamily Calochortoideae in Nepal.

4.8 Species richness

Richness value ranged 1-50. The richness value 50 indicates that all the 19 species occur in a particular locality, and the value below 1 indicates no species occurrence. The results showed maximum species richness (represented by richness value 50) in large part of the north-central and north-western regions as compared to the north-eastern region of Nepal (Fig. 53).

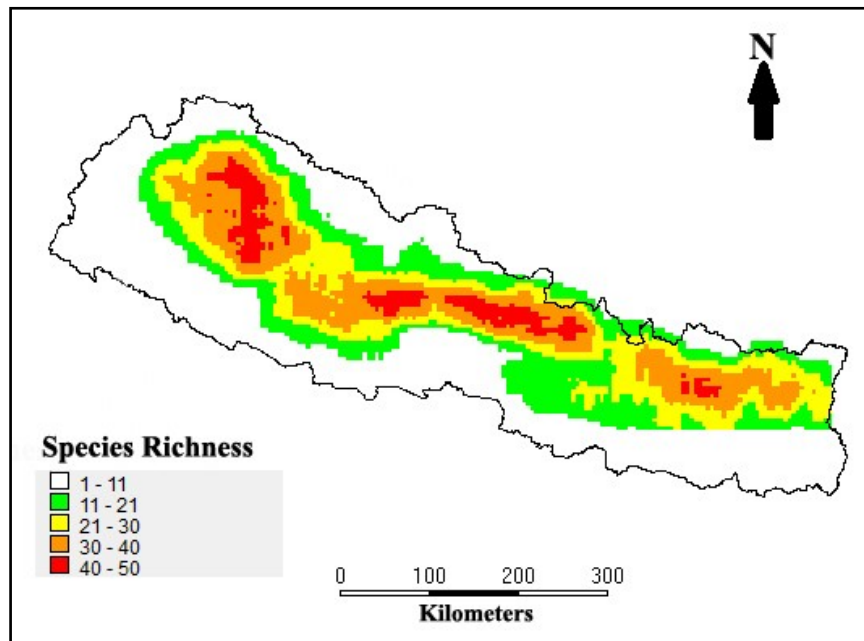


Fig. 53 Species richness pattern of the family Liliaceae in Nepal.

In north-eastern region, fir forest and East Himalayan oak-laurel forest were predicted to be richer in occurrence of species (Fig. 54). For north-central region, coniferous forests (like, fir or chir pine forest), oak forest and alpine pasture were predicted to be suitable associations for members of the family Liliaceae (Fig. 54). The model predicted higher species richness in alpine mats and scrub, fir forest, oak-laurel forest and blue pine-birch or chir pine-broadleaved forest (Fig. 54). These results indicated that fir and oak-laurel forests are highly rich in species occurrence of the family for all the three phytogeographical regions in Nepal. Hill sal forest, *Schima-Castanopsis* forest, nival zone, trans-Himalayan steppe and alpine meadows were the vegetation types with least species richness (Fig. 54).

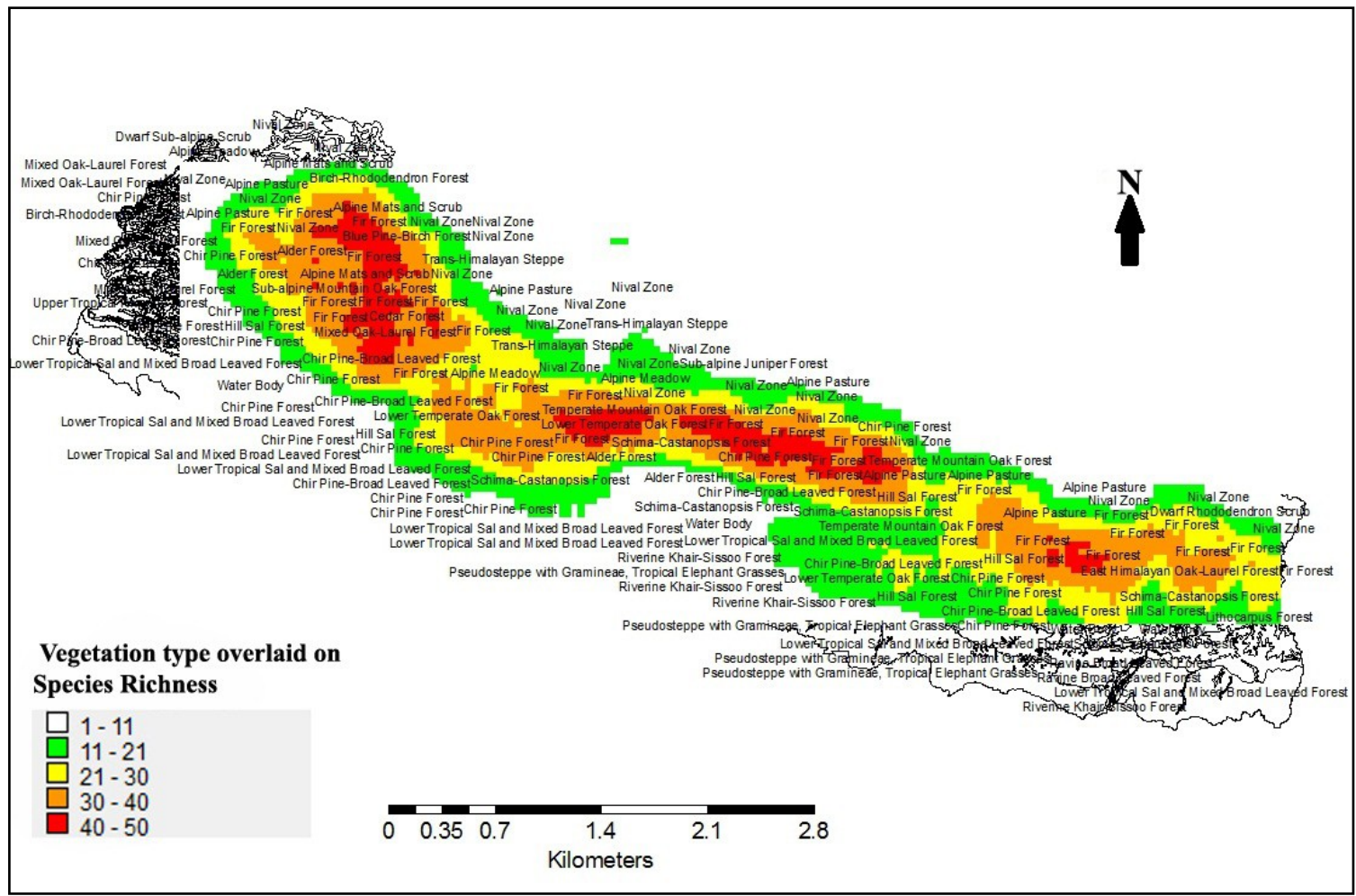


Fig.54 Species richness pattern overlaid by vegetation type for interpretation.

CHAPTER 5

DISCUSSION

5.1 Taxonomy of Liliaceae

In the present study, 19 species, belonging to 9 genera with 2 varieties and 2 forma are described under the family Liliaceae from Nepal. In the present study, only morphological (vegetative and reproductive) characters were used for delineating taxa within the family. Morphological and external form of organism has been and still is the type of information that is mostly used in plant systematic for identifying and delineating the taxa. Plants in family Liliaceae possesses certain specific characteristics which makes them possible to identify.

Some genera viz. *Cardiocrinum*, *Fritillaria*, *Gagea*, *Lilium*, *Lloydia* and *Notholirion* are bulbous members of the family, but other genera (*Clintonia*, *Streptopus* and *Tricyrtis*) are among the rhizomatous members. Noltie (1994) in 'Flora of Bhutan' treated *Cardiocrinum*, *Gagea*, *Lilium*, *Lloydia* and *Notholirion* within the family Liliaceae and *Clintonia*, *Streptopus* and *Tricyrtis* within the family Uvulariaceae because, later are Rhizomatous.

Among the bulbous members of the family, *Fritillaria*, *Lloydia* and *Notholirion* are characterized by tunicate bulbs; whereas, bulbs of *Cardiocrinum*, *Gagea* and *Lilium* are without tunics. The characteristic feature of *Notholirion bulbuliferum* is presence of bulbils.

Leaf character is another feature that distinguishes genera within the family. *Cardiocrinum* is characterized with oval leaf; *Streptopus* and *Tricyrtis* with oblanceolate leaves; *Lloydia* with filiform or linear leaves; *Fritillaria*, *Gagea* and *Notholirion* with lanceolate leaves; and *Lilium* with linear-lanceolate leaves.

Among the reproductive characters, fruit type is the most important character for delineating the genera within the family. Only *Tricyrtis* possess septicidal capsule as fruit, *Clintonia* and *Streptopus* bears berry, and rest of the genera (*Cardiocrinum*, *Fritillaria*, *Gagea*, *Lilium*, *Lloydia* and *Notholirion*) consists loculicidal capsule as fruit.

From the herbarium specimen studied during the present work, *Cardiocrinum giganteum* is up to 1.5 m tall plant. But, Noltie (1994) and Chen *et al.* (2000) described it from Bhutan and China respectively as reaching up to 3-4 m tall. The species of *Clintonia* (*C. udensis*) is distinguished by basal rosette of leaves, umbellate inflorescence and berries as fruit. In contrast, *Fritillaria cirrhosa* is delineated based on cirrhose leaf apex. The single species of *Gagea* (*G. elegans*) is distinguished on the basis of combination of characters like, single basal leaf, umbel-like inflorescence and erect flower.

In genus *Lilium*, two species *L. nanum* and *L. oxypetalum* are characterized with small flowers and tepals under 6 cm. Whereas, other two species *L. nepalense* and *L. wallichianum* have larger, showy flowers and tepal length over 6 cm. Leaves are lanceolate in *L. nepalense* and *L. oxypetalum* and it is linear in *L. nanum* and *L. wallichianum*. These distinguishing characters are also supported by Noltie (1994). But, Hooker (1894) in Flora of British India delineated taxa based on tepal colour.

The species of *Lloydia* are delineated mainly on the basis of leaf characters and filament types. *L. serotina* and *L. yunnanensis* possess up to 2 basal leaves; whereas, other four species possess 3 or more basal leaves. Filaments are hairy in *L. flavonutans*, *L. longiscapa* and *L. tibetica*; but glabrous in *L. delicatula*, *L. serotina* and *L. yunnanensis*. Except these characters plant height and tepal colour are the main characters that separate these species within the genera. Flora of Bhutan (Noltie, 1994) also used filament and tepal characters to delineate these species. Out of total six species of genus *Lloydia* in Nepal, only five species were described in Flora of Bhutan (Noltie, 1994), four species in Flora of China (Chen *et al.*, 2000) and single species in Flora of British India (Hooker, 1894).

The two species of *Notholirion* are distinguished based on plant height and flower number in inflorescence as in Flora of China (Chen *et al.*, 2000). But, Flora of Bhutan (Noltie, 1994) used tepal colour along with plant height and flower number in inflorescence above mentioned characters to separate these species.

In *Streptopus*, the size of filaments and anthers are the characteristic features that delineated two species. *S. simplex* has shorter filaments than anthers whereas, *S. parasimplex* has equal sized filaments and anthers. Noltie (1994) in Flora of Bhutan also distinguished two species on the basis of similar characters. But Chen *et al.* (2000) in Flora of China and Hooker (1894) in Flora of British India described only one species (*Streptopus simplex*).

The member of subfamily Calochortoideae (single genus *Tricyrtis* with single species) is characterized and delineated by its septicial capsule from other members of family Liliaceae.

Hierarchical cluster analysis show two main clusters, the first (cluster 1) represented by bulbous members of the family and the second (cluster 2) consisted of rhizomatous members. It is similar to the classification used by Noltie (1994) in Flora of Bhutan. Both the subclusters of cluster 1 are represented by the species belonging to the subfamily Lilioideae and tribe Lilieae. In subcluster 1, both the species of *Notholirion* are placed together, similarly all the four species of *Lilium* are also placed side by side in dendrogram because of maximum similarity in characters. *Cardiocrinum giganteum* is aligned closer to species of *Lilium* than *Fritillaria cirrhosa*, which indicates maximum sharing of characters. *Cardiocrinum* and *Fritillaria* showed maximum similarity according to dendrogram obtained and this result is also supported by chromosome morphology (Peruzzi *et al.*, 2009; Gao *et al.*, 2012). Subcluster 2 of cluster 1 is also represented by subfamily Lilioideae and Tribe Lilieae. This subcluster contains species belonging to two genera *Gagea* and *Lloydia*. Angiosperm Phylogeny Group (2009) has treated the genus *Lloydia* within *Gagea*. Similarly, Peterson *et al.* (2008) and Zarrei *et al.* (2009) have shown that *Lloydia* is not monophyletic and should be merged with *Gagea*, because of their morphological similarity. Zarrei *et al.* (2011) treated genus *Gagea* as *Gagea s.l.*, including *Lloydia* within the genus. So, the placement of *Gagea elegans* and species of *Lloydia* together in same subcluster is favourable.

Cluster 2 also consists of two subclusters: 1st subcluster is represented by two subfamilies (i.e. Streptopoideae and Calochortoideae) and 2nd subcluster is represented by species of subfamily Lilioideae and tribe Medeoleae. *Streptopus* (Streptopoideae) and *Tricyrtis* (Calochortoideae) shares maximum characters with each other and with *Clintonia* of tribe medeoleae. Noltie (1994) in Flora of Bhutan (1994) treated these three genera into a single family Uvulareaceae other than the family Liliaceae because of their rhizomatous characters. Angiosperm Phylogeny Group (2009) treated *Clintonia* within the subfamily Lilioideae; but, placed in tribe Medeoleae separating it from other members of Lilioideae which are placed in tribe Lilieae. The main reason is difference in modified stem type.

Maximum flowering and fruiting occur in the members of the family during the mid months of the year. There is no flowering or fruiting in the initial months of the year. Flowering peaked during May-August; whereas, fruiting occurs during July-October and goes up to

December in some species. It indicates that maximum species requires rainfall as an essential climatic factor for flowering and fruiting. These observations agree with others (Noltie, 1994; Chen *et al.*, 2000; Malla *et al.* 1986).

Species of the family occur from subtropical zone (above 1100 m) to above alpine zone (>4000 m, Appendix 5). Species occurrence is dominant in temperate to Alpine zone as compared to subtropical zone. This indicates that the Liliaceae species favoured high altitude drier habitats than the lower altitudes. Similarly, north-central region of Nepal seems to be rich in species occurrence, followed by north-eastern and north-western regions.

5.2 Species Distribution Modeling

Members of three subfamilies within Liliaceae differed in distribution pattern. The adaptation to seasonal habitats limits the distribution of species in different regions (West-East) of Nepal (Rajbhandary *et al.*, 2010). The suitability value for potential distribution varies for members of three subfamilies. Some of the areas shows very high suitability and are interesting for future plant collections. One of the reasons for this is that the areas with high suitability were mostly covered by field trips. Some areas with low suitability, however, were not explored. Guarino *et al.* (2002) stated that even limited information can be used to identify areas where a species has not been previously recorded but where it might be expected to occur.

The suitability percentile values ranged 0-30; where 20-30 percentiles measured excellent distribution. The climatic factors where suitability percentile values are highest (20-30) matches with the climatic conditions of actually occurring data points; but, the areas with less than 0 percentile values indicates that climatic factors of actual distribution (based on collection records) do not match with mapping site.

North-central region of the Nepal seems to be most suitable region for species distribution of the subfamilies Lilioideae and Streptopoideae, as they have highest parts with 20-30 percentile of suitability. Rainfall in Nepal is mostly monsoonal, which occur during June to August, and this rainfall decreases sharply from eastern to western Nepal. This creates fairly moderate rainfall in the north-central region of Nepal.

The occurrence of several species of subfamily Lilioideae and Streptopoideae in the north-western and north-far-western regions of Nepal is because of the ability of those species to

cope with marked seasonality in precipitation and prolonged periods of drought. But, there seems overlapping distribution of species belonging to three subfamilies in the north-eastern region of Nepal. Species of subfamily Calochortoideae do not occur in north-western region. It is because they prefer wetter habitats with high humidity even during the drier months.

Most parts of the middle and upper belts of Nepal are climatically suitable for species of these 3 subfamilies, where they are widely distributed.

For subfamily Lilioideae, excellent suitability percentile is represented by north-central region followed by north-western region and very less by north-eastern region. This result indicates that Lilioideae species favoured relatively drier habitat in north-central and north-western region than wetter habitat in north-eastern region. In contrast, predicted potential distribution map of subfamily Streptopoideae shows almost equal parts of north-central and north-eastern regions with 20-30 percentile value. These results indicate that species of subfamily Streptopoideae prefer relatively moist habitat than the species of Lilioideae. Although these two subfamilies show overlapping pattern of distribution from north-western to north-eastern regions, there occurs variation in suitability percentile for species occurrence in these regions.

There is no any region with excellent (20-30) percentile value in predicted potential distribution map of subfamily Calochortoideae. The percentile value lies within 2-20, for all the predicted regions. The reason behind this is lesser number, as well as larger distance between collections records used for modeling.

Species distribution modelling can be a valuable and cost-effective tool for understanding a species occurrence probability with given environmental data, especially in poorly-surveyed regions of the least known species (Guisan *et al.*, 2006).

5.3 Species Richness Pattern

Pattern of species richness was analyzed in 9 x 9 neighborhood grid size for the family. The results showed that species richness value was highest in north-central and north-western regions than in the north-eastern region of Nepal. Their occurrence in these regions indicates that the species requires a relatively small amount of water to establish. Except for the similarities in climatic factors of actually recorded data points and the modeled sites of

potential distribution, other reasons for occurrence of such pattern are: firstly, species richness is based solely on specimen data and hence missing data for locality will be interpreted as zero species leaving many areas for which there are no collections; secondly, only species which have a fairly wide modeled distribution will have an impact on the overall modeled species richness. A better analysis of species richness will be obtained if relating it with factors other than the climatic factors (Terribile *et al.*, 2009).

The correlation of species richness and ecology indicate that fir and oak–laurel forests along with alpine mats and pastures are among most suitable vegetation types for occurrence of the members of Liliaceae. This resulted pattern implies that some species occur widely in lower altitudes (up to 3800 m) in habitats dominated by fir and oak–laurel forests. These species preferred to grow in moist habitats under shades of dominant species and other associates. Those species, which occurred in higher altitudes on alpine mats and pastures (>3800 m), preferred drier, open and exposed habitats, with low temperature and precipitation rates. Species richness for the family Liliaceae is very low in hill sal forest, *Schima–Castanopsis* forest, nival zone, trans-Himalayan steppe and alpine meadows. Hill sal forest and *Schima–Castanopsis* forest are lower altitude ecology types from where only one or two species were recorded (based on herbarium specimens and literatures). Therefore these later vegetation types are less suitable for species occurrence. Nival zone, trans-Himalayan steppe and alpine meadows, with low temperature and very scanty rainfall during the dry months of the year, are also less favourable for species occurrence.

CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

Present study, based on Angiosperm Phylogeny Group (APG) classification, enumerated and described nine genera (*Cardiocrinum*, *Clintonia*, *Fritillaria*, *Gagea*, *Lilium*, *Lloydia*, *Notholirion*, *Streptopus* and *Tricyrtis*) and 19 species, with 2 varieties and 2 forma (*Cardiocrinum giganteum*, *Clintonia udensis*, *Fritillaria cirrhosa*, *Gagea elegans*, *Lilium nanum*, *Lilium nanum* f. *nanum*, *Lilium nanum* f. *flavidum*, *Lilium nepalense*, *Lilium oxypetalum*, *Lilium wallichianum*, *Lloydia delicatula*, *L. flavonutans*, *L. longiscapa*, *L. serotina*, *L. serotina* var. *parva*, *L. serotina* var. *serotina*, *L. tibetica*, *L. yunnanensis*, *Notholirion bulbuliferum*, *N. macrophyllum*, *Streptopus parasimplex*, *S. simplex* and *Tricyrtis maculata*) under Liliaceae from Nepal. Three species (*Lilium bakerianum*, *L. sherriffiae* and *Notholirion thomsonianum*) were not included in the taxonomic treatment because of non-availability of the herbarium specimens in any of the herbaria under study.

Vegetative and reproductive morphological characters are of much significance in delimiting taxa within the family Liliaceae. In contrast to APG classification, which recognized three subfamilies, the present taxonomic revision of the family Liliaceae reveals that 9 genera within it can be grouped into two main clusters based on morphological characters. Genera like *Cardiocrinum*, *Fritillaria*, *Gagea*, *Lilium*, *Lloydia* and *Notholirion* are placed in bulbous group and *Clintonia*, *Spreptopus* and *Tricyrtis* into rhizomatous group. The cluster analysis proved to generate basic idea on the relationship among the members within the family.

Species within the family are distributed from subtropical to alpine zone of Nepal. Most of them occur in north-central region, followed by north-eastern and north-western regions. However, members under three subfamilies differ in their suitability value for potential distribution. Species of subfamilies Lilioideae and Streptopoideae are distributed in all the phytogeographic regions; whereas, species of Calochortoideae have potential distribution in north-eastern and very less in north-central region. Species of Calochortoideae favor wetter climates than the species of other two subfamilies. Species richness values were highest for

north-central and north-western regions of Nepal than for north-eastern region. Fir and oak-laurel forests and alpine mats and pastures are richest in terms of species number.

Use of geographic location of the collection sites in combination with the relatively simple GIS software (such as DIVA-GIS) allowed prediction on distribution and estimation of species richness for the family Liliaceae. Species distribution models can provide valuable information about where species are likely to be found. As well as being an important tool for conservation, they can help to determine the aspects of species' environment that are important in determining its distribution and thus advance our understanding of ecological niches. Species distribution modeling can not replace fieldwork intended to collect more distributional data, but can be a useful tool for data exploration to help identify potential knowledge gaps and provide direction to fieldwork design. Current potential distribution of species enumerated in the family Liliaceae has provided new localities for future expeditions and explorations.

6.2 Recommendation

1. Additional molecular researches are needed to fill gaps in our knowledge and to resolve the taxonomic limitations of family Liliaceae in Nepal. In particular, molecular phylogenetic study to investigate the possible link between past geological events and the diversification of plant species.
2. There is lack of detail information on herbarium labels of many specimens housed at National herbaria (KATH and TUCH). Such information is vital for systematic revision. Therefore, it is recommended that labels containing most of the information about the species should be maintained for any future collections.
3. As the present study is solely based on herbarium specimens deposited at different herbaria, it supports possibility of finding new species if explorations are carried out extensively in Nepal.
4. Lack of information on type also slowed the study. Therefore, there must be a mechanism so that at least researchers could get easy access to the information on type specimens.

5. Future research also needs to focus on identifying the variables that have a direct effect on the occurrence of species, in order that more accurate and more generalizable models can be made.

6. The species distribution modeling enhances our understanding about spatial patterns of biodiversity, as well as provides directions to fieldwork design and explorations. Therefore, more work in this field is recommended by taking in particular consideration to the plant species that are highly threatened in order to protect them from future extinctions.

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APPENDICES

Appendix 1

List of 19 bioclimatic variables used for predicting the species distribution

(<http://www.worldclim.org/bioclim>)

Bioclimatic Variables	
Derived from max & min temperature	BIO1 = Annual Mean Temperature
	BIO2 = Mean Diurnal Range (Mean of monthly (max temp –min temp))
	BIO3 = Isothermality (P2/P7) (* 100)
	BIO4 = Temperature Seasonality (standard deviation *100)
	BIO5 = Max Temperature of Warmest Month
	BIO6 = Min Temperature of Coldest Month
	BIO7 = Temperature Annual Range (P5–P6)
	BIO8 = Mean Temperature of Wettest Quarter
	BIO9 = Mean Temperature of Driest Quarter
	BIO10 = Mean Temperature of Warmest Quarter
	BIO11 = Mean Temperature of Coldest Quarter
Derived from precipitation	BIO12 = Annual Precipitation
	BIO13 = Precipitation of Wettest Month
	BIO14 = Precipitation of Driest Month
	BIO15 = Precipitation Seasonality (Coefficient of Variation)
	BIO16 = Precipitation of Wettest Quarter
	BIO17 = Precipitation of Driest Quarter
	BIO18 = Precipitation of Warmest Quarter
	BIO19 = Precipitation of Coldest Quarter

Appendix 2

Remaining list of herbarium specimen examined.

Cardiocrinum giganteum (Wall.) Makino

Western Nepal: *Bajhang*, Between Dhuli and Inuldar, 2510 m, 26th July 1976, H. Tabata, K.R. Rajbhandari and K. Tsuchiya, 1704 (KATH). *Dolpa*, Kaigaon–Ela, 9000 ft, 23rd June 1966, T.B. Shrestha, 5225 (KATH). *Kaski*, Humde, 1450 m, 22nd May 1992, N.P. Manandhar and S.K. Acharya, 130-92 (KATH). *Parbat*, Ghandruk–Banthanti, 2500 m, 11th July 1983, K.R. Rajbhandari, 7508 (KATH); Banthanti–Gorepani Deorali, 2650–3170 m, 12th July 1983, H. Obha, H. Kanai, M. Wakabayashi, M. Suzuki and S. Akiyama, 8330361 (E). **Central Nepal:** *Lalitpur*, Phulekoki, 2743 m, 3rd July 1986, 10574 (KATH). **Eastern Nepal:** *Solukhumbu*, Kurki–Pangkongma–Pangkongma–Kharikhola, 2100–3650 m, 29th August 1997, M. Bakabayashi, M. Amano, M. Mori, K.R. Rajbhandari and K. Shinozaki, 97/30392 (KATH). *Taplejung*, Bhirkuna, 2300 m, 20th May 1992, K.R. Rajbhandari, 16262 (KATH); Amji Khola–Dupi Danda–Yamphudin, 1680–2400 m, 13th June 1992, S. Noshiro, S. Akiyama and N. Acharya, 9240787 (KATH); Papung–Donge–Mewa Khola Bridge–Sewaden, 1940–2490 m, 12th June 1998, M. Suzuki, K.R. Rajbhandari, S. Noshiro, S. Akiyama, H. Koba and N. Acharya, 9262065 (KATH). *Panchthar*, Chyangthapu, 8000 ft, 06–11th June 1969, T.B. Shrestha, 1557 (KATH).

Fritillaria cirrhosa D. Don

Western Nepal: *Darchula*, Ghuruchi Lakh, 11000ft, 11th June 1966, T.B. Shrestha, 5159 (KATH); Darchula, 3620 m, 18th May 1971, P.R. Shakya and D. Joshi, 547 (KATH); Surmasarowar, 3500 m, J.F. Dobremez, DBR NEP N 2121 (KATH); Kawa Lakh, 3620 m, 18th May 1971, P.R. Shakya and D. Joshi, 547 (KATH). *Bajhang*, Khaptad, 2590 m, 3rd July 1981, P.R. Shakya, L.R. Sharma and K.R. Amatya, 6303 (KATH); Khaptad, 3000 m, 7th April 1984, N. Pradhan and N. Dabadi, 1223 (KATH); Tapuan, 3800 m, 25th July 1984, P.R. Shakya, N.K. Adhikari and H.N. Subedi, 8154 (KATH). *Dolpa*, Phoksundo–Gandala, 4200 m, 15th June 1987, N.K. Bhattarai and M.N. Subedi, 87/91 (KATH). *Kaski*, Ghopta odar, 3650 m, 13th June 1972, P.R. Shakya 1486 (KATH). **Central Nepal:** *Gorkha*, Gyalchok VDC, Dhamara goth area, E-Facing, 4040 m, 18th September 1995, Olsen, 340 (KATH). *Rasuwa*, Langtang valley, c.13500 ft, 25th June 1965, 423 (KATH); Laurivinayak, 3800 m, 9th June 1986, N.K. Bhattarai, 86/417 (KATH); Langtang, 3750 m, 31st May 1993, N.P. Manandhar, 176-93 (KATH); Around Kyanjin gompa (East side of Tajar Chu–stream, North of Kyangjin Gompa), 3800 m, 21st May 2001, S. Akiyama, M. Amano, C. Mouri, M.N. Subedi, H. Tsukaya, 20100163 (KATH); South of Gosainkunda, 4400 m, 31st August 2006, N. Shrestha, D. Prasai and B. Karki, 225 (TUCH). **Eastern Nepal:** *Solukhumbu*, Chhomalang Base Camp–Rato Odara, 4495–4820 m, 18th August 1995, F. Miyamoto, M. Amano, H. Ikeda, C.M. Joshi, K. Arai and T. Komatsu, 9592320 (KATH).

Sankhuwasabha, Giddhe, 12000 ft, 22nd July 1971, T.B. Shrestha and D.P. Joshi, 234 (KATH); Above Dhramshala Kharka, 3460 m, 14th June 1994, P.R. Shakya, K.K. Dangol, 10104 (KATH). *Taplejung*, Kangrang, 12500ft, 17th June 1989, T.B. Shrestha 15718 (KATH), Deuma Kharka–Knagcarkaha Kh–Mongma Kharka–Tipta La–Deuma Kharka, 3855 m, 27th May 1992, M. Suzuki, K.R. Rajbhandari, S. Noshiro, S. Akiyama, H. Koba and N. Acharya, 9262211 (KATH); Bhitte Kharka–Dobola Kharka–Broad Ridge–Iwanagi Kharka, 3410–3900 m, 16th June 1992, S. Noshiro, S. Akiyama and N. Acharya, 9240884 (KATH); Deuma, KCA, 4000 m, August 2000, S. Sherpa, ss12/00 (TUCH). *Panchthar*, Phedung Danda (Budipani Kharka)–Deurali–Dur Kharka–Gairi Kharka, 3720–3270 m, 20th June 1992, S. Noshiro, S. Akiyama and N. Acharya, 9240916 (KATH).

Gagea elegans Wall. ex D. Don

Western Nepal: *Bajhang*, Near Dogadi Khola, 13000 ft, 17th June 1954, Stainton, Sykes and Williams, 3179 (E). *Dolpa*, Balangra Pass, 12000 ft, 26th May 1952, O. Polunin, W.R. Sykes and L.H.J. Williams, 1013 (E); North face Jangla pass, 31st May 1966, 5050 (E). *Mustang*, Lete, south of Tukucha, Kali Gandaki, 10000 ft, 6th September 1954, Stainton, Sykes and Williams, 1056 (E). *Baglung*, Near Dhorpatan, 9500 ft, 17th October 1954, Stainton, Sykes and Williams, 9069 (E).

Lilium nanum Klotzsch forma **nanum**

Western Nepal: *Dolpa*, Maharigaon (3 miles N.E.), 14500 ft, 13th July 1952, O. Polunin, W.R. Sykes and H.J. Williams, 129 (E). *Mustang*, Thinigaon, Muktinath Himal, 14000 ft, 21st June 1954, Stainton, Skyes and Williams, 1266 (E). *Manang*, Rambrong, Lamjung Himal, 12500 ft, 1st July 1954, Stainton, Skyes and Williams, 6065 (E). *Gorkha*, Samdo: East of village on south side of Sanam Khola river valley, 4160 m, 8th August 2008, H. Ikeda, T. Kawahara, O. Yano, N. Yamamoto, M.F. Watson, Z.H. Li, M.N. Subedi and S.K. Acharya, 20815169 (E). **Eastern Nepal:** *Sankhuwasabha*, Arun Tamur Watershed, South of Topke Gola, 14000 ft, 4th July 1956, J.D.A. Stainton, 856 (E); Around Makalu Base Camp, 4680 m, 26th July 1988, M. Suzuki, N. Naruhashi, S. Kurosaki, Y. Kadota, M.N. Subedi, M. Minaki, S. Noshiro and H. Ikeda, 8850641 (E).

Lilium nanum forma **flavidum** (Rendle) H. Hara

Western Nepal: *Dolpa*, Maharigaon, 12000 ft, 16th June 1966, T.B. Shrestha, 5108 (KATH). **Central Nepal:** *Rasuwa*, Langsisa, Langtang, 3990 m, 25th August 2000, M.N. Subedi, 400354 (KATH).

Lilium nepalense D. Don

Western Nepal: *Darchula*, Kasoti–Chheti, 2500 m, 20th July 1984, P.R. Shakya, N.K. Adhikari, H.N. Subedi, 7976 (KATH). *Bajhang*, Gurd lekh, 3000 m, 1st September 1990, K.R. Bhattarai, 90/1193 (KATH). *Mugu*, Jima, 16th June 1936, F.M. Bailey, (E). *Dolpa*, Tarakot, 3100 m, 19th July 1973,

Einarsson, Skarby, Wetterhall, 2498 (KATH). *Mustang*, Taglung, 2622 m, 21st July 1964, T.B. Shrestha and M.S. Bista, 2486 (KATH), Lete–Devithan, 2744 m, 21st July 1964, Mrs. Pradhan and Miss Thapa, 1861 (KATH); Mustang, 2500 m, 24th July 1974, Joshi and Bhattacharya, 74/1967 (KATH). *Baglung*, Nr. Dhorpatan, 2896 m, 12th July 1954, Stainton, Skyes and Williams, 3465 (E). *Kaski*, Chhomrong, 2100 m, 3rd July 1971, P.R. Shakya, S. Poudel, 10511 (KATH). *Parbat*, Above Ranthang, 2439 m, 5th July 1978, P.R. Shakya, K.R. Rajbhandari and H.K. Sajiu, 2818 (KATH); Ghandruk deorali–Banthanti, 2600 m, 11th July 1983, H. Obha, S. Akiyama, M. Suzuki, H. Kanai and M. Wakabayanshi, 8310277 (KATH). *Lamjung*, Rambrong, 2896 m, 27th June 1954, Stainton, Skyes and Williams, 5946 (E); Jagat–Dharapani, 1430–2000 m, 22nd July 1979, D.P. Joshi and M.M. Amatya, 73/389 (KATH). *Gorkha*, Ripche–Dumje Thumje–Lungdang Gompa, 2400 m, 28th July 1994, H. Obha, S. Akiyama, M. Suzuki, H. Kanai and M. Wakabayanshi, 9485185 (E); Namrung to Lho, 2660 m, 1st July 2008, H. Ikeda, T. Kawahara, O. Yano, N. Yamamoto, M.F. Watson, Z.H. Li, M.N. Subedi and S.K. Acharya, 20811109 (E); Dyang to Ghap, 2110 m, 30th July 2008, H. Ikeda, T. Kawahara, O. Yano, N. Yamamoto, M.F. Watson, Z.H. Li, M.N. Subedi and S.K. Acharya, 20816060 (E); Ghap to Namrung Near Nambache, 2160 m, 31st July 2008, H. Ikeda, T. Kawahara, O. Yano, N. Yamamoto, M.F. Watson, Z.H. Li, M.N. Subedi and S.K. Acharya, 2081768 (E). **Central Nepal:** *Rasuwa*, Langtang–Birdim, 2592 m, 28th June 1949, O. Polunin, 689 (E); Khanging–Syarpa Gaon–Langtang Gorgu, 2300–2600–2420–2600 m, 11th July 1970, H. Kanai and P.R. Shakya, 672436 (KATH); Domze, 9950 m, 16th July 1977, N.P. Manandhar, 108 (KATH); Kyanjin, 3800 m, 10th June 1977, N.P. Manandhar and Perty, 535 (KATH); Lama Lodge, 2500 m, 11th July 1984, H.K. Saiju and B. Roy, 17 (KATH), Langtang–Thangshab–Ghora Tabela–Chumna Lodge–Lama Lodge, 3100 m, 23rd July 1992, H. Takayama, K. Arai, H. Hatta, T. Hoshino, F. Miyamoto, M.N. Subedi and S. Takatsuki, 9233128 (E); Near Lama Hotel, 2360 m, 11th July 1992, M.N. Subedi, 9237033b (KATH); Syabru Bensi–Parbati Kund (near Gatlang), 1430–2690 m, 24th July 1994, F. Miyamoto, K.R. Rajbhandari, S. Akiyama, M. Amano, H. Ikeda and Y. Tsukaya, 9420003 (KATH); Gumsa, 3200 m, 14th July 2001, G.D. Bhatt, D.B. Karkee and N.B. Pradhan, 135 (KATH). *Lalitpur*, Godawari, Phulchoki, 2438 m, 12th July 1961, S.B. Malla, 217 (KATH); Phulchoki, 2743 m, 5th July 1968, Mrs. Pradhan and Miss Thapa, 10572 (KATH); Kathmandu valley–Phulchoki, 1350–2700 m, 30th June 1983, H. Obha, S. Akiyama, M. Suzuki, H. Kanai and M. Wakabayanshi, 8350046 (KATH). **Eastern Nepal:** *Sankhuwasabha*, Arun valley, Chhoyang Khola, W. of Num, 2439 m, 24th June 1965, J.D.A. Stainton, 761 (KATH). *Tehrathum*, Basantpur–Tsute–Chauki, Tehrathum, 2820 m, 3rd August 1999, Y. Omori, N. Acharya, K. Fujikawa, M. Munemasa, M. Okada, R.H. Ree, M. Tateno and N. Thapa, 9920019 (KATH). *Taplejung*, Mauwa Khola, 2896 m, 7th August 1967, T.B. Shrestha, 16035 (KATH). *Ilam*, Maimajhuwa, Chibe, 2482 m, 1st September 2007, R.M. Kunwar, M.K. Dhamala, J. Pandey, N.B. Khatri Chhetri, Y.R. Poudel and R.K. Rai, LKSRC 106 (E).

Lloydia flavonutans H. Hara

Central Nepal: Manang, Rambrong, Lamjung Himal, 13500 ft, 3rd June 1954, Stainton, Sykes and Williams, 6108 (E). **Eastern Nepal:** Solukhumbu, Seto Pokhari–Chhomalung Base Camp, 4810–4495 m, 17th August 1995, F. Miyamoto, M. Amano, H. Ikeda, C.M. Joshi, K. Arai, and T. Komatsu, 9584193 (KATH); Chalem Kharka–Panch Pokhari–Khola Kharka, 3450–4300–4100 m, 8th May 1997, M. Wakabayashi, M. Amano, M. Mori, K.R. Rajbhandari and K. Shinozaki, 9730135 (KATH).

Lloydia longiscapa Hook.

Western Nepal: Dolpa, Near Jangla, Bhanjyang, 13500 ft, 30th June 1952, O. Polunin, W.R. Sykes and L.H.J. Williams, 2346 (E); Maharigaon, 15000 ft, 20th July 1952, O. Polunin, W.R. Sykes and L.H.J. Williams, 230 (KATH); Lekh of Maharigaon, 12000 ft, 16th June 1966, T.B. Shrestha, 5107 (KATH); Jungla Bhanjang, 3800 m, 5th June 1973, Einarsson, Skarby and Wetterhall, 506 (KATH). **Mustang,** Tukucha, Kali Gandaki, 13000 ft, 15th June 1954, Stainton, Sykes and Williams, 1143 (E). **Manang,** Rambrong, Lamjung Himal, 13000 ft, 3rd June 1954, Stainton, Sykes and Williams, 6107 (E). **Kaski,** Machhapuchre Base Camp–Annapurna Base Camp, 3550 m, 28th June 2001, P.R. Shakya and S. Poudel, 10450 (KATH). **Gorkha,** Samdo: E of village, on South side of Sanam Khola river Valley, 4170 m, 9th August 2008, H. Ikeda, T. Kawahara, O. Yano, N. Yamamoto, M.F. Watson, J.H. Li, M.N. Subedi and S.K. Acharya, 20817111 (E). **Central Nepal:** Rasuwa, Mul Kharka–Chilime Khola, 3800–4100 m, 4th July 1970, H. Kanai and P.R. Shakya, 158 (KATH). **Sindhupalchok,** Helambu, 4114 m, 11th, June 1971, John and Naomi Bishop, WF 16 (KATH). **Eastern Nepal:** Sankhuwasabha, Bhalukhop to Jumley, 13500 ft, 24th July 1971, T.B. Shrestha and D.P. Joshi, 287 (KATH); Jaljale Himal, Jaljale–Acol–Tin Pokhari, 4030–4170–4130 m, 22nd July 1991, H. Obha, S. Akiyama, H. Ikeda, S. Noshiro, Y. Omori, M.N. Subedi, T. Kikuchi, and M. Wakabayashi, 9110167 (KATH); Wame danda, 3700 m, 14th June 1994, P.R. Shakya and K.K. Dangol, 10121 (KATH).

Lloydia serotina var. **parva** (C. Marquand & G. Shaw) H. Hara

Central Nepal: Sankhuwasabha, Jaljale Himal, Around Banduke, 4150 m, 25th July 3rd August 1991, H. Obha, S. Akiyama, H. Ikeda, S. Noshiro, Y. Omori, M.N. Subedi, T. Kikuchi and M. Wakabayashi, 9110266 (KATH).

Lloydia serotina (L.) Rchb. var. **serotina**

Western Nepal: Bajhang, Aletnouds, Near Saipal, 4362 m, 31st January 1976, Hideo Tabata, K.R. Rajbhandari and K. Taushiya, 1923 (KATH). Bajura, Above Dogadi Khola, 14000 ft, 17th June 1954, Stainton, Sykes and Williams, 3174 (KATH). **Humla,** Dozam Khola, near Simikot, 11500 ft, 30th May 1952, O. Polunin, W.R. Sykes and L.H.J. Williams, 4226 (KATH). **Dolpa,** Balangra Pass, also Barbung Khola, 14000 ft, 29th May 1952, O. Polunin, W.R. Sykes and L.H.J. Williams, 1032 (E);

Near Rahagaon, Suligad, 11500 ft, 5th June 1952, O. Polunin, W.R. Sykes and L.H.J. Williams, 2153 (KATH). *Mustang*, Chhairogaon, N. of Tukucha, 11500 ft, 31st May 1954, Stainton, Sykes and Williams, 824 (KATH). Muktinath, 15500 ft, 26th June 1954, Stainton, Sykes and Williams, 1455 (KATH). *Baglung*, Pharsey, 14000–16000 ft, 1930, Major Lall. Dhwoj, 189 (KATH). *Manang*, Braga, 11500ft, 5th June 1950 (KATH). *Gorkha*, Between Sama and Sabai, 3600 m, 2nd June 1983, P.R. Sharma, M.K. Adhikari and M.N. Subedi, 7721 (KATH); E of Chhedy, 11000 ft, 21st July 1965, T.B. Shrestha, 4241 (KATH). **Central Nepal:** *Rasuwa*, Chobuk, 4450 m, 27th July 1977, K.R. Rajbhandari and B. Roy, 1954 (KATH). *Ramechhap*, Jata Pokhari–West of Panch Pokhari–Jata Pokhari, 4220–2560 m, 14th July 1985, N. Kurosaki, K.R. Rajbhandari and S.K. Wu, 8570464 (KATH).

***Notholirion macrophyllum* (D. Don) Boiss.**

Western Nepal: Lare Khola, 3300 m, 4th June 2000, D. Pyakurel, 40 (TUCH). *Mugu*, Mangni Orangja, 9–10000 ft, 13th October 1927, Sir Clive Wigram, 39 (E). *Jumla*, Valley of Jumla, 8–9000 ft, 29th June 1952, O. Polunin, W.R. Sykes and H.J. Williams, 4390 (E). *Dolpa*, Near Tarakot, Bheri river, 10500 ft, 5th July 1952, O. Polunin, W.R. Sykes and H.J. Williams, 2377 (E); Babaria lekh, Naphukona, 10000 ft, 9th July 1952, O. Polunin, W.R. Sykes and H.J. Williams, 91 (E); Tarakot, 3700 ft, 28th June 1973, Einarsson, Skarby and Wetterhall, 1298 (KATH). *Mustang*, Bhurungdi Khola, 10000 ft, 5th June 1954, Stainton, Skyes and Williams, 5787(E); Above Maikot, 12000 ft, 26th June 1954, Stainton, Skyes and Williams, 3259 (E); Kulopani, 2500 m, 14th July 1975, D.P. Joshi and T.K. Bhattacharya, 75/3267 (KATH). *Baglung*, Near Dhorpatan, 9500 ft, 17th October 1954, Stainton, Skyes and Williams, 9069 (E). *Manang*, Chami–Pisang, 2730–3330 m, 11th July 1973, D.P. Joshi and D.P. Joshi, 73/517 (KATH). *Lamjung*, Chamche, 1300 m, 20th April 2000, K. Gurung, 4 (TUCH). **Central Nepal:** *Rasuwa*, Upper Langtang valley, 13500ft, 28th June 1965, N. Thapa, 447 (KATH); Sherpagaon, Langtang, 8800 ft, 13th July 1967, 9023 (KATH); Kyangchin Kharka Langtang, 11200 ft, 16th July 1967, 9156 (KATH); Chandanbari, 10300 ft, 16th July 1977, N.P. Manandhar, 184 (KATH); Lama Hotel–Ghoda Tabela, 2880 m, 12th July 1992, M.N. Subedi, 9237050 (KATH); Ghumsa, 3200 m, 14th July 2001, D.B. Karkee, G.D. Bhatt and N.B. Pradhan, 137 (KATH); Cholangpati, 3350 m, 9th July 2001, D.B. Karkee, G.D. Bhatt and N.B. Pradhan, 34 (KATH); Langtang village, 3500 m, 15th July 2001, D.B. Karkee, G.D. Bhatt and N.B. Pradhan, 136 (KATH); Cholangpati to Lauribinayak, 3900m, 8th July 2006, K. Devkota, 65 (TUCH); Cholangpati, 3110 m, 9th July 2006, K. Paudel, 20 (TUCH); Chandanbari–Gosaikunda, 3750 m, 9th July 2006, N.B. Ranjitkar, 38 (TUCH); Lauribinayak, 3900 m, 9th July 2006, D. Karki, 93 (TUCH). *Dolakha*, Kalinchok, 10500 ft, 1st July 1975, P.R. Shakya, K.R. Rajbhandari and H.K. Saiju, 2732 (KATH); Beding, 11500 ft, 13th July 1975, P.R. Shakya, K.R. Rajbhandari and H.K. Saiju 2946 (KATH); Chhusa to Chhulema, 3500 m, 20th July 1977, K.R. Rajbhandari and B. Roy, 1587 (KATH); Chhumigaljo to Beding, 3400 m, 21st July 1977, K.R. Rajbhandari and B. Roy, 1734 (KATH). **Eastern Nepal:** *Solukhumbu*, Thesiyo, north of Thesebu

Khola Valley, 3535 m, 15th September 2005, M.F. Watson, K.R. Rajbhandari, K.K. Shrestha, D. Knott, C.A. Pendry, S.K. Acharya, U. Koirala, L.N. Mandar, N. McCheyne, R.C. Poudel, S. Rajbhandary and S. Vaidya, DNEP3 BX97 (E). *Taplejung*, Kyapra to Pheri, Ghunsa Khola, 2700 m, 9th July 1989, KEKE322 (E).

Clintonia udensis Trautv. & C. A. Mey.

Western Nepal: *Darchula*, Dhuli, 3000 m, 14th May 1973, J.F. Dobremez, DBR NEP N 2224 (KATH). *Humla*, Chankhuli, 3350 m, 14th August 1985, P.R. Shakya, H.N. Subedi and R.K. Uprety, 8646 (KATH). *Jumla*, Napani, 2700 m, 20th September 1982, N.P. Manandhar and N.K. Bhattarai, 9025 (KATH). **Central Nepal:** *Rasuwa*, Tharepati, 3300 m, 24th May 1993, N.P. Manandhar, 118-93 (KATH); Kharka–Chyauche Kharka, 3600 m, 11th August 1994, F. Miyamoto, K.R. Rajbhandari, M. Amano, H. Ikeda, S.V. Tsukaya, and S. Akiyama, 9410256 (KATH); Kharka (Near Ganesh base camp)–Pass–Chyauche Kharka, 3400–3960–3600 m, 11th August 1994, F. Miyamoto, K.R. Rajbhandari, M. Amano, H. Ikeda, S.V. Tsukaya, and S. Akiyama, 10256 (KATH). **Eastern Nepal:** *Sankhuwasabha*, Thudam valley, 11200 ft, 30th July 1971, T.B. Shrestha and D.P. Joshi, 395 (KATH); Above Dharmasala kharka, 3530 m, 14th June 1994, P.R. Shakya and K.K. Dangol, 10106 (KATH); Samakang Kharka–Dudh Kund, 3530–4440 m, 24th August 1995, F. Miyamoto, M. Amano, H. Ikeda, C.M. Joshi, K. Arai and T. Komatsu, 9592416 (KATH). *Taplejung*, Tate–Hesingnasa, 11000 ft, 28th May 1958, Shesbagiri Rao Rolla, 14156 (KATH); Sewaden–Mewa Khola Bridge–a Kharka–Topke Gola, 2490–2830–3120–3590 m, 15th May 1992, M. Suzuki, K.R. Rajbhandari, S. Noshiro, S. Akiyama, H. Koba and N. Acharya, 9262090 (KATH); Sigre Danda–Top of a ridge (Dobala Danda)–Bhitte Kharka, 3100–3500 m, 15th June 1992, S. Noshiro, S. Akiyama and N. Acharya, 9240810 (KATH); Wolangchung Gola–Tamur–Yangma Khola Junction–Chemi Kharka–Thasa Kharka, 3110–3260 m, 29th May 1992, M. Suzuki, K.R. Rajbhandari, S. Noshiro, S. Akiyama, H. Koba and N. Acharya, 9240378 (KATH); Thasa kharka–Seon Kharka–Nango La–Thasa Kharka, 3260–4030–4590–3260 m, 30th May 1992, M. Suzuki, K.R. Rajbhandari, S. Noshiro, S. Akiyama, H. Koba and N. Acharya, 9240421 (KATH); Walungchung Gola, 3200 m, 2nd May 2000, Shova Sherpa, 30 (TUCH).

Streptopus parasimplex H. Hara & H. Ohashi

Eastern Nepal: *Solukhumbu*, Rangdu Kharka–Mosom Kharka–Horsola Kharka, 3300–3600–3800 m, 10th August 1997, M. Wakabayashi, M. Amono, M. Mori, K.R. Rajbhandari and K. Shinozaki, 9715131 (E). *Taplejung*, Topke Gola–Sewaden, 3590–2490 m, 17th May 1992, M. Suzuki, K.R. Rajbhandari, S. Noshiro, S. Akiyama, H. Koba and N. Acharya, 9262115 (KATH); Julung Chhyango, 3750 m, 21st June 1972, P.R. Shakya, 1685 (KATH); Gyabla–Nag Pokhari Khola–Fale–Ghunsa, 2630–3300 m, 6th June 1992, S. Noshiro, S. Akiyama and N. Acharya, 9240606 (KATH, E); Yamphodin, 10000 ft, 24th June 1969, T.B. Shrestha, 15931 (KATH).

Streptopus simplex D. Don

Western Nepal: Bajhang, Ghodilekh, 3333 m, 13th August 1976, H. Tabata, K.R. Rajbhandari and K. Tsuchiya, 2432 (KATH). *Bajura*, Pategaon–Ghodi Lekh Deorali–Badigaon, 2190–3350–2230 m, 16th August 1991, M. Suzuki, H. Hatta, N. Kurosaki, M. Mikage, F. Miyamoto, K.R. Rajbhandari, H. Takayama and K. Terada, 9160664 (E). *Mustang*, Ghasa, South of Tukucha, Kali Kandaki, 10000 ft, 4th July 1954, Stainton, Sykes and Williams, 1537(E); Taglung, south of Tukucha, 12000 ft, 12th July 1954, Stainton, Sykes and Williams, 1757 (E). *Baglung*, Annapurna Himal, Seti Khola, 11000 ft, 14th August 1954, Stainton, Sykes and Williams, 8604 (E). *Manang*, Rambrong, Lamjung Himal, 11500 ft, 28th June 1954, Stainton, Sykes and Williams, 5992 (E); Lamjung Himal, 10500 ft, 16th July 1954, Stainton, Sykes and Williams, 6383 (E). **Central Nepal:** *Makwanpur*, Gogane, 11000–12000 ft, 1930, 19 (E). *Rasuwa*, Laurivinayak, 12500 ft, 27th July 1967, Dr. S.B. Malla, 9237 (KATH); Gosaikunda, 17th July 1973, H.K. Saiju and P.M. Regmi, 810 (KATH); Deurali, 2685 m, 8th August 2006, D. Karki, 64 (TUCH); Chandanbari, 3480 m, 9th July 2006, P. Sharma, 75 (TUCH); Chandanbari–Cholangpati, 3520 m, 9th July 2006, E. Poudel, 64 (TUCH). *Dolakha*, Simigeon, 9000 ft, 19th July 1975, P.R. Shakya, K.R. Rajbhandaari, H.K. Saiju, 2376 (KATH); Chhulema, 3800 m, 20th July 1997, K.R. Rajbhandari and B. Roy, 1647 (KATH). **Eastern Nepal:** *Sankhuwasabha*, Bhainsi Kharka–Danda Kharka–Unshisa Kharka–Khongma, 3140 m, 4th August 1990, M. Minaki, C. Yonebayashi, F. Miyamoto, H. Takayama, H. Sugita, H. Yagi, M.N. Subedi and H. Ikeda, 9070128 (E). *Taplejung*, Tamur valley, Mewa Khola, S.E. of Topke Gola, 11500 ft, 16th May 1956, J.D.A. Stainton, 321 (E); Bhajapate Kharka–Dhupi Kharka, 9600ft, 3rd Oct 1981, P.R.Shakya, 7168 (KATH); Khade Khola–Painya, 9800 ft, 23rd July 1966, Dr. Banerjii and P.R. Shakya, 5603 (KATH).

Tricyrtis maculata (D. Don) J. F. Macbr.

Eastern Nepal: *Sankhuwasabha*, Above Shinbun–Hatia Gola, 2100–1600 m, 3rd August 1977, H. Ohashi, H. Obha, H. Kanai and Y. Tareishi, 771774 (KATH); Chichila–Kuwapani–Sakrate–Hurchure (Fururu)–Mude (Mure), 1870–2040 m, 9th July 1988, M. Suzuki, H. Narushashi, S. Kurosaki, S. Noshiro, Y. Hedota, M. N. Subedi, M. Minaki, and H. Ikeda, 8880227 (KATH); Tashigaon–Kersing Kharka–Navagaon (Nabagaon)–Sedua, 2160–1590 m, 1st August 1988, M. Suzuki, H. Narushashi, S. Kurosaki, S. Noshiro, Y. Hedota, M. N. Subedi, M. Minaki, and H. Ikeda, 8821137 (KATH); Tashigaon–Navagaon, 2150 m, 1st August 1988, M.N. Subedi, 8890681 (KATH); Chichila–Kuwapani–Sakrate–Hurchure (Fururu), 1870–2040 m, 30th July 1990, M. Minaki, C. Yonebayashi, F. Miyamoto, H. Takayama, H. Sugita, H. Yagi, M.N. Subedi, and H. Ikeda, 9040136 (KATH).

Appendix 3.

Data matrix for cluster analysis.

S.N.	Taxon	Character code																		
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	<i>Cardiocrinum giganteum</i>	0	1	0	2	0	0	0	1	1	0	1	1	2	1	0	2	1	1	1
2	<i>Clintonia udensis</i>	1	0	0	0	0	2	1	1	2	1	0	1	2	1	0	0	1	0	0
3	<i>Fritillaria cirrhosa</i>	0	1	1	1	0	1	1	0	3	1	1	1	1	0	0	2	1	1	1
4	<i>Gagea elegans</i>	0	0	0	0	0	1	1	0	1	1	0	1	0	0	0	1	1	1	0
5	<i>Lilium nanum</i>	0	1	0	1	0	1	1	0	0	1	1	0	2	1	0	2	1	1	1
6	<i>Lilium nepalense</i>	0	1	0	1	0	2	1	1	1	1	1	1	3	1	0	2	1	1	1
7	<i>Lilium oxypetalum</i>	0	1	0	1	0	2	1	0	1	1	1	1	2	1	0	2	1	1	1
8	<i>Lilium wallichianum</i>	0	1	0	1	0	1	1	0	0	1	1	1	1	1	0	2	1	1	1
9	<i>Lloydia delicatula</i>	0	0	1	0	0	1	1	0	0	1	0	1	1	0	0	1	0	1	1
10	<i>Lloydia flavonutans</i>	0	0	1	0	0	1	1	0	0	1	0	1	1	0	1	2	0	1	1
14	<i>Lloydia longiscapa</i>	0	0	1	0	0	1	1	0	0	1	0	1	1	0	1	1	0	1	1
11	<i>Lloydia serotina</i>	0	0	1	0	0	1	1	0	0	1	0	1	1	0	0	0	0	1	1
12	<i>Lloydia tibetica</i>	0	0	1	0	0	1	1	0	0	1	0	1	1	0	1	0	0	1	1
13	<i>Lloydia yunnanensis</i>	0	0	1	0	0	1	1	0	0	1	0	1	1	0	0	2	0	1	1
15	<i>Notholirion bulbuliferum</i>	0	1	1	2	0	1	1	0	1	1	1	1	1	1	0	2	1	1	0
16	<i>Notholirion macrophyllum</i>	0	1	1	2	0	1	1	0	1	1	1	1	1	1	0	2	1	1	0
17	<i>Streptopus simplex</i>	1	0	0	1	1	2	1	0	2	0	1	1	1	0	0	1	1	0	0
18	<i>Streptopus parasimplex</i>	1	0	0	1	1	2	1	0	2	0	1	1	1	0	0	1	1	0	0
19	<i>Tricyrtis maculata</i>	1	0	0	1	1	2	1	0	2	0	1	0	1	1	0	2	1	2	0

Appendix 4

Species abbreviations used in hierarchial cluster analysis.

S. No.	Abbreviations	Species name
1	Card_gig	<i>Cardiocrinum giganteum</i>
2	Clin_ude	<i>Clintonia udensis</i>
3	Frit_cir	<i>Fritillaria cirrhosa</i>
4	Gage_ele	<i>Gagea elegans</i>
5	Lili_nan	<i>Lilium nanum</i>
6	Lili_nep	<i>Lilium nepalense</i>
7	Lili_oxy	<i>Lilium oxypetalum</i>
8	Lili_wal	<i>Lilium wallichianum</i>
9	Lloy_del	<i>Lloydia delicatula</i>
10	Lloy_fla	<i>Lloydia flavonutans</i>
11	Lloy_lon	<i>Lloydia longiscapa</i>
12	Lloy_ser	<i>Lloydia serotina</i>
13	Lloy_tib	<i>Lloydia tibetica</i>
14	Lloy_yun	<i>Lloydia yunnanensis</i>
15	Noth_bul	<i>Notholirion bulbuliferum</i>
16	Noth_mac	<i>Notholirion macrophyllum</i>
17	Stre_par	<i>Streptopus parasimplex</i>
18	Stre_sim	<i>Streptopus simplex</i>
19	Tric_mac	<i>Tricyrtis maculata</i>

Appendix 5

Distribution of Liliaceae in Nepal (vertical and horizontal distributions)

S. No.	Taxon	Vertical distribution	Horizontal distribution
1	<i>Cardiocrinum giganteum</i>	1200–3650 m	WCE
2	<i>Clintonia udensis</i>	1600–4000 m	WCE
3	<i>Fritillaria cirrhosa</i>	3000–4600 m	WCE
4	<i>Gagea elegans</i>	2800–4300 m	WC
5	<i>Lilium nanum</i>	3400–4600 m	WCE
6	<i>Lilium nepalense</i>	2000–3200 m (–3800 m)	WCE
7	<i>Lilium oxypetalum</i>	3100–3850 m	W
8	<i>Lilium wallichianum</i>	(870–)1100–2000 m	WC
9	<i>Lloydia delicatula</i>	3600–4600 m	CE
10	<i>Lloydia Flavonutans</i>	(3800–)4000–5200 m	CE
11	<i>Lloydia longiscapa</i>	2500–5000 m	WCE
12	<i>Lloydia serotina</i>	3300–4900 m	WCE
13	<i>Lloydia tibetica</i>	2300–4100 m	WC
14	<i>Lloydia yunnanensis</i>	2300–4300 m	CE
15	<i>Notholirion Bulbuliferum</i>	(1830–)3000–4500 m	WCE
16	<i>Notholirion macrophyllum</i>	2500–4400 m	WCE
17	<i>Streptopus parasimplex</i>	3100–4200 m	CE
18	<i>Streptopus simplex</i>	1800–4000 m.	WCE
19	<i>Tricyrtis maculata</i>	1300–2500(–3900 m)	CE

Source: Based on herbarium specimen records and literature.

Appendix 6

CHECKLIST

LILIACEAE Jussieu

Cardiocrinum Lindl., Veg. Kingd. 205 (1846).

Cardiocrinum giganteum (Wall.) Makino., Bot. Mag. (Tokyo) **27**: 125 (1913).

Clintonia Raf., Amer. Monthly Mag. & Crit. Rev. **2**: 266 (1818).

Clintonia udensis Trautv. & C. A. Mey., *Reise Sibir.* **1** (Theil 2, Bot. Lief. 3): 92 (1856).

Clintonia alpina Kunth ex Baker = **Clintonia udensis** Trautv. & C. A. Mey.

Clintonia udensis var. *alpina* (Kunth ex Baker) H. Hara = **Clintonia udensis** Trautv. & C. A. Mey.

Fritillaria L., Sp. Pl. **1**: 303 (1753).

Fritillaria cirrhosa D. Don., Prodr. Fl. Nepal. 51 (1825).

Fritillaria cirrhosa var. *bonatii* (H. Léveillé) S. C. Chen = **Fritillaria cirrhosa** D. Don

F. cirrhosa var. *viridiflava* S. C. Chen = **Fritillaria cirrhosa** D. Don

Lilium bonatii H. Léveillé = **Fritillaria cirrhosa** D. Don

Gagea Salisb., Ann. Bot. (König & Sims) **2**: 555 (1806).

Gagea elegans Wall. ex D. Don., in Royle, III. Bot. Himal. Mts. **2**: t. 95, f. 2, (1833–1840).

Gagea lutea (L.) Ker Gawler = **Gagea elegans** Wall. ex D. Don

Gagea coreana Nakai = **Gagea elegans** Wall. ex D. Don

Gagea coreanica Koidzumi = **Gagea elegans** Wall. ex D. Don

Lilium L., Sp. Pl. **1**: 302 (1753).

***Lilium bakerianum** Collette and Hemsl., J. Linn. Soc., Bot. **28**: 138, t.22 (1890).

Lilium nanum Klotzsch., in Klotzsch, Bot. Ergebn. Reise Waldemar. 53 (1862).

Fritillaria gardneriana Wall. ex Baker = **Lilium nanum** Klotzsch.

Fritillaria stracheyi Hook. f = **Lilium nanum** Klotzsch.

Nomocharis nana (Klotzsch) E.H. Wilson = **Lilium nanum** Klotzsch.

Lilium nanum Klotzsch, in Klotzsch Bot. Ergebn. Reise Waldemar. 53 (1862) forma **nanum**

Nomocharis nana (Klotzsch) E. H. Wilson = **Lilium nanum** Klotzsch forma **nanum**

Lilium nanum forma **flavidum** (Rendle) H. Hara., Fl. E. Himalaya. 132 (1975).

Fritillaria flavida Rendle = **Lilium nanum** forma **flavidum** (Rendle) H. Hara
Lilium euxanthum (W.W. Smith & W. E. Evans) Sealy = **Lilium nanum** forma **flavidum** (Rendle) H. Hara
L. nanum f. *flavidum* (Rendle) H. Hara = **Lilium nanum** forma **flavidum** (Rendle) H. Hara
Nomocharis euxantha W. W. Smith & W. E. Evans = **Lilium nanum** forma **flavidum** (Rendle) H. Hara
Lilium nepalense D. Don., Mem. Wern. Nat. Hist. Soc. **3**: 412 (1821).
Lilium ochroleucum Wall. ex Baker = **Lilium nepalense** D. Don
Lilium oxypetalum (D. Don) Baker, J. Linn. Soc., Bot. **14**: 234 (1874).
Nomocharis oxypetala (Royle) E. H. Wilson = **Lilium oxypetalum** (D. Don) Baker
***Lilium sherriffiae** Stearn., J. Roy. Hort. Soc., London. **75**: 192 (1950).
Lilium wallichianum J. A. & J. H. Schult., Syst. Veg. **7(2)**: 1689 (1830).
Lilium batisua Buch.–Ham. ex D. Don = **Lilium wallichianum** J. A. & J. H. Schult.
Lilium longiflorum Wall. = **Lilium wallichianum** J. A. & J. H. Schult.

Lloydia Salisb., Fl. Germ. Excurs. 102 (1830), nom. cons.
Lloydia delicatula Noltie., Edinb. J. Bot. **50 (1)**: 55 (1993).
Lloydia flavonutans H. Hara., J. Jap. Bot. **49**: 202 (1974).
Lloydia longiscapa Hook., Icon. Pl. **9**: t. 834 (1852).
Lloydia serotina (L.) Rchb., Fl. Germ. Excurs. 102 (1830).
Lloydia himalensis Royle = **Lloydia serotina** (L.) Rchb.
Lloydia serotina var. **parva** (C. Marquand & G. Shaw) H. Hara in Fl. E. Himalaya **2**: 166 (1971)
Lloydia serotina f. *parva* C. Marquand & Airy Shaw = **Lloydia serotina** var. **parva** (C. Marquand & G. Shaw) H. Hara
Lloydia serotina forma *parva* Marquand & Shaw
Lloydia serotina (L.) Rchb., Fl. Germ. Excurs. 102 (1830) var. **serotina**
Bulbocodium serotinum Linnaeus = **Lloydia serotina** (L.) Rchb. var. **serotina**
Anthericum serotinum (Linnaeus) Linnaeus = **Lloydia serotina** (L.) Rchb. var. **serotina**
Lloydia alpina Salisb. = **Lloydia serotina** (L.) Rchb. var. **serotina**
Lloydia himalensis Royle = **Lloydia serotina** (L.) Rchb. var. **serotina**
Lloydia serotina var. *unifolia* Franchet. = **Lloydia serotina** (L.) Rchb. var. **serotina**
Lloydia tibetica Baker ex Oliv. in Icon. Pl. **23**: t. 2216 (1892).
Giraldiella montana Dammer = **Lloydia tibetica** Baker ex Oliv.

Lloydia montana (Dammer) P. C. Kuo = **Lloydia tibetica** Baker ex Oliv.

L. tibetica var. *lutescens* Franchet. = **Lloydia tibetica** Baker ex Oliv.

Lloydia yunnanensis Franch., J. De Bot. **12** (12): 192 (1898).

Notholirion Wall. ex Boiss., Fl. Orient. **5**: 190 (1882).

Notholirion bulbuliferum (Lingelsh.) Stearn, Kew Bull. **1950**: 421 (1950).

Liliastrum bulbuliferum (Lingelsh.) Rothm. = **Notholirion bulbuliferum** (Lingelsh.) Stearn

Lilium hyacinthinum E. H. Wilson = **Notholirion bulbuliferum** (Lingelsh.) Stearn

Notholirion hyacinthinum (E. H. Wilson) Stapf = **Notholirion bulbuliferum** (Lingelsh.) Stearn

Notholirion macrophyllum (D. Don) Boiss., Fl. Orient. **5**: 190 (1882)

Fritillaria macrophylla D. Don. = **Notholirion macrophyllum** (D. Don) Boiss..

Lilium hookeri Baker = **Notholirion macrophyllum** (D. Don) Boiss.

Lilium macrophyllum (D. Don) Voss. = **Notholirion macrophyllum** (D. Don) Boiss.

***Notholirion thomsonianum** (Royle) Stapf., Kew Bull. 1934: 95 (1934).

Fritillaria thomsoniana D. Don = **Notholirion thomsonianum** (Royle) Stapf.

Lilium thomsonianum (D. Don) Lindl. = **Notholirion thomsonianum** (Royle) Stapf.

Streptopus Michx., Fl. Bor.–Amer. **1**: 200 (1803).

Streptopus parasimplex H. Hara & H. Ohashi., J. Jap. Bot. **48**: 101, f. 2B (1973).

Streptopus simplex D. Don., Prodr. Fl. Nepal. 48 (1825).

Hektorima candida Kunth. = **Streptopus simplex** D. Don

Tricyrtis Wall., Tent. Fl. Nepal. 61 (1826), nom. cons.

Tricyrtis maculata (D. Don) J. F. Macbr., Contr. Gray Herb., n.s. **3**: 5 (1918).

Compsanthus maculatus (D. Don) Spreng. = **Tricyrtis maculata** (D. Don) J. F. Macbr.

Tricyrtis pilosa Wallich = **Tricyrtis maculata** (D. Don) J. F. Macbr.

Note: * Excluded species.

Appendix 7

Photographs of some herbarium specimens examined



A. *Cardiocrinum giganteum*



B. *Clintonia udensis*



C. *Fritillaria cirrhosa*



D. *Gagea elegans*



E. *Lilium nanum*



F. *Lilium nepalense*



G. *Lilium oxypetalum*



H. *Lilium wallichianum*



I. *Lloydia delicatula*



J. *Lloydia flavonutans*



K. *Lloydia longiscappa*



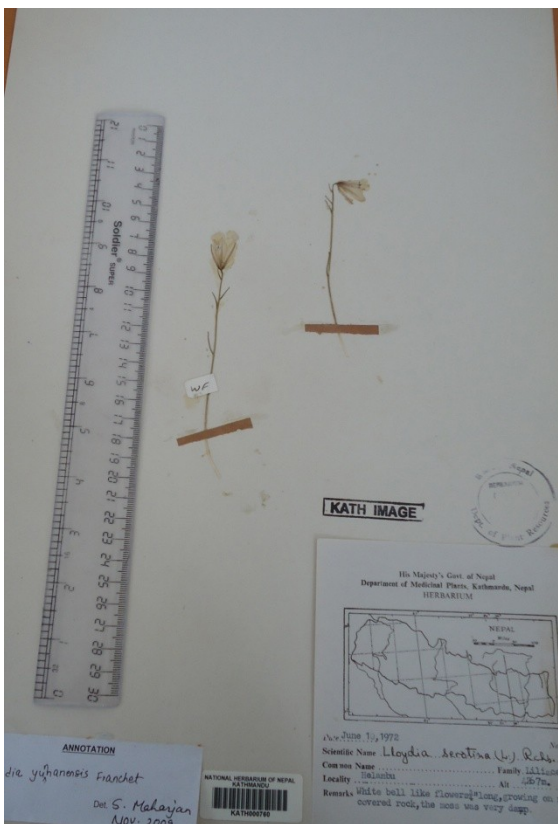
L. *Lloydia tibetica*



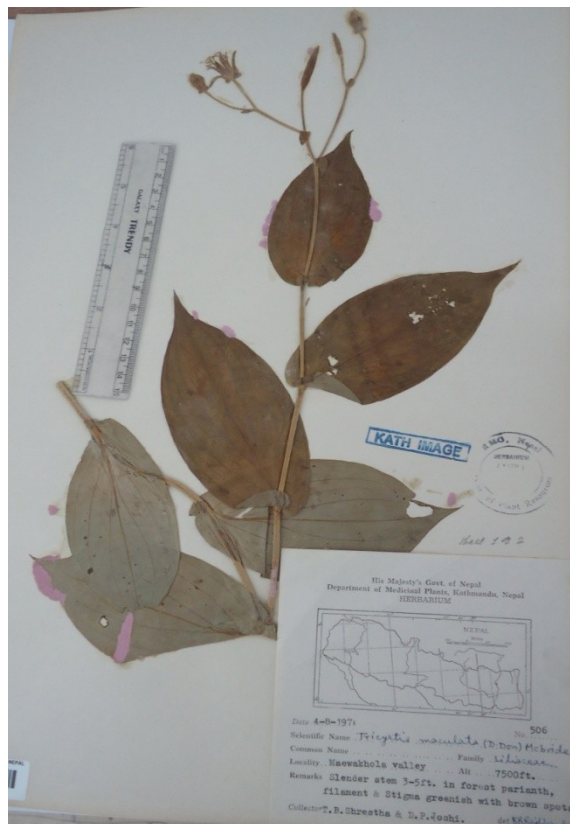
M. *Lloydia serotina* var. *parva*



N. *Lloydia serotina* var. *serotina*



O. *Lloydia longiscapa*



P. *Tricyrtis maculata*

Photographs of Type Specimen



A. *Cardiocrinum giganteum*



B. *Fritillaria cirrhosa*



D. *Lilium nanum*



E. *Lilium nepalense*



F. *Lilium wallichianum*



G. *Streptopus parasimplex*



H. *Streptopus simplex*